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SUMMARY

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THE EFFECT OF STRAW INCORPORATION INTO THE SOIL ON SOIL CARBON DIOXIDE EMISSION

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Abstract

In this study, straw was incorporated into different soil depth and then soil CO_2 emission was recorded for 45 days after the tillage operation. For this purpose, four treatments were investigated as bare soil surface (A), straw incorporated into 5 cm soil depth (B), straw incorporated into 10 cm soil depth (C), straw spreaded at the soil surface (D). Approximately, 0.5 kg straw was used per square meter. Soil carbon dioxide emission was recorded by mobile soil CO_2 flux system. Concomitantly, soil temperature, soil water evaporation and soil moisture was recorded.
According to results, soil CO_2 emission for A, B, C, and D treatments are 0.176, 0.213, 0.211 and 0.097 g CO_2 m^{-2} $h^{-1,}$ respectively. Soil temperature for A, B, C, and D treatments are 13.2°C, 13.2°C, 13.2°C and 13.3°C, respectively. Soil water evaporation for A, B, C, and D treatments are 2.24, 3.00, 2.40, and 2.01 g m^{-2} h^{-1}, respectively. Soil moisture for A, B, C, and D treatments are 16.7%, 18.4%, 18.3%, and 18.1%, respectively.
According to results, the least soil CO_2 emission was determined in D treatment. The highest soil CO_2 emission was determined for B and C treatments. Results showed that soil CO_2 emissions increased with the incorporating of straw into the soil.

Key words: *soil CO_2 emission, tillage, straw, greenhouse gasses*.

INTRODUCTION

Agricultural activities, use of fossil fuels, deforestation, rapid population growth, and the community's propensity to consume increased the amount of greenhouse gases (CO_2, NH_4 and N_2O). These gases have the greenhouse effect thereby resulting in global warming and climate changes. Soil CO_2 emissions varies depending on the types and number of equipment used in seed bed preparation. (Akbolat et al., 2004). Therefore, one of the scientific research topics in recent years is to reduce soil CO_2 emissions. Stubble burning, plow tillage and continuous production have very important role in the increase of soil CO_2 emission (Lal and Kimbele, 1997). Ball et al. (1999) reported that soil compaction, tillage and soil structure quality affect the transportation, production and consumption of CO_2 and N_2O gasses. Additionally, soil compaction and tillage are highly effective on gas movement in the soil affecting soil quality. In a sort term research, comparing the effect of 1 kPa and 6 kPa compression on soil CO_2 and N_2O emission, it was concluded that soil CO_2 and N_2O emission were reduced with the compaction (Ball et al., 2008). There is always a standard respiration on the soil as CO_2 of 0.5-10 mg m^{-2} day^{-1} in normal agricultural soil (Haktanır and Arcak, 1997).
The most important physical factors affecting gas emissions are soil temperature and humidity (Smith et al., 2003). Nitrate accumulation and microbial activity affect soil CO_2 emissions. Therefore, it affects the quality of the soil and the atmospheric environment (Calderon and Jackson, 2002). Tillage systems also show the intensity of the effects to the soil. In a study on tillage systems, the maximum CO_2 emissions were found in the conventional tillage system, followed by the reduced tillage system and no-till system (Akbolat et al., 2009). In one study, the effect of mixing the hay into the soil or leaving it on the soil surface was investigated on soil CO_2 emissions. 280 kg da^{-1} straw was used in the study. The test plot was irrigated every two days. According to the results of the research, it is reported that distribution of the straw to the soil surface reduced soil carbon dioxide emissions (Curtin et al., 1998).

It is understood from previous studies that the residues left on the soil surface or incorporated into the soil affect the decomposition, organic carbon accumulation and soil carbon dioxide emission. In this study, the effects of leaving straw on soil surface or burying with different depths of soil on soil CO_2 emission was investigated.

MATERIALS AND METHODS

The experiment was carried out at the Agricultural Research Station of the Faculty of Agriculture of Suleyman Demirel University in Isparta (37.75^o N, 30.55^o E). The experiment was conducted over a 45 days period in November and December 2015. The main soil properties of the experimental site for the depth of 0-30 cm were as follows: 33.9% sand, 22.3% clay, 1.7% soil organic matter, and pH 7.87 (Akgul and Basayigit, 2005).

Plots of 10 m x 2 m were used for each replication.

The straw was distributed homogeneously on the plot surfaces as 500 kg per decar, then treatment B was tilled 5 cm tillage depth, and treatment C was tilled 10 cm tillage depth by self-propelled rotary tiller. The straw was left on the plot surface at the fourth treatment (D). This treatment was not tilled. In the first treatment (A), no stubble was left on plot surface as control. Details of treatments are given in Table 1.

Table 1. Details of treatments

Treatments	Details
A	No straw on the soil surface, no-till soil
B	Straw was incorporated in to the 5 cm soil depth by rotovator
C	Straw was incorporated in to the 10 cm soil depth by rotovator
D	Straw was spreaded on to the soil surface, no-till soil

In situ soil respiration was measured using a CFX-2 soil CO_2 flux system (PP Systems, Hitchin, UK) consisting of integral CO_2 analyzer and H_2O sensor, soil respiration chamber, and soil temperature probe (Akbolat et al., 2009). Measurements of soil net CO_2 efflux are based on concentration differences between air entering and leaving the chamber and the flow rate under normal soil atmosphere exchanges, with an accuracy of better than 1% and 2% for CO_2 and H_2O concentrations, respectively.

Three recording were randomly taken at different locations from every plot. A soil CO_2 flux chamber was installed 1.5 cm deep into the randomly selected locations for the plots, and thus was isolated from the outer atmosphere.

The measurements were made on days 1, 2, 6, 9, 21 and 45 after the tillage. Amount of soil CO_2 emission are expressed in g CO_2 m^{-2} h^{-1} throughout the text. In addition, evaporation, and soil temperature, were concomitantly measured.

Soil samples taken from a soil depth of 0-20 cm were analyzed at 105^{o}C for 24 hours, based on a gravimetric method for moisture content (Blake ve Hartge, 1986). A randomized complete block design with three replication was selected for the experiment.

RESULTS AND DISCUSSIONS

The data obtained in this study to determine the effect of straw left on the soil surface or incorporated into the soil on soil CO_2 emissions is given in Table 2.

The equal amount of straw was applied to all treatments. Straw was distributed homogenously on the replications as much as possible. According to data obtained (Table 2), minimum soil carbon dioxide emission was determined for D treatment, maximum soil carbon dioxide emission was determined for B and C treatments. The difference between B and C treatments was not significant.

The amount of carbon dioxide emissions was higher in the first days after the soil tillage, but decreased in later period (Figure 2a). The high level of emissions on the 6th day after tillage was caused by rainfall in the days before the record. Soil evaporation (H_2O emission) which are effective on soil CO_2 emissions are parallel to soil carbon dioxide emissions.

The cumulative CO_2 emission evolution over the 45-day period is given in Figure 1. It can be seen that the highest soil CO_2 emission at the end of 45 days was determined for B treatment.

Table 2. Results obtained from the research

Treatments	Time after the tillage (days)						Mean
	1	2	6	9	21	45	
	Soil CO_2 emission (g CO_2 m^{-2} h^{-1})						
A	0.226^{ab}	0.169^{bc}	0.359^{a}	0.157^{ab}	0.083^{ab}	0.063^{ab}	0.176^{a}
B	0.259^{a}	0.264^{ab}	0.357^{a}	0.215^{a}	0.104^{ab}	0.083^{a}	0.213^{a}
C	0.302^{a}	0.314^{a}	0.285^{ab}	0.231^{a}	0.066^{b}	0.072^{ab}	0.211^{a}
D	0.114^{b}	0.086^{c}	0.138^{b}	0.057^{b}	0.144^{a}	0.044^{b}	0.097^{b}
	Soil evaporation (g H_2O m^{-2} h^{-1})						
A	$3.07a^{b}$	3.00^{b}	3.18^{b}	0.98^{b}	0.75^{ab}	2.43^{a}	2.24^{a}
B	3.98^{a}	4.59^{a}	4.13^{a}	0.98^{b}	0.77^{ab}	3.23^{a}	3.00^{b}
C	3.78^{a}	3.39^{b}	2.94^{bc}	1.36^{a}	0.73^{b}	2.20^{a}	2.40^{a}
D	1.96^{b}	3.23^{b}	2.33^{c}	0.58^{c}	1.09^{a}	2.86^{a}	2.01^{a}
	Soil temperature (°C)						
A	10.4^{a}	10.6^{c}	9.1^{b}	15.9^{a}	17.3^{a}	15.5^{ab}	13.2
B	10.9^{b}	11.2^{a}	9.3^{b}	15.2^{b}	16.8^{b}	15.8^{a}	13.2
C	11.0^{b}	10.9^{b}	9.9^{a}	15.7^{a}	16.7^{b}	14.5^{b}	13.2
D	11.1^{b}	11.3^{a}	9.8^{a}	15.1^{b}	16.8^{b}	15.9^{a}	13.3

According to the results, total soil carbon dioxide emission for A, B, C and D treatments after the 45 days were 36.3, 47.9, 41.5, and 26.0 g m^{-2} day^{-1} respectively. These results are in accordance with Curtin et al. (1998). There was no significant difference between the soil temperatures depending on treatments. Soil temperature in all treatments was low in the first 6 days and increased in the following days. But the recent rise in temperature has not been effective on soil CO_2 emissions. Comparisons of treatments of soil temperatures can be seen in Figure 2b. It is possible to say that the change in soil temperature is related to the climatic condition. Soil evaporation depending on the treatments is given in Figure 2c. Although there was a difference in soil evaporation between the B treatment and the others at the first stage, this difference was significantly reduced after the 6th day. It is expected to be more evaporated in the C treatment because of the deeper soil tillage than the other treatments. But the expectation has not been realized. Soil moisture amount as a function of time is given Figure 2d. Soil moisture is highly effective on soil CO_2 emissions. For this reason, soil moisture values have been determined in parallel with CO_2 emission records. Soil moisture for all treatments was found quite high on days of 6th and 9th. It can be said that the soil CO_2 emission increases especially on the 6th day depending on the soil moisture content.

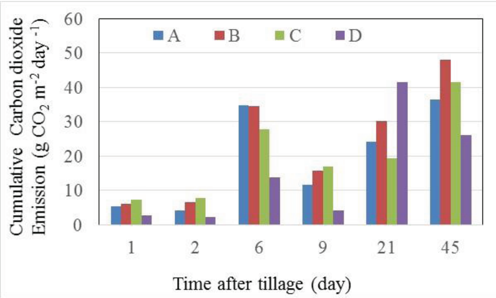

Figure 1. Cumulative soil CO_2 emission

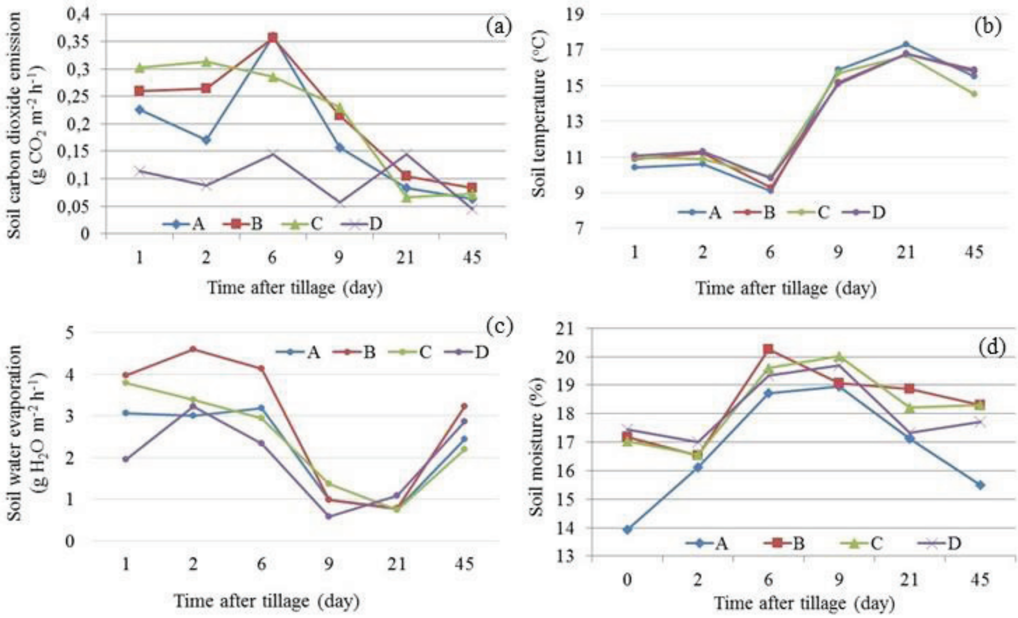

Figure 2. Soil carbon dioxide emission (a), soil temperature (b), soil water evaporation (c), and soil moisture content (d)

CONCLUSIONS

According to the results of the research, it was determined that incorporating straw into soil increased soil CO_2 emissions. In addition, less CO_2 emissions were determined on the soil surface covered with straw than the bare soil surface treatment. For this reason, it has been determined by the study that plant wastes should not be incorporated into the soil and left on the soil surface in order to reduce evaporation and CO_2 emissions from soil.

REFERENCES

Akbolat D., Ekinci K., Camcı Çetin S., ve Çoskan, A., 2004. Farklı Toprak işleme Sistemlerinin Toprakta Organik Maddenin Ayrışmasına Etkisi. Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Dergisi 8, 152-160.

Akbolat D., Evrendilek F., Coskan A., Ve Ekinci, K., 2009. Quantifying soil respiration in response to short-term tillage practices: a case study in southern Turkey. Acta Agriculturae Scandinavica Section B Soil & Plant Science 59, 50-56.

Ball B.C., Crichton I., Horgan G.W., 2008. Dynamics of upward and downward N 2 O and CO 2 fluxes in ploughed or no-tilled soils in relation to water-filled pore space, compaction and crop presence. Soil and Tillage Research, 101(1), 20-30.

Ball B.C., Scott A., Parker J.B., 1999. Field N_2O, CO_2 and CH_4 fluxes in relation to tillage, compaction and soil quality in Scotland. Soil Tillage Research 53, 29-30.

Blake G.R., Hartge K.K., 1986. Bulk density. In: Klute A (ed), Methods of Soil Analysis, Part 1. Physical and Mineralogical Methods: Agronomy Monograph No: 9, Soil Science Society of America Publications, Madison, 363-382.

Calderon F., Jackson L.E., 2002. Rototillage, disking, and subsequent irrigation: Effects on soil nitogen dynamics, microbial biomass, and carbon dioxide efflux. J. Environmental quality, 31, 752-758.

Curtin D., Selles F., Wang H., Biederbeck V.O., Campbell, C.A., 1998. Carbon dioxide emissions and transformation of soil carbon and nitrogen during wheat straw decomposition. Soil Science Society of America Journal, 62(4), 1035-1041.

Haktanır K., Arcak S., 1997. Toprak Biyolojisi. Ankara Üniversitesi (1486), Ziraat Fakültesi (447) Yayınları ANKARA.

Karatepe M., 2000. SDÜ Çiftlik Topraklarının Elverişli Bazı Bitki Besin Elementleri Dağılımının Araştırılması, Yüksek lisans Tezi, SDÜ. Fen Bilimleri Enstitüsü, Toprak Anabilim dalı, ISPARTA (in Turkish).

Lal R., Kimbele J.M., 1997. Conservation Tillage for Carbon Sequestration. Nutrient Cycling in Agroecosystems 49: 243-253.

Smith K.A., Ball T., Conen F., Dobbie K.E., Massheder, J., Rey A., 2003. Exchange of greenhouse gases between soil and atmosphere: interactions of soil physical factors and biological processes. European Journal of Soil Science, 54(4), 779-791.

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EFFECTS OF MYCORRHIZA, GYPSUM AND PHOSPHORUS APPLICATIONS ON WHEAT PLANT GROWTH AND NUTRIENT UPTAKE

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Abstract

A pot experiment was carried out to determine the effects of phosphorus as triple super phosphate and sulfur as $CaSO_4$ (gypsum) applications along with mycorrhiza inculcation on wheat plant growth and nutrient uptake. Gypsum was applied as equivalent to 0, 40 and 80 kg S ha^{-1} with 0, 40 and 80 kg of P_2O_5 ha^{-1}. Glomus mossea was used as an inoculant. The highest infection rate determined in 40 kg ha^{-1} S applied pots as 67%. Based on the mean values both S and P applications were decreased the infection rate. The highest shoot dry weight value was in mycorrhiza inoculated control plot which S and P were not applied (3.21 g); however, based on the mean values no statistical differences determined between mycorrhiza inoculated and non-inoculated pots. Mycorrhizal inoculation increased nitrogen contents of the plants, the highest mean nitrogen value gathered from mycorrhiza applied pots as 1.49%. Although the rather higher infection rate observed in mycorrhiza inoculated pot, P concentration was not influenced from these considerable infection rates. Ca concentration was significantly improved from P application, whereas Mg concentration was not affected from any of the treatment tested. Fe concentration of the plant was the highest in mycorrhiza inoculated and 80 kg ha^{-1} P_2O_5 applied pot as 45 mg kg^{-1}, while there was no influence of gypsum application on Fe. Similarly, Zn contents was influenced from P application but other treatments were not effective. Surprisingly mycorrhiza inoculation was not effective as expected, even some parameters were adversely effected.

***Key words**: mycorrhiza, plant nutrition, gypsum, phosphorus fertilization.*

INTRODUCTION

Mycorrhiza has great influence on nutrient uptake of the plants that growing in calcareous soil where soil pH is generally high. As two third of the soils in Turkey have deficiencies of Fe, Zn or both (Eyupoglu et al., 1998), sulfur containing additives are widely recommended to overcome this nutritional disorders. On the other hand mycorrhizal inoculation is biological approach to improve plant micronutrient uptake which economic and environmentally friendly. The presence of indigenous mycorrhizal has a potential enhancement on the growth and on the root morphology under arid and semiarid conditions (Almaca and Ortas, 2010). Almaca et al. (2013a) reported 5.4% and 12.7% yield increase by mycorrhiza inoculation while *Glomus mossea* species reported more effective on pepper yield then *Glomus etunicatum*. Moreover, stimulating effects of phosphorus on mycorrhizal contribution was also reported Almaca et al. (2013a). Sulphur is one of the deficient nutrients in the soil especially in the high pH condition (Almaca et al., 2013b), thus, sulphur application is recommended in those soils. Almaca et al. (2013b) reported 3.3-17.1% yield increase by depending on the Sulphur application rates. Arshadullahet al. (2013) recommended 150 kg ha^{-1} gypsum dose for maximum benefit in saline-sodic soils. The soils used in this experiment has slightly higher pH; therefore, maximum gypsum dose selected around half of Arshadullahet al. (2013) recommendation. The aim of this research was to evaluate the effects of gypsum and phosphorus applications on wheat plant growth and nutrient uptake in mycorrhiza inoculated and non-inoculated conditions.

MATERIALS AND METHODS

Experiment was carried out as a pot experiment at 2012-2013 growing season, using the soils of Harran series which located Sanliurfa, Turkey.

The basic properties of experimental soil are presented in Table 1. Relatively undisturbed 2 kg of soils were placed to pots that have a *Glomus mossea* mycorrhiza spores containing culture layer which embed 5 cm deep from the soil surface. Firat 93 wheat seeds were used as a test plant.

Table 1. Basic properties of experimental soil

Texture	C
Organic matter (%)	1.3
EC (dS/m)	1.22
pH (1:2.5)	7.87
$CaCO_3$ (%)	24.6
P_2O_5 (kg da^{-1})	5.3
K_2O (kg da^{-1})	199

Each pot was fertilized by nitrogen as ammonium nitrate that equivalent to 100 kg N ha^{-1}. The experimental design was factorial which mycorrhizal inoculation (M+: inoculated or M-: non-inoculated), $CaSO_4$ and phosphorus incorporations were the factors. The doses of $CaSO_4$ were equivalent to 0 (S0), 40 (S40) and 80 (S80) kg ha^{-1} of Sulphur (S) whereas phosphorus were provided from triple super phosphate which equivalent to 0 (P0), 40 (P40) and 80 (P80) kg ha^{-1} of P_2O_5.

Analytical

The texture, pH (1:2.5), EC, $CaCO_3$, organic matter, available phosphorus, exchangeable potassium and magnesium properties of the experimental soil were evaluated by the methods described by Bouyoucous (1951), Jackson (1958), Richards (1954), Hizalan and Unal (1966), Walkey (1947), Olsen et al., 1954) and Thomas (1982).

When the plants were reached to desired harvest stage they have been cut near above soil surface, washed thoroughly and dried at 65 °C until they reach constant weight. All samples were grinded by agate mill (Walsh and Beaton, 1973). To analyze P, K, Fe, Cu, Zn and Mn, 0.2 g of samples were dry digested at 550 °C for 5 hour. The 2 ml of 1/3 HCl solution was added to each sample then filtered to 20 ml capacity container. Phosphor contents of samples were determined according to Murphy and Riley (1962) using spectrophotometer at 882 nm. The K, Zn, Fe, Cu, Mn, Ca and Mg concentration determined by atomic absorption spectrophotometer (Kacar, 1972). Total nitrogen contents were determined by Kjeldahl method (Bremner, 1965). Biomass developments were determined by analytical balance. Results obtained statistically analyzed by MSTAT-C software (Crop and Soil Sciences Department, Michigan State University, Version 1.2) according to randomized block design. Means were grouped using Duncan test at 0.05 alpha level (Efe et al., 2000).

Mycorrhizal infection determination

At the end of the experiment roots were sampled, cleaned and stained according to Koske and Gemma (1989). According to this method, once the roots have been thoroughly washed and the dead roots have been removed. The remaining roots were placed into a petri dish and cut into lengths of 1 cm. Samples were transferred to test tubes (1 cm in diameter and 20 cm length), 2.5% (w:v) KOH solution were added. After 45 minute of the duration in 90 °C of water bath, KOH solution was discarded and 1% of HCl solution added to as much as overlaying the samples. Once the previously added acid has been removed from the tubes, sufficient amount of acidified Glycerol and Trypan Blue solutions were added to the same tubes. The constituent of the tubes once again transferred to clean petri dishes, 10 of tiny root pieces selected and they were placed to microscope slides. Afterwards, infection rates were determined according to Giovanetti and Mosse (1980) with a magnification of 40-60 under the microscope.

RESULTS AND DISCUSSIONS

The mycorrhizal infection rates which were influenced from mycorrhizal inoculation as well as gypsum ($CaSO_4$) and phosphorus applications are presented in Table 2. Mycorrhizal infections were positively affected by mycorrhiza spore inoculations; therefore the higher values obtained from mycorrhiza inoculated plants. Although the highest infection rate was in S40 variant as 67%, based on the mean values both S and P applications were decreased the infection rate.

Table 2. Infection rates

	S doses	P doses 0	P doses 40	P doses 80	Averages
M+	0	47 ab	63 ab	47 ab	52 a
	40	67 a	27 bc	20 bc	38 b
	80	30 bc	43 ab	17 bc	30 b
	Avg.	48 **a**	44 **ab**	28 **b**	40 **A**
M-	0	7 c	3 c	7 c	6 c
	40	7 c	7 c	3 c	6 c
	80	17 bc	17 bc	0 c	11 c
	Avg.	10 **c**	9 **c**	3 **c**	7 **B**
Averages		29 ***A***	27 ***AB***	16 ***B***	

No infection was observed in the highest dose of S and P applied pots indicating both applications have diminishing effects on mycorrhiza spores. Biomass weight (Table 3) was not in accordance with infection rates, where no statistical differences determined between mycorrhiza inoculated and non-inoculated pots. The highest values were in mycorrhiza inoculated S0P0 pot as 3.21 g. P doses were also not effective on plant dry weights. When mycorrhiza inoculation and P doses were evaluated together, it was found that the lower P application (P40) cause the highest dry biomass weight in inoculated pots, while, the highest P dose required to reach same amount of biomass in non-inoculated conditions.

Table 3. Biomass weight (g)

	S doses	P doses 0	P doses 40	P doses 80	Average
M+	0	3.21 a	3.12 ab	2.73 bc	3.02 a
	40	2.76 bc	3.04 ab	2.74 bc	2.85 a
	80	2.69 bc	2.97 ab	2.79 a-c	2.82 a
	Avg.	2.89 **ab**	3.04 **a**	2.75 **b**	2.89 **A**
M-	0	2.84 a-c	2.85 a-c	3.06 ab	2.92 a
	40	2.74 bc	2.53 c	3.07 ab	2.78 a
	80	2.94 a-c	2.83 a-c	2.86 a-c	2.87 a
	Avg.	2.84 **ab**	2.74 **b**	3.00 **a**	2.86 **A**
Average		2.86 ***A***	2.89 ***A***	2.88 ***A***	

Almaca and Ortas (2013a) reported increased pepper yield by increasing P addition; however, contribution of mycorrhizae on yield were higher under high level of P addition. In this results presented indicating that higher dose is necessary only in case of non-inoculated conditions.

Nitrogen contents of the shoot are presented in Table 4. As well known, mineral nitrogen in soil is rather dynamic which plants don't need any mediator to reach; however, in this particular case, mycorrhizal inoculation increased nitrogen contents of the plants, where the highest mean nitrogen value gathered from mycorrhiza applied pots. Unexpectedly, the higher N contents were achieved in both P0 and P80 deses, while P40 cause reduction of wheat N contents. When mean values of S and mycorrhizal inoculation interactions viewed together, inoculated pots provide higher N contents and increasing S dose reduced nitrogen contents ($p<0.05$). No effects were seen in M- and S dose interaction.

Table 4. Nitrogen contents (%)

	S Doses	P doses 0	P doses 40	P doses 80	Average
M+	0	1.70 a	1.48 a-d	1.59 a-c	1.59 a
	40	1.38 b-d	1.44 a-d	1.51 a-d	1.44 ab
	80	1.64 ab	1.29 cd	1.42 a-d	1.45 ab
	Avg.	1.57 **a**	1.40 **bc**	1.51 **ab**	1.49 **A**
M-	0	1.32 cd	1.27 d	1.44 a-d	1.34 b
	40	1.42 a-d	1.25 d	1.32 c-d	1.33 b
	80	1.28 d	1.35 b-d	1.48 a-d	1.37 b
	Avg.	1.34 **c**	1.29 **c**	1.41 **bc**	1.35 **B**
Average		1.46 ***A***	1.35 ***B***	1.46 ***A***	

The values related the P contents of wheat plant are presented in Table 5. Only the P concentrations as a main factor were influenced from P doses. The P40 dose was not caused any changes on P concentrations whereas the P80 was provided the higher mean value as 0.30%. Although the quite higher infection rate observed in M+ (Table 2), P concentration was not influenced from these higher infection rates. This situation seems to be arising due to limited resources in the pots.

Table 5. Phosphorus contents (%)

	S doses	P doses 0	P doses 40	P doses 80	Average
M+	0	0.26 a-c	0.24 a-c	0.35 a	0.28 a
	40	0.24 a-c	0.21 c	0.27 a-c	0.24 a
	80	0.25 a-c	0.23 c	0.34 ab	0.28 a
	Avg.	0.25 **b**	0.23 **b**	0.32 **a**	0.27 **A**
M-	0	0.24 a-c	0.24 a-c	0.30 a-c	0.26 a
	40	0.25 a-c	0.29 a-c	0.26 a-c	0.27 a
	80	0.21 c	0.25 a-c	0.29 a-c	0.25 a
	Avg.	0.23 **b**	0.26 **b**	0.28 **ab**	0.26 **A**
Average		0.24 ***B***	0.24 ***B***	0.30 ***A***	

None of the factors such as mycorrhizal inoculation, gypsum and phosphorus applications were solely affected on K uptake (Table 6). But mycorrhiza-P interaction was significantly changed K concentration which the highest mean K values achieved in M+ and P0 (1.93%), and M- and P80 (1.75%) combinations. As clearly seen in Table 6, the effectiveness of mycorrhiza is reduced by increasing dose of P, while P application improved K concentration in M- condition.

Table 6. Potassium contents (%)

	S doses	P doses 0	P doses 40	P doses 80	Average
M+	0	1.92 a-c	1.63 b-d	1.77 a-d	1.77 a
	40	1.81 a-d	2.10 a	1.62 b-d	1.84 a
	80	2.06 ab	1.61 b-d	1.76 a-d	1.81 a
	Avg.	1.93 **a**	1.78 **ab**	1.71 **ab**	1.81 **A**
M-	0	1.74 a-d	1.65 b-d	1.67 a-d	1.69 a
	40	1.69 a-d	1.51 cd	1.81 a-d	1.67 a
	80	1.45 d	1.76 a-d	1.77 a-d	1.66 a
	Avg.	1.63 **b**	1.64 **b**	1.75 **ab**	1.67 **A**
Average		1.78 ***A***	1.71 ***A***	1.73 ***A***	

Phosphorus applications increased Ca concentration of the plant; however, neither mycorrhiza inoculation nor gypsum doses was effective on Ca (Table 7). In general, mycorrhiza-P dose interaction was stimulated Ca uptake where the highest values were determined from M+ and P80 dose.

Table 7. Calcium contents (%)

	S doses	P doses 0	P doses 40	P doses 80	Average
M+	0	0.55 ab	0.55 ab	0.62 a	0.57 a
	40	0.41 a-c	0.51 a-c	0.61 a	0.51 a
	80	0.47 a-c	0.39 a-c	0.65 a	0.50 a
	Avg.	0.48 **b**	0.48 **b**	0.62 **a**	0.53 **A**
M-	0	0.28 c	0.45 a-c	0.52 a-c	0.42 a
	40	0.51 a-c	0.34 b-c	0.51 a-c	0.45 a
	80	0.43 a-c	0.62 a	0.40 a-c	0.49 a
	Avg.	0.41 **b**	0.47 **b**	0.48 **b**	0.45 **A**
Average		0.44 ***B***	0.48 ***AB***	0.55 ***A***	

Magnesium concentration of the wheat plant was not influenced from any of the application tested in this research (Table 8). Mycorrhiza inoculation increased Mg uptake slightly which there is no statistical differences between M+ and M- ($p>0.05$).

Table 8. Magnesium contents (%)

	S doses	P doses 0	P doses 40	P doses 80	Average
M+	0	0.46 a	0.43 a	0.56 a	0.48 a
	40	0.38 a	0.55 a	0.64 a	0.52 a
	80	0.43 a	0.54 a	0.54 a	0.50 a
	Avg.	0.42 **a**	0.50 **a**	0.58 **a**	0.50 **A**
M-	0	0.29 a	0.45 a	0.42 a	0.39 a
	40	0.42 a	0.35 a	0.42 a	0.40 a
	80	0.52 a	0.56 a	0.34 a	0.48 a
	Avg.	0.41 **a**	0.46 **a**	0.40 **a**	0.42 **A**
Average		0.42 ***A***	0.48 ***A***	0.49 ***A***	

None of the application was significantly effective on Cu contents of the plant (Table 9). However, both gypsum and phosphorus reduced Cu uptake. Due to the fungicide features, cupper is one of the most widely used elements in both conventional and organic farming. Thus copper accumulation has recently been mentioned in the soils in Turkey, thus, gypsum and phosphorus applications would be recommended Cu accumulated soil to prevent excessive Cu uptake of the plants.

Table 9. Cupper contents (mg Cu kg^{-1})

	S doses	P doses 0	40	80	Average
M+	0	25 a	19 a	15 a	20 a
	40	18 a	17 a	13 a	16 a
	80	14 a	24 a	19 a	19 a
	Avg.	19 **a**	20 **a**	16 **a**	18 **A**
M-	0	10 a	13 a	8 a	10 a
	40	11 a	21 a	10 a	14 a
	80	19 a	10 a	13 a	14 a
	Avg.	13 **a**	14 **a**	10 **a**	13 **A**
Average		16 ***A***	17 ***A***	13 ***A***	

Fe and Zn deficiencies are very common in Turkey soil (Eyupoglu et al., 1998); however, none of the application was improved Fe concentration of wheat plant (Table 10). Only interactions of three of the applications significant on Fe contents, the highest value was observed in M+ S0 P80 interaction.

Table 10. Iron contents (mg Fe kg^{-1})

	S doses	P doses 0	40	80	Average
M+	0	32 a-c	36 a-c	43 a	37 a
	40	32 a-c	33 a-c	33 a-c	33 a
	80	35 a-c	29 bc	30 a-c	32 a
	Avg.	33 **a**	33 **a**	35 **a**	34 **A**
M-	0	29 c	32 a-c	34 a-c	31 a
	40	34 a-c	27 c	34 a-c	32 a
	80	38 a-c	41 ab	33 a-c	38 a
	Avg.	34 **a**	33 **a**	34 **a**	34 **A**
Average		33 ***A***	33 ***A***	35 ***A***	

Mycorrhizal infection encouraged Mn concentration where the higher mean Mn observed in M+. P doses were also improved Mn uptake, P80 provided the highest Mn content (Table 11).

Mycorrhizal inoculation did not significantly change the zinc content of the plant (Table 12). While gypsum doses did not affect Zn contents, increasing P doses increased Zn content and highest determined Zn content was in P80 dose.

Table 11. Manganese contents (mg Mn kg^{-1})

	S doses	P doses 0	40	80	Average
M+	0	38 a-c	31 b-e	45 a	38 a
	40	27 e	28 de	40 ab	32 b
	80	37 a-e	31 c-e	33 b-e	34 ab
	Avg.	34 **b**	30 **b**	39 **a**	34 **A**
M-	0	29 c-e	31 b-e	34 b-e	31 b
	40	36 a-e	29 c-e	32 b-e	32 b
	80	27 de	37 a-d	30 c-e	31 b
	Avg.	31 **b**	32 **b**	32 **b**	32 **B**
Average		32 ***AB***	31 ***B***	36 ***A***	

Table 12. Zinc contents (mg Zn kg^{-1})

	S doses	P doses 0	40	80	Average
M+	0	19 bc	19 bc	24 a-c	21 a
	40	19 bc	23 a-c	21 a-c	21 a
	80	17 c	25 a-c	31 a	24 a
	Avg.	18 **c**	22 **a-c**	25 **a**	22 **A**
M-	0	17 bc	18 bc	27 ab	21 a
	40	19 bc	17 bc	22 a-c	19 a
	80	20 bc	24 a-c	25 a-c	23 a
	Avg.	19 **bc**	20 **a-c**	24 **ab**	21 **A**
Average		19 ***B***	21 ***B***	25 ***A***	

CONCLUSIONS

The results gathered in this experiment were slightly out of expectations where mycorrhizal inoculation did not influence concentration of several plant nutrients analyzed. Infection rate values clearly indicate successful mycorrhizal inoculation; however, biomass weight, P, K, Ca, Mg, Cu, Zn and Fe concentrations were not influenced from mycorrhizal inoculation. P application was reduced infection rate in inoculated variants while improved P, Ca, Mn and Zn concentrations. Gypsum was also reduced infection rate; however, increased nitrogen concentration in mycorrhiza applied pots.

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REFERENCES

Almaca A., Almaca N.D., Oktem A.G., 2013b. The effects of sulphur fertilization on the yield of cotton (*Gossypium hirsutum* L.) grown in the Harran Plain Journal of Food, Agriculture & Environment 11:(3&4): 800-803.

Almaca A., Almaca N.D., Soylemez S., Ortas I., 2013a. The effects of mycorrhizal species and different doses of phosphorus on pepper (*Capsicum annuum* L.) yield and development under field conditions. Journal of Food, Agriculture & Environment 11:(3&4):647-651.

Almaca A., Ortas I., 2010. Growth response of maize plants *(Zea mays* L.) to wheat and lentil pre-cropping and to indigenous mycorrhizae in field soil. Spanish Journal of Agricultural Research, 8(S1):131-136

Arshadullah M., Hyder S.I., Ali A., Mahmood I.A., 2013. Cumulative Effect of Sulfur and Calcium On Wheat Growth and Yield Under Saline-Sodic Soils. Pakistan J. Agric. Res.26:(1)38-45.

Bouyoucos G.J., 1951. A recalibration of the hydrometer method for making mechanical analysis of soils. Agronomy Journal 43: 434-438.

Bremner J.M., 1965. Method of soil analysis. Part 2. Chemical and microbiological methods. American Society of Agronomy Inc. Madison Wise, S.1149-1178, USA.

Efe E., Bek Y., Şahin M., 2000. SPSS'te çözümleri ile istatistik yöntemler II. Kahramanmaraş Sütçü İman Üniversitesi Rektörlüğü yayın no: 10.

Eyuboglu F., Kurucu N., Talaz S., 1998. General Situation of Plant Available Micronutrients Elements (Fe, Cu, Zn, Mn) of Turkish Soils. The Rupiblic of Turkey, Soil and Fertilizer Research Institute, Ankara (in Turkish).

Giovannetti M., Mosse B., 1980. An evaluation of techniques for measuring vesicular arbuscular mycorrhizal infection in roots. New Phytologist, 84: 489-500.

Hızalan E., Ünal H., 1966. Topraklarda önemli kimyasal analizler. Ankara Üniversitesi Ziraat Fakültesi Yayınları, No: 278, Ankara.

Jackson M.L., 1958. Soil chemical analysis. Prentice-Hall, Inc. Englewood Cliffs, New Jersey U.S.A.

Kacar B., 1972. Bitki ve toprağın kimyasal analizleri II, Bitki Analizleri, Ankara Üniv. Ziraat Fakültesi Yayınları: 453

Koske R.E., Gemma J.N.A., 1989. Modified procedure for staining roots to detect VAM. Mycol.Res. 92, 486-505.

Murphy Y., and Riley J.P.A., 1962. Modified single solution method for determination of phosphate in natural waters. Analytica Chimica Acta, 27: 31-36.

Olsen S.R., Cole V., Watanabe F.S., Dean L.A., 1954. Estimations of available phosphorus in soils by extractions with sodium bicarbonate. U.S. Dept. of Agric. Cric, 939-941.

Richards L.A., 1954. Diagnosis and improvement of saline and alkali soils, Agricultural Handbook No. 60, U.S. Department of Agriculture, Washington, DC.

Thomas G.W., 1982. Exchangeable cations. In: Methods of soil analysis, part 2. Chemical and microbiological properties, 2nd edn. (eds A.L. Page, R.H. Miller & D.R. Keeney), pp. 159–165. ASA and SSSA, Madison, WI. Agronomy Monograph 9.

Walkley A., 1947. A critical examination of a rapid method for determining organic carbon in soils - effect of variations in digestion conditions and of inorganic soil constituents. Soil Sci. 63:251-264.

Walsh L.M., and Beaton J.D., 1973. Soil testing and plant analysis. Soil Science Society of America Journal, Inc. Madison, Wisconsin, USA.

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ECONOMIC EFFICIENCY IN THE USE OF ORGANIC AND MINERAL FERTILIZERS ON WHEAT GROWN ON REDDISH PRELUVOSOIL

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Abstract

This paper will present the results obtained on the reddish preluvosoil, in the period of 2014-2016, situated on the experimental field of the Department of Soil Sciences, at Moara Domneasca. The wheat crop is part of a crop rotation wheat-barley-sugar beet. The experience is a two-factor concept, organised in three repetitions, with the next factors: a - organic fertilization and b - mineral fertilization. The research aims to find the perfect balance between the used resources and the best results, in an economic point of view. As natural fertilizers were used plant residues and manure, nutrient needs are supplemented with mineral fertilizer based mostly on nitrogen. The research has shown, that nitrogen fertilization with organic and mineral nitrogen increases wheat production along with profits. In terms of production, the best is a3 – b4 (40 t/ha leaves an pices of sugar beet and a dose of N_{150}), but, economically, the variant a1-b4 (unfertilized organically with a dose of N_{150}) gives the best outcome for the farm.

***Key words**: costs, fertilizer, profit magin, wheat.*

INTRODUCTION

In agriculture, as in any activity with an economic purpose, the goal is to maximizd production and thus profits.

The volume of production is closely connected with tillage, seeding quality, labor and the treatments applied to the crop. All these components are assigned an economic value which takes the form of production cost.

Economic performance has a wide scope of coverage, essentially reflects the relation between effects and efforts (Zahiu et al., 1997).

Independent investment strategy is a strategy that must be inclusive, or rather to integrate other strategies aimed at achieving the overall strategy of the agricultural firm (Bogdan, 2004).

According to the National Statistics Institute, in Romania, most of the farms are in private households. Also, the wheat acreage is maintained at a high level, one of this country's favorite crops, along with corn.

Wheat is a whole grain, with multi-purposes, rich in nutrients necessary for human consumption (proteins, lipids, carbohydrates), but given also use in food for animals. To obtain a high yield of wheat is recommended to include it in a rational rotation. Wheat monoculture should not be practiced, as it leads to the expansion of diseases, pests and weed appearance, specific to wheat, leading to the gradual reduction in the yields obtained. Nitrogen, as a basic element in plant nutrition is the main ingredient of proteins from wheat, addition application helps increase its protein content. In their nutrition, plants accumulate soil nitrogen in ammonia and nitric form, and convert it through amination and transamination reactions in protein substances (Borlan and Hera, 1994).

To optimize the application of mineral nitrogen, wheat requirements must be taken into consideration, together with the conditions provided by the soil (Dincă et al., 2010; Gîdea et al., 2015).

MATERIALS AND METHODS

The research on organic and mineral fertilization for growing autumn wheat on red preluvosoil began in 1991, in the experimental field of the Department of Soil Sciences at Moara Domneasca farm.

The paper presents data obtained between the years of 2014-2016. The wheat crop is part of a rotation wheat-barley-sugar beet.

The two factors experience is organized by the subdivided parcels method, in three repetitions factors: a - organic fertilization and b - mineral fertilizer.

Factor a - organic fertilization - included 3 experimental versions: a_1- unfertilized, a_2- residual from 30 t/ha manure and a_3- leaves and pieces of sugar beet + N_{50}.

Factor b - mineral fertilization - included 5 different experimental versions: b_1 – unfertilized, b_2 - N_{60}, b_3 - N_{100}, b_4 - N_{150} and b_5 - N_{200}.

For all the scenarios it was provided a mineral fund of P_{70} and it was used Glosa wheat.

Determinations carried out on variations and repetitions consisted in determining production, number of ears, hectolitre mass and weight of a thousand grains (MMB). The results were calculated and statisticaly interpreted by variant analysis method.

In designing these expenses came: cost of mechanized work (machinery depreciation, fuel, labor, maintenance and repair of machinery), the cost of mineral fertilizers and organic, cost of seed and pesticide costs. Economic efficiency was assessed by calculating gross profit margin for each experimental variant.

To calculate revenue was used for wheat average price of 0.6 RON/kg of February 2016 in Muntenia Region (www.madr.ro).

In calculating the expenditure was considered a price of 1.2 RON/kg for ammonium nitrate (33.5%) and 2 RON/kg superphosphate (46%).

For manure was used an average price of 30 RON / t. The total value of organic fertilization with manure was divided as follows: 50% for sugar beet, 30% for wheat and 20% for barley.

RESULTS AND DISCUSSIONS

Analyzing the data presented in Table 1, we have the next observations: organic fertilization increases wheat production for all variants of mineral fertilizer.

Mineral fertilization effect is higher for unfertilized organically, or control variant. The highest production is obtained for variant a_3 - b_4 (40 t/ha of leaves and epicotyls of sugar beet + N_{50} with a dose of mineral nitrogen - N_{150}). Variant a_3 - b_5 (40 t/ha of leaves and epicotyls of sugar beet + N_{50} with a dose of mineral nitrogen - N_{200}) causes a decrease in production compared to variant a_3 - b_4.

Table 1. Influence of mineral and organic nitrogen fertilization on wheat production

Fertilizer: Organic / Mineral	a_1 – unfertilized organically			a_2 - 30 t/ha of manure applied to the preceding crop			a_3 - 40 t/ha of leaves and epicotyls of sugar beet + N50		
	Prod. (q/ha)	Dif. (q/ha)	Semn.	Prod. (q/ha)	Dif. (q/ha)	Semn.	Prod. (q/ha)	Dif. (q/ha)	Semn.
b_1 – N_0	43.47	Mt		47.04	Mt		69.39	Mt	
b_2 – N_{60}	58.7	15.23	***	62.45	15.41	***	76.17	6.68	***
b_3 – N_{100}	74.63	31.15	***	71.98	24.94	***	90.42	21.03	***
b_4 – N_{150}	84.12	40.65	***	85.42	38.38	***	101.40	32.01	***
b_5 – N_{200}	90.52	47.05	***	90.49	43.45	***	98.42	29.03	***

For each variant was conducted a set of agricultural tasks, together with the application of treatments. The cost of each activity or input, is presented in Table 2. The activities and input mentioned in the table above, were the starting point of our analysis, and were used for variant a_1 - b_1(unfertilized organically with a dose of N_{100}).

Table 2. Technological data for the wheat crop

Activity	Price for mechanized task (RON/ha)	Input quantity (Kg/ha)	Price for inputs (RON/ha)
Plowing - 22 cm	300		
Soil preparation - disc harrow (2 passes)	250		
Fertilizing with superphosphate	60	152	305
Sowing	150	300	360
Herbicides	60	3.6	295
Harvested and chopped straw	300		

For the other experimental variants was added the extra cost of inputs, such as increased doses of nitrogen, manure and preparing the leaves and epicotyls of sugar beet.

Table 3. Total expenditure (RON/ha)

Fertilizer	a_1 – unfertilized organically	a2 - 30 t/ha of manure applied to the preceding crop	a3 - 40 t/ha of leaves and epicotyls of sugar beet + N50
$b_1 – N_0$	2080	3076	3740
$b_2 – N_{60}$	2418	3414	4016
$b_3 – N_{100}$	2582	3576	4242
$b_4 – N_{150}$	2802	3798	4462
$b_5 – N_{200}$	3040	4038	4702

By analyzing total costs presented in Table 3, we can draw the following observations: the amount of expenditures on organic fertilization increases in direct proportion to the amount of mineral nitrogen and administered.

The highest value is achieved for total expenditures variant a3-b5 (40 t/ha of leaves and epicotyls of sugar beet + N_{50} with an extra dose of mineral nitrogen – N_{200}), where nitrogen is the maximum dose.

Our goal is to see if what we spend in inputs is found in the revenue.

Table 4. Revenue (RON/ha)

Fertilizer	a_1 – unfertilized organically	a2 - 30 t/ha of manure applied to the preceding crop	a3 - 40 t/ha of leaves and epicotyls of sugar beet + N50
$b_1 – N_0$	2608	2822	4163
$b_2 – N_{60}$	3522	3747	4568
$b_3 – N_{100}$	4477	4319	5425
$b_4 – N_{150}$	5047	5125	6084
$b_5 – N_{200}$	5429	5429	5905

The amount of revenue is directly influenced by the production obtained. Revenue increases at the same time as the dose of mineral nitrogen, except for variant a3-b5 (40 t/ha of leaves and epicotyls of sugar beet + N_{50} with a dose of mineral nitrogen – N_{200}). Organic fertilization also triggers increased production, leading to increased revenue. The maximum income recorded was for a3-b4 solution, the variant with the highest production.

Table 5. Profit for all experimental variants (RON/ha)

Fertilizer	a_1 – unfertilized organically	a2 - 30 t/ha of manure applied to the preceding crop	a3 - 40 t/ha of leaves and epicotyls of sugar beet + N50
$b_1 – N_0$	528	-254	423
$b_2 – N_{60}$	1104	108	552
$b_3 – N_{100}$	1895	743	1181
$b_4 – N_{150}$	2245	1327	1622
$b_5 – N_{200}$	2387	1391	1203

The analysis recorded profits, it is found that the highest values of profit are obtained for organic unfertilized variant (a_1). The amount of profit increases with the dose of mineral nitrogen. Variant a_2-b_1 is the only variant with loss.

Table 6. Profit margin (%)

Fertilizer	a_1 – unfertilized organically	a2 - 30 t/ha of manure applied to the preceding crop	a3 - 40 t/ha of leaves and epicotyls of sugar beet + N50
$b_1 – N_0$	20.25%	-9.00%	10.16%
$b_2 – N_{60}$	31.35%	2.88%	12.08%
$b_3 – N_{100}$	42.33%	17.20%	21.77%
$b_4 – N_{150}$	44.48%	25.89%	26.66%
$b_5 – N_{200}$	43.97%	25.62%	20.37%

Analyzing the data presented Table 6, there was an increase in profit margin at the same rate with mineral nitrogen dose increase, up to version b_4 (N_{150}). After the dose of N_{150}, the profit margin registers a downtrend for b_5 variant, for all variants of organic fertilization. The biggest profit margin is obtained for variant a_1-b_4.

CONCLUSIONS

Nitrogen fertilization organic and mineral nitrogen triggers increased production of winter wheat.

The optimum solution in terms of output obtained for organic nitrogen fertilization is a_3-40 variant t/ha of leaves and epicotyls of sugar beet + N_{50}.

Expenses increase proportionally with dose of mineral nitrogen. The highest cost recorded is for variant a3-b5, which also has a downtrend in production. This is not a viable option economically.

The largest revenue is for the variant a_3-b_4 (40 variant t/ha of leaves and epicotyls of sugar beet + N_{50} with an extra dose of N_{150}), and it records the highest production/ha.

The profit obtained increases with the dose of mineral nitrogen and obtains the highest value variant for a_1-b_5.

The profit margin, the most important indicator in the economic analysis, marks the highest value for variant a_1-b_4 (44.48%). The variant with the largest production per hectare recorded a profit margin of only 26.66%, due to high costs.

As for organic fertilizers, the lowest profit margins are for variant a_2 - 30 t/ha of manure applied to the preceding crop, with any mineral suppliment.

For mineral fertilizer, is not recommended to use o dose of nitrogen above $N_{150,}$ because the the cost are to high and so profit margins start to decrease.

REFERENCES

Borlan Z., Hera C., 1994. Fertilitatea si fertilizarea solurilor (compediu de agrochimie). Editura Ceres, Bucureşti.

Bogdan I., 2004. Management financiar, Editura Universitara, Bucuresti.

Dincă L., Săndoiu D.I., Obrişcă M., Răducioiu G.A., 2010. Influence of organic and mineral nitrogen fertilization on wheat yield on the reddish preluvosoil in Danube Plain. Lucrări Ştiinţifice USAMV Bucureşti, Seria A, LIII, p. 200-206.

Gîdea M., Ciontu C., Săndoiu D.I., Penescu A., 2015. The role of Rotation and Nitrogen Fertilization Level upon the Economic Indicators at Wheat and Crops in Condition of a Long Term Experience. Journal of Agriculture and Agricultural Science-Procedia, Elsevier, Vol. 6, p. 24-29.

Zahiu L., Gheorghita M., Nastase M., Leonte M.J.C, Stoian M., 1997. Economia intreprinderii Note de curs, Ed ASE, Bucuresti, p 421

www.insse.ro

www.madr.ro

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DETERMINATION OF SOME MICROBIAL ACTIVITY IN SOIL MANAGED WITH STUBBLE BURNED-UNBURNED, TRADITIONAL AND NO-TILLAGE SYSTEMS

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Abstract

Most of farmers in Turkey have been burning wheat stubble every June or July to prepare their field for second crops. It is believed that as a result of stubble burning, soil is becoming more productive and healthy. Stubble burning may be caused some yield benefits for short-term but in long-term it is caused degradation on soil quality. The purpose of this research was to determine the effects of stubble burning on microbial activity of soil under traditional tillage and no-tillage system. In accordance with this purpose, some microbial analyses have been followed in soils. Soil respiration rate (CO_2 formation), dehidrogenase enzyme activity (DHA) and microbial biomass carbon content (MBC) were analysed according to Isermayer (1952), Thalman (1967) and Ohlinger (1993), respectively. Results revealed that soil microbial activity was lower in the stubble burned and conventional tillage (SBCT) applied plots. In this plot, as a mean values CO_2 formation, DHA and MBC determined as 14.6 mg C 100 g^{-1} 24h^{-1}, 193 μg TPF 10 g^{-1} 24h^{-1} and 25.6 mg C 100 g^{-1}, respectively. These values were 16.9, 309.3 and 19.5 in conventional tillage (SCT) plots whereas 15.4, 620.6 and 11.0 in no tillage (NT) plots. In general, DHA was the most influenced factor among the other biologic activity indicators determined.

Key words: *stubble burning, CO_2, microbial activity, soil quality, soil tillage systems.*

INTRODUCTION

Microbial activities drives directly affect the functioning and sustainability of soil ecosystems. Soil microbial activity (SMA) was effected by different tillage system including agricultural practices, and stubble burning. Stubble burning decreases in fertile agricultural lands and loses sustainable fertility of soils. Stubble burning is an improper agricultural practice applied every year in June-July in Turkey, as a routine and seriously damages the long-term aspects of soil fertility (Kılıç et al., 2013). The ways in which these operations are implemented affect the physical and chemical properties of the soil, which in turn affect soil microorganisms (Coşkan and Doğan, 2011). Burning of crop residue on the soil surface reduces soil micro-organisms and increased soil pH. This is an increase of soluble salts from the soil. Burning stubble and straw decreased soil organic matter. In addition, the amount of water and fat soluble compounds and hemic acids show a downward trend (Hesammi et al., 2014). Soil tillage methods have complex effects on physical, chemical and biological properties of soil. Because of the changing physical and chemical properties of soil by soil tillage methods, the biological properties of soil may also change. Actually these changes are indirect results of tillage. Changed physical and chemical soil properties by soil tillage methods effect the parameters directly related with soil microbial activities such as organic matter, soil humidity, temperature and ventilation as well as the degrees of interaction between soil mineral and organic matter. As a result of these effects, significant differences can be observed in the population of microbial activities in soil (Kladivko, 2001; Lavelle, 2000; Wardle, 1995; Saggar et al., 2001; Coşkan et al., 2010; Walker et al., 1986). People burn stubble because it improves weed control and creates easier passage for seeding equipment. But unfortunately the practice of burning stubble has recently declined due to concerns about soil erosion and loss of soil organic matter. In addition burning is damaged to other important soil properties (Clark et al., 1999; Coşkan and Doğan, 2011; Rasmusen et al., 1980).

MATERIALS AND METHODS

A long-term field experiment was carried out from 2006 to 2012. In this research, it was evaluated the effects of three different tillage practices on some biological activities of an alluvial and clay soil of southern Turkey during the sixth years of a wheat–soybean–wheat crop sequence. This research was carried out in a long term experiment field area in Çukurova Region in south of Turkey (Figure 1). Soil type is alluvial, clay texture and calcareous. Research area has typical Mediterranean climate. Research tillage variants were Stubble burned and conventional tillage (SBCT: Burning the stubble; Plowing, 30-33 cm, Disk horrow, 13-15 cm, and 2 times; Packing, 2 times; Wheat planting with a universal planter, 4 cm), with stubble conventional tillage (SCT: Chopping the residues Plowing (30-33 cm) Disk horrow;13-15 cm and 2 times. Packing 2 times. Wheat planting with a universal planter 4 cm) and no tillage with direct seeding (NTDS: Chopping the residues; Herbicide application; Wheat seeding with direct seeder, 4 cm) system. After six years study period soil samples were collected from three field replications in June at three different depths (0-5 cm; 5-10 cm; 0-10 cm) and prepared to microbial analyses (Figure 2). All analytical results were calculated on the basis of oven-dried (105^{0}C) weight. Biological activities were evaluated in summer. CO_2 analyses were done by titration method which CO_2 was captured by $Ba(OH)_2$ and remaining BaOH titrated by HCl (Isermayer, 1952). Dehydrogenase enzyme activity (DHA) was determined according to Thalman (1956). Microbial biomass carbon (MBC) content was
determined by fumigation-extraction method (Ohlinger, 1993). Completely randomized design was used, obtained results were statistically analysed via MSTAT-C pocket software and ranged with Duncan multiple range test.

RESULTS AND DISCUSSIONS

Effect of different tillage applications on soil respiration rate (CO_2 production) is presented in Table 1. The effect of tillage application on CO_2 production was not statistically significant ($p>0.05$). Close values were observed from all three tillage systems. Among the all values, CO_2 formation varied between 12.0 (NTDS 0-10 cm) to 17.6 (SCT 5-10 cm) mg CO_2 100 g^{-1} $24h^{-1}$.

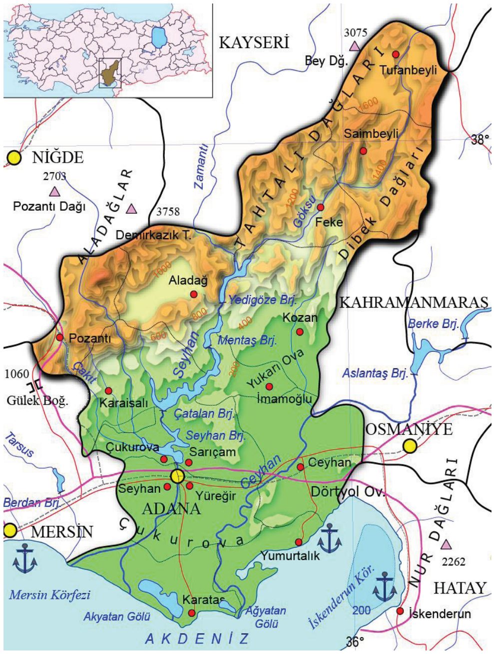

Figure 1. Geographic location of research Area (http://cografyaharita.com, 2017)

Figure 2. Taken soil samples in burning field areas

Table 1. Effect of different soil tillage applications on CO_2 produce (mg/100 g. ds. 24 h.) in soil

Soil Tillage	Depth (cm)	CO_2 (mg/100 g ds 24 h)	
With stubble conventional tillage (SCT)	0-5	16.4	b-d
	5-10	17.6	b-d
	0-10	16.7	b-d
	Average	**16.9**	**A**
Stubble burned and conventional tillage (SBCT)	0-5	16.5	b-d
	5-10	14.2	b-d
	0-10	13.0	Cd
	Average	**14.6**	**A**
No tillage with direct seeding (NTDS)	0-5	14.0	b-d
	5-10	20.2	a-d
	0-10	12.0	D
	Average	**15.4**	**A**
Average Depth (cm)	0-5	**15.6**	**A**
	5-10	**17.3**	**A**
	0-10	**13.9**	**A**

The DHA results are presented in Table 1. Effects of applications on dehydrogenase enzyme activities were statically important ($p<0.05$). The highest value was determined as 632 µg TPF/10 g ds 24 h in no tillage with direct seeding (NTDS) plots soils in depth of 0-10 cm. The lowest value of the table is 165 µg TPF/10 g ds 24 h which was determined in SBCT plots in soil depth of 0 - 5 cm. Dehydrogenase enzyme activity (DHA) results, belong to stubble conventional tillage (SCT) soil, higher than stubble burned and conventional tillage (SBCT) soil's value however the highest DHA value was found in No tillage with direct seeding (NTDS) soils. Long-term no tillage may enhance soil C sequestration and alter soil C and N dynamics and this case may increase to microbial activities especially enzyme activities. Soil dehydrogenase enzymes are one of the main components of soil enzymatic activities. DHA is very important and sensitive indicator for biochemical mechanisms in the soil. DHA is responding natural and anthropogenic disturbances very quickly. In a research by Doğan (2012), it was investigated the effect of genetically modified (GM) tobacco plants (pcVChMTIIGFP), used in phytoremediation purposes, and different heavy metals applications (Cd: 0, 0.5, 1, 2, 4; Zn: 0, 100,200, 400, 800; Cu: 0, 50, 100, 200, 400 mg kg^{-1}) on microbial activity in root zone soil. According to the above mentioned research results of Cd, Zn and Cu experiments DHA values with non-GM (SR-1 non-transgene) were found higher than GM plants (pcV-ChMTIIGFP)'s DHA (µg TPF/10 g kt) values. However in the same research, CO_2 and MBC values weren't effected negatively as much as DHA were. Most of similar research show that DHA very sensitive to both natural and anthropogenic disturbances and show a quick response to the induced changes (Kumar et al., 2013; Dick, 1994; Doğan, 2012). Thus, soil enzyme activity like DHA is very important parameter to determine biological activity.

Table 2. Effect of different soil tillage applications on Dehydrogenase enzyme activity (DHA) (µg TPF/10 g ds 24 h)

Soil Tillage	Depth (cm)	Dehydrogenase enzyme activity (DHA) (µg TPF/10 g ds 24 h)	
With stubble conventional tillage (SCT)	0-5	247	D
	5-10	365	b-d
	0-10	317	Cd
	Average	**309.3**	**B**
Stubble burned and conventional tillage (SBCT)	0-5	165	D
	5-10	170	D
	0-10	244	D
	Average	**193.0**	**B**
No tillage with direct seeding (NTDS)	0-5	599	a-c
	5-10	631	a-c
	0-10	632	a-c
	Average	**620.6**	**A**
Average Depth (cm)	0-5	337	A
	5-10	388	A
	0-10	398	A

Microbial biomass carbon (MBC) content (mg C kg^{-1}) were given in Table 3. Tillage systems had no significant impacts ($p<0.05$) on MBC content at any soil depth. Minimum and maximum values (mg C kg^{-1}) of MBC in Table 3 are 10.82 in NTDS soils (5-10 cm) and 21.42 in SCT soils (0 - 5 cm). With stubble conventional tillage (SCT) MBC results were found higher than others tillage applications. However no tillage with direct seeding (NTDS) MBC results were determined lower than other applications. According to this results MBC wasn't effected different tillage applications. In a similar study by Wright et al. (2005) which was carried out to investigate the impacts of tillage on soil C and N sequestration and microbial C and N dynamics of corn (*Zea mays* L.) and cotton (*Gossypium hirsutum* L.)

cropping sequences after 20 years of management. They found no effect to tillage systems on MBC significantly.

Table 3. Effect of different soil tillage applications on microbial biomass carbon (MBC) (mg C kg^{-1})

Soil Tillage	Depth (cm)	Microbial biomass carbon (MBC) (mg C kg^{-1})	
With stubble conventional tillage (SCT)	0-5	21.42	a
	5-10	16.29	a
	0-10	20.85	a
	Average	**19.52**	**A**
Stubble burned and conventional tillage (SBCT)	0-5	16.50	a
	5-10	11.77	a
	0-10	19.14	a
	Average	**15.80**	**A**
No tillage with direct seeding (NTDS)	0-5	11.24	a
	5-10	10.82	a
	0-10	10.82	a
	Average	**10.96**	**B**
Average Depth (cm)	0-5	16.38	**A**
	5-10	12.96	**A**
	0-10	16.94	**A**

Ammonium (NH_4-N) results were given Table 4. Soil NH_4-N concentrations were not impacted by tillage and did not vary with soil depth. Minimum and maximum NH_4-N concentrations are determined 3.85 mg kg^{-1} (0-10 cm) and 6.40 mg kg^{-1} (0 - 5 cm) in SCT soils respectively.

Table 4. Effect of different soil tillage applications on NH_4^+-N (mg/kg) concentrations

Soil Tillage	Depth (cm)	NH_4^+-N (mg/kg)	
with stubble conventional tillage (SCT)	0-5	6.40	A
	5-10	4.48	ab
	0-10	3.85	ab
	Average	4.91	A
Stubble burned and conventional tillage (SBCT)	0-5	4.25	ab
	5-10	4.09	ab
	0-10	5.43	ab
	Average	4.59	A
No tillage with direct seeding (NTDS)	0-5	4.25	ab
	5-10	4.31	ab
	0-10	4.48	ab
	Average	4.35	A
Average Depth (cm)	0-5	4.97	A
	5-10	4.30	A
	0-10	4.59	A

The effects of different soil tillage applications on Nitrate (NO_3^--N) concentrations were given Table 5. With stubble conventional tillage (SCT) was effected on Nitrate (NO_3^--N) concentrations significantly ($p<0.05$) in 0-5 cm depth. SCT caused to higher Nitrate (NO_3^--N) concentrations results. However according to general average results tillage wasn't effect to this parameter significantly. Table 5 values changed between 2.65-7.35 mg kg^{-1}.

Table 5. Effect of different soil tillage applications on NO_3^--N (mg/kg) concentrations

Soil Tillage	Depth (cm)	NO_3^--N (mg/kg)	
with stubble conventional tillage (SCT)	0-5	7.35	a
	5-10	3.17	c-e
	0-10	4.32	b-l
	Average	4.95	A
Stubble burned and conventional tillage (SBCT)	0-5	2.65	e
	5-10	5.69	ab
	0-10	3.82	b-e
	Average	4.05	A
No tillage with direct seeding (NTDS)	0-5	2.65	e
	5-10	4.35	a-c
	0-10	3.17	c-e
	Average	7.11	A
Average Depth (cm)	0-5	4.22	A
	5-10	4.40	A
	0-10	3.77	A

General effect of different soil tillage and soil depth on CO_2 production (mg/100 g kt 24 h), DHA enzyme activities (µg/10 g kt 24 h) and MBC content (mg C /kg ds) were given Figure 3. According to Figure 3 CO_2 value in with subble conventional tillage (SCT) is higher than others tillage soils and values of soil in 5 - 10 cm depth is higher than the other soil depths values. DHA enzyme activities to determined in no tillage with direct seeding (NTDS) soils are higher than others tillage soils. The highest DHA activities were found in 0 - 10 cm depth of soil. The highest MBC value is determined in with stubble conventional tillage (SCT) soils.

No tillage applications increase organic matter levels in surface soil layers (Alvear et al., 2005; Crovetto, 1996). So that biological activity has been found to be higher in soils under no tillage management than other tillage management (Bolinder et al., 1999). Also, under NT management with crop residues over the soil, an increased activity of some enzymes has been found, mainly acid phosphomonoesterase, arylsulphatase, dehydrogenase, urease and b-glucosidase (Alvear et al., 2005; Mullen et al., 1998).

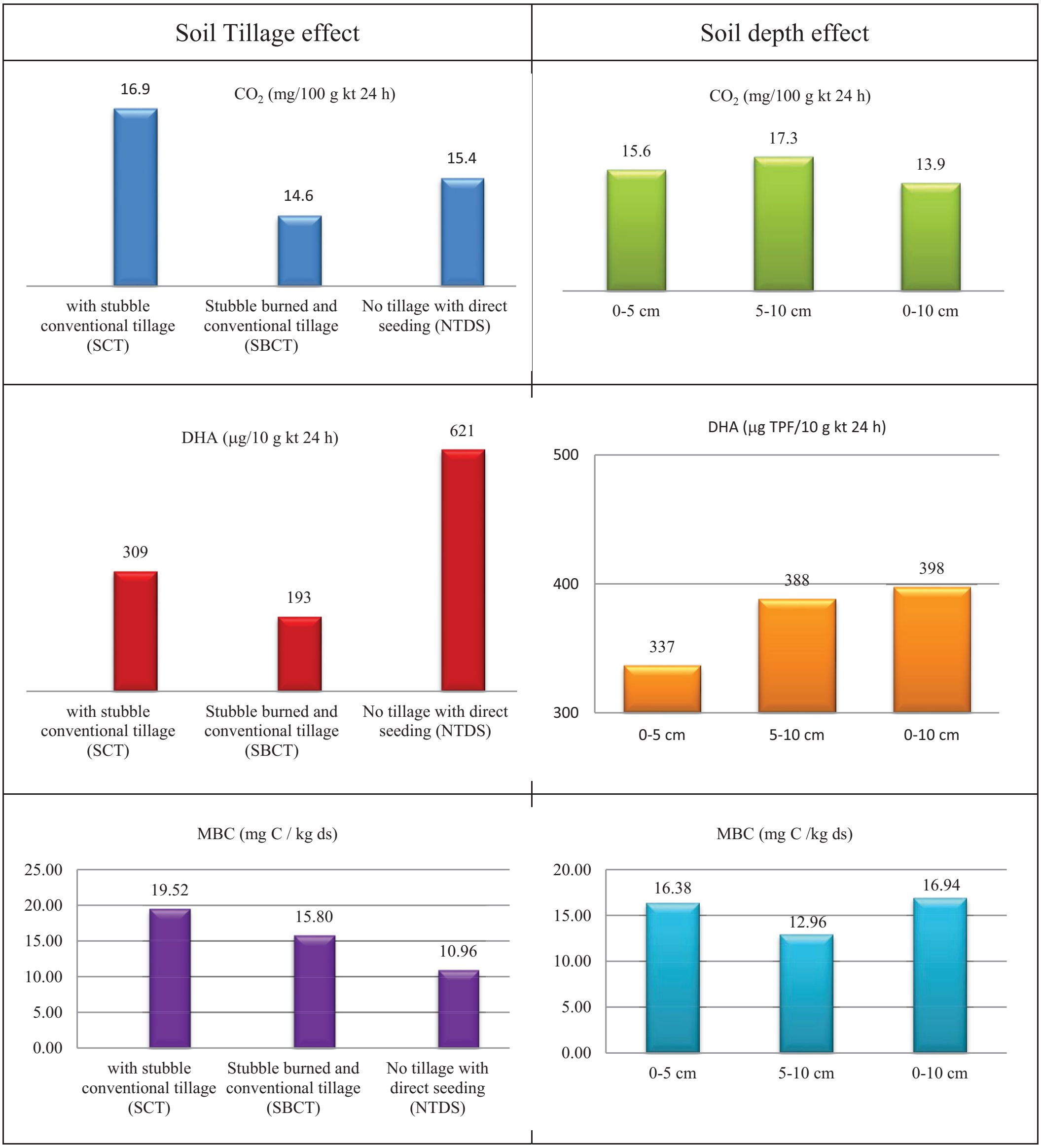

Figure 3. General effect of Different soil tillage applications and soil depth on CO_2 (mg/100 g kt 24 h), DHA (mg/10 g kt 24 h) and MBC (mg C/kg ds)

CONCLUSIONS

During to six years management in Cukurova Region's alluvial and clay soils in south of Turkey, some soil biological properties were effected from different soil tillage applications and stubble burning. Especially soil DHA enzyme activities were affected negatively from both different tillage and stubble burning. Soil respiration rate and MBC content of soil weren't effected the different tillage applications and burning as DHA enzyme activities. However six years term may not to be enough for a long-term research period. Although short term study, even this research is given effective results of soil microbial activities especially DHA activities. Stubble burning and intensive tillage damage to soil microbial activities which soil microbial activity effects to soil quality and productivity. Soil quality can be defined as its capacity to work properly within ecosystem boundaries to maintain biological productivity, environment quality and also to promote plant and animal health (Doran and Parkin, 1994; Alvear et al., 2005). Microbial biomass (MBC exc.) and soil enzymes (DHA exc.) have been suggested as potential indicators of soil quality because of their relationship to soil biology, ease of measurement, rapid response to changes in soil management (different tillage) and high sensitivity to temporary soil changes originated by management and environment factors (Marx et al., 2001; Jime´nez et al., 2002; Alvear et al., 2005). Initially because of micro damage of burning problems don't occur short-term periods. This micro damages are became grave soil problem year after year if no action is taken. Serious researches should be done to prevent stubble burning and protect to soil sustainability and quality.

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REFERENCES

Alvear M., Rosas A., Rouanet J.L., Borie F., 2005. Effects of three soil tillage systems on some biological activities in an Ultisol from southern Chile.

Anonymous, 2017. http://cografyaharita.com/ turkiye_fiziki_harirtalari.html. Map picture fig.1 25.01.2017.

Bolinder M., Angers D., Gregorich E., Carter, M., 1999. The response of soil quality indicators to conservation management. Can. J. Soil Sci. 79, 37–45.

Clark M.S., Ferris H., Klonsky K., Lanini W.T., Van Bruggen A.H. C., Zalon F.G., 1999. Agronomic. Economic and environmental Comparison of pest management in conventional and alternative tomato and corn system in Northern California Agriculture. Ecosystems and Environment. 68 (1) :51-71.

Coskan A., Dogan K., 2011. Symbiotic Nitrogen Fixation in Soybean. Soybean Physiology and Biochemistry, Hany A. El-Shemy (Ed.), ISBN: 978-953-307-534-1, InTech, Available from: http://www.intechopen.com/articles/show/title/symbiotic-nitrogen-fixation-in-soybean.

Coskan A., Gök M., Doğan K., 2010. The Denitrification Rate and Biological Activity of Soil under the Soybean Vegetation With Respect to Wheat Stubble Burning and Tobacco Waste Applications. Trends Soil Sci Plant Nutr J 2010 1(1):6-12.

Crovetto C., 1996. Stubble Over the Soil, American Society of Agronomy, Madison, WI (264 pp).

Dick R., 1994. Soil enzyme activities as indicators of soil quality. In: Doran, J.W., Coleman, D.C., Bezdicek, D.F., Stewart, B.A. (Eds.), Defining Soil Quality for a Sustainable Environment, Soil Science Society of America, Madison, pp. 107–124.

Doğan K., 2012. Transgenik Tütün Bitkisi (pcV-ChMTIIGFP) ile Bazı Ağır Metal Uygulamalarının Kök Bölgesi Toprakta Mikrobiyal Aktiviteye Etkisi. Alatarım Dergisi, 11, (2): 17-23.

Doran J., Parkin T., 1994. Defining and assessing soil quality. In: Doran, J.W., Stewart, B.A. (Eds.), Defining Soil Quality for a Sustainable Environment. Soil Science Society of America, Madison, (special publication no. 35), pp. 3–21.

Fabig W., Ottow J.C.G., Müller F., 1978. Mineralization von 14 C-Markiertem Benzoat mit Nitrat als Wasserstoff-Akseptor Unter Vollstaendig anaeroben Bedingungen sowie bei Verminderten Saurstoffpartialdruck. Landwitsch. Forsch. 35: 441-453.

Hesammi E., Benjavad A.T., Hesammi H., 2014. A review on the burning of crop residue on the soil properties. WALIA journal 30(1): 192-194.

Isermayer H., 1952. Eine Einfache Methode zur Bestimmung der Bodenatmung und der Karbonate im Boden. Z. Pflanzenernehr. Bodenkd. S 56.

Jime´nez, M.de la Paz, de la Horra A.M., Pruzzo L., Palma R.M., 2002. Soil quality: a new index based on microbiological and biochemical parameters. Biol. Fertil. Soils 35, 302–306.

Kılıç Ş., Doğan K., Keskin S.G., 2013. Yanlış Arazi Kullanımı ve Anız Yakma Sorununa Çözüm Önerileri. Tralleis Elektronik Dergisi. 1 (2013) 36-44.

Kladivko J.K., 2001. Tillage systems and soil ecology. Soil Tillage Res. 61(1-2):61-76.

Kumar S., Chaudhuri S., Maiti S.K., 2013. Soil Dehydrogenase Enzyme Activity in Natural and Mine Soil - A Review. Middle-East Journal of Scientific Research 13 (7): 898-906.

Lavelle P., 2000. Ecological challenges for soil science. Soil Sci. 165(1):73-86.

Marx M.C., Wood M., Jarvis S.C., 2001. A microplate fluorimetric assay for the study of enzyme diversity in soils. Soil Biol. Biochem. 33, 1633–1640.

Mullen M., Melhorn C., Tyler C., Duck, D., 1998. Biological and biochemical soil properties in no-till corn with different cover crops. J. Soil Water Conserv. 5, 219–224.

Öhlinger R., 1993. Bestimmung des Biomasse-Kohlenstoffs mittels Fumigation-Exstraktion. In:Schinner, F., Öhlinger, R., Kandler, E., Margesin, R. (eds.). Boden biologische Arbeits methoden. 2. Auflage. Springer Verlag. Berlin, Heidelberg.

Rasmussen P.E., Rohde C.R., 1988. Stubble burning effects on winter wheat yield and nitrogen utilization under semiarid conditions. Agronomy journal. Nov/Dec 1988. v. 80 (6).

Saggar S., Yeates G.W., Shepherd TG., 2001. Cultivation effects on soil biological properties, microfauna and organic matter dynamics in Eutric Gleysol and Gleyic Luvisol soils in New Zealand. Soil & Tillage Research. 58, 55-68.

Thalman A., 1967. Über die mikrobielle Aktivitaet und ihre Beziehungen zur Fruchtbarkeitsmerkmalen einiger Ackerböden unter besonderer Berücksichtigung der Dehydrogenase aktivitaet (TTC-Reduktion) Diss. Giessen (FRG).

Walker J., Raison R.J., Khanna P.K., 1986. Fire. In: Australian soils – the human impact, eds JS Russell & RF Isbell, University of Queensland Press Brisbane pp 185–216.

Wardle D.A., 1995. Impacts of disturbance on detritus food webs on agro-ecosystems of contrasting tillage and weed management practices. In: Advances in Ecological Research, Begon, M, Fitter, AH. Vol: 26. Academic Press. New York p. 105-185.

Wright A.L., Honsa F.M., John E., Matocha Jr. J.E., 2005. Tillage impacts on microbial biomass and soil carbon and nitrogen dynamics of corn and cotton rotations. Applied Soil Ecology 29 (2005) 85–92.

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GENESIS AND EVOLUTION OF FOREST AND ARABLE SOILS FROM CODRI AREA FORMED UNDER DECIDUOUS FOREST VEGETATION

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Abstract

Soils formed under forest vegetation in the forest steppe zone of Russia were named by V. Dokuceaev as gray forest soils, like a transition type of soils from podzols to chernozems. In Moldova these soils formed under forest vegetation in the hilly Moldavian forests areas, named Codri, were also called gray forest soils in spite of the fact that climatic conditions, pedogenesis processes and diagnostic indicators differs from the Russian steppe. Recent soil research have established that in these soils formed in humid warm climate suitable for chernozems formation, podzolic process characterized by the formation of free iron and aluminum sesquioxides is not characteristic. Taking into account the soil formation conditions, processes that formed the investigated soils, their genetic horizons characteristics and color, it is recommended for them to be called brown soils (brunizems).

Key words: *gray soil, brown soil, forest vegetation, genesis, evolution.*

INTRODUCTION

The problem of forest soils genesis in central part of Moldova is one of the most difficult and questionable, due of specific composition of pedogenesis factors in this area. This led to the formation of very complex and polygenetic soil cover in central part of Moldova. The definitive formation of contemporary soils under the deciduous forests occurred in the late Holocene, Subboreal (4600-2500 years ago) and Subatlantic (2500-800 years ago) periods.

According to the results of archaeological research carried out in the territory of Ivancea, Trebujeni and Furceni villages, during the historical period called „culture of farmers" or „Cucuteni - tripole" (5500-2750 BC) here started forest deforestation by humans, and the process continued with interruptions until the invasion of the Huns in 260 year. Released land were used in agriculture (Александровский, 1988).

Romanian historian Xenopol wrote that between high migrations of nations from east to west, after the 260 year when the territory was conquest by nomads, over a period of hundreds and thousands years they attacked and destroying like a grasshopper the local population employed in agriculture of this territory (Xenopol, 2006).

After that most of the arable land were abandoned and were covered with steppe vegetation. Along the way of hundreds years in the extension phase of pedogenesis under restored steppe vegetation, originally soils formed under forest vegetation have evolved in chernozems. However, the largest areas of forest were cut during the years 1800-1950 (Bejan, 2006).

Most of this land hitherto is used as arable and due the anthropogenic pedogenesis phase along more than 100 years soils have not evolved in chernozems. This fact does not correspond to some researchers assertion that as a result of arable use, more than 100 years this soils formed under deciduous forests and evolve in chernozems (Чендев, 2006; Dokuceaev, 1954).

V.V. Dokuceaev named the soils formed under forest vegetation from Russian forest steppe as gray forest soils, and ranked them as a type of transition from podzols to chernozems. Further in the text we call these soils „Grayzems", name used by FAO UNESCO in world soils map legend for called by V.V. Docuceaev and others gray forest soils.

MATERIALS AND METHODS

The research was carried out on the territory of the Institute of Pedology, Agrochemistry and Soil Protection „Nicolae Dimo" experimental field from the village Ivancea, district Orhei. This area, located within 170-210 m absolute altitudes represents scientific interest because here it is known the period of gray soil use in agriculture. On one in the past forest area the grayzems were plowed for about 120 years (120 ± 10 years) period.

In the field was made morphological description of profiles - pairs located opposite to each other in the forest (profile 1 and 51) and in the arable land (profile 2 and 52), located at a distance of approximately 150 m from each other (Figure 1).

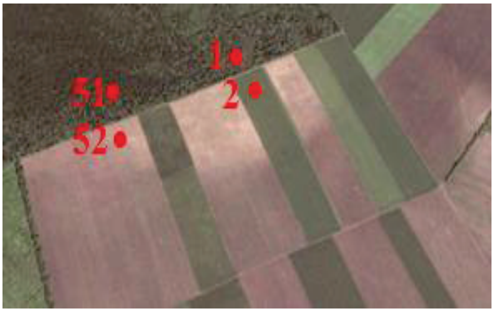

Figure 1. The area (light color) of gray soils (grayzems) in Experimental Station fields:
1 and 51 - soil profiles located in the forest;
2 and 52 - soil profiles placed on arable land.

In the field was determined bulk density and soils penetration resistance. Simultaneously have been collected soil samples for laboratory analysis. To perform the field and laboratory determinations were used nationally approved methods.

RESULTS AND DISCUSSIONS

Area of arable gray soils (grayzems) spread on the studied Experimental Station territory is highlighted on the ortho-photo map by pale color of the land located next to the forest (Figure 1).

The history of this arable soil area formation is the next. In the 1852 the Ivancea village territory was bought by Armenian Karabet Arakelean Balioz (Голуб, Сорочинский, 1950). He cut in the years 1860-1880, the forest on the today arable sector for commercial purposes. The investigated soil profiles are shown in Figure 2.

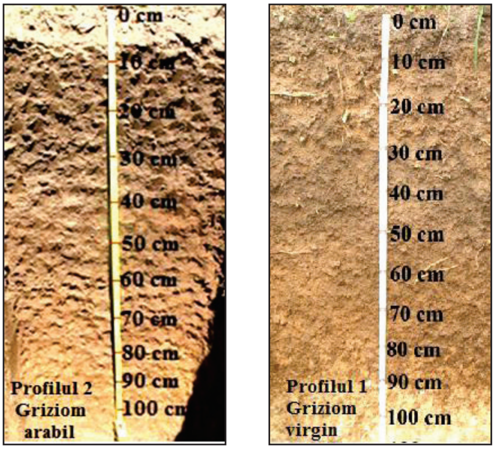

Figure 2. Profile composition of forest and arable gray soil (grayzems)

Forest grayzem has the next profile type: *AEhţ (0-9 cm) → AEH (9-21 cm) → BEhtw (21-34 cm) → Bhtw (34-51 cm) → BCtw (51-80 cm) → BCtwk (80 -100 cm) → BCK (100-120 cm).* This soil (profile 1) is characterized by clear differentiation profile. In the range of 0-34 cm depths is highlighted three horizons:

AEhţ, AEH and BEhtw with medium texture and low compaction, which is located below the iluvial-cambic compacted horizon (Table 1 and Table 2).

The layer 0-30 cm of arable soil consists from the first three forests soil horizons with genetic material mixture: AEhţ, AEH and BEhtw. Under these layers is located the iluvial-cambic very compacted horizon identical to his forest soil horizon analog. Significant changes in profiling occurred just artificially created only arable layer. The arable layer lost its favorable glomerular - grained structure and the resistance to compaction. It became rough and very compacted, the color from gray changed into red-brown (Table 1 and Table 2).

Some characteristics of grayzems in central part of Moldova have been described by V.V. Dokuceaev, who was amazed by the high content (7-10%) of organic matter in the layer 0-8 cm (Dokuceaev, 1950).

There are three hypotheses on the origin of gray soils genesis:

1. The hypothesis of V.V. Dokuceaev who consider gray forest soils primary origin as a result of soil formation process under deciduous forest vegetation.
2. S.I. Korjinskii's hypothesis regarding grayzems formation as a result of chernozems degradation under deciduous forest vegetation as a result of forest invasion in the steppes during the colder and wetter Holocene.
3. V.R. Viliams's hypothesis, that the gray soils were formed as a result of podzolic soils developed under the influence of steppe vegetation as a result of the steppes invasion in the forests during the drier Holocene.

Subsequent research confirmed that all three hypotheses have the right to life; only the last two are individual cases. So then, grayzems or soils appointed by the V.V. Dokuceaev gray forest soils are formed as a result of the podzolic pedogenesis process and the humus accumulation process merge.

The profiles of these soils may show inherited traits or characters that were formed as a result of iron and aluminum sesquioxides iluvial process from higher in a lower horizon in the water-soluble chelat forms. So it is necessary to assess under what conditions were formed grayzems in central part of Moldova.

This dilemma can only be solved by highlighting the process that led to their profile textural differentiation: soil spodic process, lessivage or argillic alteration *in situ*. To answer this question has been researched forest and arable soils in the territory village Ivancea, Orhei district and have used the results of previous research on this territory, made in Lysimeter (Грати, 1977). Based on the research results from stationary placed in forestry soils in the village Ivancea were made the following conclusions:

1. Under the forest toward the autumn is used all available soil moisture reserves. Autumn-winter precipitation are only enough to wet the soil to a depth 150 cm. As a result, at this depth in spring is observed maximal moisture deficit and carbonates accumulation.
2. In early spring the soil moisture in 0 - 100 cm layer is equal to field capacity, but the rapid rise of temperatures and intensive use of water by forest vegetation leads to available water reserves depletion in June - July in this layer, which confirms contrast humidity regime in these soils.

For the most part of the year the soils in the forest are well aerated and aerobic processes dominate in their profile, which does not favor the evolving gleic soil process (minerals mass reduction processes) in the superficial horizons (prerequisite for the development of podzolic soil process).

Lysimeter waters reaction in almost all investigated soils is neutral or slightly alkaline; it can be explained by the fact that litter is rich in calcium. The concentration of iron and aluminum in the Lysimeter waters on the profile of both forest and arable soil is low and stable, and decreases sharply in parental rock. The lack sesquioxides increasing in Lysimeter waters, after this are going through the eluvial horizon, doubts the presence of podzolic process in investigated soils and the existence of clay films on the pores walls and in the microcracks iluvial horizon, confirms the existence of lessivage process of colloidal particles from top to down in the profile. Gray soil textural differentiation of the profile is linked to the intensity of two processes: eluvial (lessivage) process and strong argillic alteration *in situ* in the middle part of profile.

From the materials presented in the monograph written by V. Grati (1977) is resulted that soils formed under forest vegetation in central Moldova differ from soils called gray forest soils from Russian steppe zone by the lack or very weak development of podzolic process and it's replacing with the lessivage process with comparatively low intensity.

In the textural differentiation of the soil profile in this area plays a key role clay alteration process *in situ* of Btw horizon mineral part.

Although listed findings show that soils in the hilly part of Codri area differ clear from all points of view to those called grayzems or gray forest soils, V. Grati has not proposed revision of their taxonomy. Research by us research findings largely confirmed V. Grati.

The specific properties of investigated soils are shown in Tables 1 - 3. The BCk and Ck horizons were considered as part of the weakly amended mineral part of the soil profile by iluvial processes and alteration *in situ*. As a result of textural differentiation (Canarache,

1990) and argillic alteration coefficients calculating we find the following:
- forest soils have medium differentiated profile and arable land are poorly differentiated textural as a result of argillic alteration *in situ* process intensification in the arable layer;
- iluvial-cambic horizons of soils studied is characterized by high clay content predominantly colloidal;
- loss of clay in eluvial horizons (AEhţ, AEH, BEH) in grayzems from the forest are about 9 times less than its accumulation in iluvial-cambic horizons, that confirms the leading role *in situ* alteration processes in the texture differentiation of their profile.

Low and very low textural differentiation of profile in studied agricultural soils is due to the *in situ* alteration process intensification in the upper part of the profile as a result of their hydrothermal regime change, weak acid reaction and eluvial-iluvial process stopping.

A key indicator of the studied soils genesis is their total composition, because it reflects the result of the pedogenesis process. Forestry soils are characterized by a little enrichment with silicate in eluvial (soil from forest) and posteluvial horizons (arable layer of agricultural soils). At the same time it detects a higher content of iron and aluminum compounds in iluvial-cambic horizons as a result of alteration processes and their leaching from above horizons.

Generally, studied soils profiles differentiation in terms of the genetic horizons chemical composition is low as a result of hydrothermal warmly and contrast regime. Data on the non - silicate iron compounds content in investigated soils confirming their weak or moderate accumulation in the iluvial - cambic horizon Btw, as a result of clay co-migration from the AE to Btw horizon. Brown color of the horizons of forest soils is due to iron oxides.

So now, research results confirm that the textural differentiation of forest soils in central part of Moldova occurred as outcome of argillic alteration *in situ* in the central part of their profile and the weak or moderated process of clay and free sesquioxides co-migration (lessivage) from the horizon AE to Btw and not podzolic process characteristic for gray forest soils (grayzems). Forest soils in this area climate are more correctly to be called *brown* or *brunizems.*

The soil cover in the hilly Codri Plateau in Central Moldova, depending on the stage of the recent and previous pedogenesis and can consist of brown forest soils, brown arable soil, brown arable at different stages of transition to chernozems, cambic chernozems, cambic postarable chernozems at different levels of transition to brunizems as a result of the long pedogenesis under the secondary forests of originally formed chernozems.

Table 1. Physical and chemical properties of the forest (profile 51) and 100 years arable (profile 52) grayzems

Horizon and the depth, cm	The faction, %			Textural differen-tiation index	Coeffi-cient of argillic alteration	Bulk density g/cm^3	Fe_2O_3 total, %	pH	$CaCO_3$, % g/g	Humus content, %
	<0.0001 mm	<0.001 mm	<0.01 mm							
Forest loamy-clay grayzem (profile 51)										
Ahţ 0-8	11.4	23.4	43.9	1.0	0.9	0.84	3.82	6.8	0.0	8.63
Aeh 8-21	12.2	23.8	43.7	1.0	0.9	1.22	3.56	5.0	0.0	2.65
EB 21-30	15.4	28.4	48.4	1.2	1.0	1.38	4.17	5.4	0.0	1.87
Btwh 30-50	28.5	37.5	58.4	1.6	1.4	1.64	4.80	5.3	0.0	1.14
Btw 65-80	29.4	39.4	60.8	1.7	1.5	1.64	5.13	6.9	0.0	0.68
BCtwk 80-00	26.8	35.0	57.6	1.5	1.3	1.57	4.83	7.7	16.7	0.58
BCk 100-120	14.8	27.9	53.6	1.1	1.0	1.46	3.98	7.8	22.3	0.52
Ck 130-150	14.2	27.1	49.3	1.1	1.0	1.46	3.98	8.0	24.7	0.47
Arable loamy-clay grayzem (profile 52)										
Ahp1 0-30	14.9	33.1	50.8	1.0	1.2	1.44	3.85	6.5	0.0	2.23
Bhtw 30-50	26.9	37.7	58.7	1.1	1.4	1.60	4.89	5.6	0.0	1.25
Btw 50-72	28.1	38.7	60.2	1.2	1.4	1.61	4.83	6.1	0.0	0.73
BCtwk 72-90	24.3	34.0	57.8	1.0	1.3	1.55	4.55	7.8	16.4	0.68
BCk 90-110	14.8	27.8	51.4	0.8	1.0	1.46	4.19	8,1	23.0	0.58
Ck 130-140	14.5	27.3	49.3	0.8	1.0	1.45	3.92	8.1	23.4	0.34

Table 2. Main physical properties of forest (profile 1) and arable (profile 2) grayzems

Horizon and the depth, cm	The faction, %		D	DA	PT, % v/v	AH	CH	Moisture content in the field 14.05.2015	Resistance to penetration, kgf/m^2
	<0.001 mm	<0.01 mm	g/cm^3			% g/g			
Profile 1. Gray forest soil (grayziom)									
AEhţ 0-9	24.6	42.4	2.48	0.86	65.3	7.8	9.2	-	3
AEh 9-21	25.6	44.0	2.61	1.27	51.3	7.4	7.8	-	7
BEhtw 21-34	34.6	54.2	2.66	1.45	45.5	7.6	8.4	-	14
Bhtw 34-51	40.8	61.5	2.70	1.62	40.0	8.5	10.2	-	24
BCtw 51-80	40.7	60.9	2.71	1.61	40.6	8.0	10.0	-	-
BCtwk 80-00	35.3	55.6	2.72	1.60	41.2	6.5	7.9	-	-
Ck 100-120	32.4	50.5	2.73	-	-	6.2	7.5	-	-
Profile 2. Arable gray soil (grayziom)									
Ahp1 0-10	31.5	55.9	2.59	1.38	46.7	3.8	7.8	17.9	12
Ahp1 10-20	32.0	56.2	2.60	1.55	40.4	3.8	7.9	20.2	19
Ahp2 20-35	32.9	56.3	2.62	1.57	40.1	4.0	8.7	21.6	21
Bhtw 35- 50	41.8	62.2	2.69	1.61	40.1	7.0	12.2	23.2	26
BCtw 50-80	41.1	61.9	2.72	1.62	40.4	6.7	12.0	23.0	-
BCtwk 80-100	38.0	58.0	2.73	1.59	41.8	6.6	10.5	20.8	-
Ck 100-120	35.2	55.1	2.73	-	-	6.5	10.4	20.8	-

Note: *D - density; DA - bulk density; PT - total porosity; AH - hygroscopic water; CH - coefficient of hygroscopicity.*

Table 3. The chemical characteristics of forest and arable gray soils (grayzems)

Horizon and the depth, cm	pH (H_2O)	$CaCO_3$	P_2O_5 total	Humus	N total	C : N	P_2O_5	K_2O	$N\text{-}NH_4$	$N\text{-}NO_3$
		% g/g					mg/100 g sol			
Profile 1. Gray forest soil (grayziom)										
AEhţ 0-9	6.3	0	0.17	8.72	0.411	12.3	3.4	28	-	-
AEh 9-21	5.5	0	0.11	3.21	0.181	10.3	2.3	14	-	-
BEhtw 21-34	5.6	0	0.10	1.31	0.078	9.7	1.0	12	-	-
Bhtw 34-51	5.2	0	0.08	1.16	0.073	9.2	0.4	10	-	-
BCtw 51-80	5.7	0	-	0.76	-	-	-	-	-	-
BCtwk 80-00	7.5	7.7	-	0.63	-	-	-	-	-	-
Ck 100-120	8.1	19.4	-	0.47	-	-	-	-	-	-
Profile 2. Arable gray soil (grayziom)										
Ahp1 0-10	6.6	0	0.09	2.30	0.136	9.8	2.7	22	2.4	0.5
Ahp1 10-20	6.4	0	0.09	2.13	0.130	9.5	2.2	19	2.3	0.4
Ahp2 20-35	6.4	0	0.08	1.77	0.110	9.3	1.6	18	1.9	0.3
Bhtw 35- 50	6.4	0	0.07	1.05	0.071	8.6	0.6	22	1.4	0.2
BCtw 50-80	7.0	0	-	0.64	-	-	-	-	-	-
BCtwk 80-100	7.9	3.6	-	0.58	-	-	-	-	-	-
Ck 100-120	8.1	13.6	-	0.45	-	-	-	-	-	-

CONCLUSIONS

The south-eastern and south-western hills of the Central Codri Plateau from Republic of Moldova are characterized by specific composition of the pedogenesis factors. Soils formed under deciduous forest vegetation in the peripheral part of Codri, recently called gray soils or grayzems, differ analogical from forest steppe soils from the Russia called gray soils by V.V. Dokuceaev: They have evolved in warm and semi humid climates; textural profile differentiation is low or moderate and predominantly caused by the "in situ" alteration of the parental material and only partly by the colloids fraction lessivage but not due the podzolic process characterized with sesquioxides migration, characteristic for gray soil. Taking into account the soil formation conditions, processes that formed the investigated soils, their genetic horizons characteristics and color, it is recommended for them to be called brown soils (brunizems).

As result of soils gray using in agriculture were occurred essential negative changes in their characteristics, among which: the decrease of humus content in the arable layer almost 2 times compared to forestry soils, destructuration and strong compacting of arable layer, and acidification - which is a difficult problem to their recovery.

Remediation of arable gray soil characteristics consist in: increasing organic matter flux in arable layer, restoration of unfavorable structural status of ploughing layer, periodically loosening by subsoiling the upper iluvial - cambic horizon.

REFERENCES

Bejan I., 2006. Dinamica structurii fondului funciar pe teritoriul Republicii Moldova. Revista Economica, Chisinau, nr. 4, p. 44-49.

Canarache A., 1990. Fizica solurilor agricole. Ed. Ceres, Bucureşti, 268 p.

Xenopol A., 2006. Istoria romanilor din Dacia traiana. Dacia in vremea năvălirilor barbare 270-1290. Bucureşti, Elf, 244 p.

Александровский А.Л., 1988. Эволюция почв Восточной Европы на границе между лесом и степью. В: Естественная и антропогенная эволюция почв. Сборник научных трудов. Пущино: Институт Почвоведения и Фотосинтеза, с. 82-93.

Голуб В., Сорочинский И., 2001. Иванчеа. Орхей, 142 с.

Грати В.П., 1977. Лесные почвы Молдавии и их рациональное использование. Кишинев: Штиинца, 136 с.

Докучаев В.В.,1950. К вопросу о почвах Бессарабии. Кишинев: Государственное изд. Молдавии, 55 с.

Докучаев В.В., 1954. Естественноисторическая классификация русских почв. В: Избранные сочинения, М: Наука, 640 с.

Чендев Ю.Г., 2006. Почвенные агрохронорядыв широколиственно-лесных ландшафтах центральной лесостепи. В: Проблемы древнего земледелия и эволюции почв в лесных и степных ландшафтах Европы. Белгород, с. 70-79.

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INFLUENCE OF FERTILIZATION AND SOIL TILLAGE SYSTEM ON WATER CONSERVATION IN SOIL, PRODUCTION AND ECONOMIC EFFICIENCY IN THE WINTER WHEAT CROP

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Abstract

During the last years, in the Romanian agricultural practice, the alternatives of soil minimum tillage and no-tillage are very much applied in the winter wheat crop. During droughty autumns, when the soil is very dryand we can't have any plowing or the result of plowing would beclods very hard to chop, preparing the field by minimum tillage or direct sowing are prefered to plowing in order not to delay the wheat sowing, but also from an economic point of view. The paper presents the influence of thesoil tillage (conventional and no-tillage), of the fertilization systemand of the agricultural year (expressed by different climate conditions), on the soil humidity, production andeconomic efficiency in the winter wheat crop. The experience was polyfactorial, placed on a Faeoziom type of soil from the Transylvanian Plain (the average multiannual temperature of 9.1°C and average multiannual rainfall of 518.6 mm). The wheat crop responded favourably to the no-tillage technology, the production registered (6285 kg/ha) is very close to the one obtained in the conventional system (6320 kg/ha). The no-tillage system has the advantage of a better water preserve in the soil, which can be used in stages by the plants during drought seasons. Additional wheat fertilization (with N_{40}) brings a production increase of 111 kg/ha. The economic efficiency of the no-tillage system results mainly from the reduced fuel consumption (approximately by 50%) and the reduced number of tillage, which determines a reduction by 19.2% of the total technological expenses.

Key words: *soil tillage, fertilization, water preserve, production, economic efficiency, wheat.*

INTRODUCTION

Preparing the field for wheat sowing is often difficult due to the time left since the harvest of the preceding and up to the sowing, the difficult climate conditions during the tillage (drought from the end of the summer and the beginning of the autumn) and of the big surfaces which must be prepated and sowed during a relatively short period of time (Rusu et al., 2007). During the last years, in the Romanian agricultural practice, the alternatives of soil minimum tillage and no-tillage are very much applied in the winter wheat crop (Rusu et al., 2015). During droughty autumns, when the soil is very dry and we can't have any plowing or the result of plowing would be clods very hard to chop, preparing the field by minimum tillage or direct sowing are prefered to plowing in order not to delay the wheat sowing, but also from an economic point of view (Cociu and Cizmas, 2013; Dinca et al., 2013).

The conventional soil tillage system, having plowing as the basic tillage, preparing the germinative bed and maintenance works lead in time to soil compaction due to heavy machine traffic. The total loading on the axisof agricultural machines determines the compaction of the lower soil layer from beneath the working depth of the soil processing organs (Gheres, 2007). The effects of compaction are: increase of the apparent density, reduction of total porosity, of the hydraulic conductivity, water and air permeability. The negative effects of soil compaction are multiple, they influence even cultivated plants, the production capacity drops and therefore production is reduced (Rusu and Gus, 2007). As a consequence, a series of negative effects accelerates through a bigger loss of water, a weaker mineralization of vegetable scraps, formation of hard pan, end of continuity of capillarity, and if the plowing of slopy fiends is done according to the line of the highest slope, erosion is favoured (Calegari and Alexander, 1998; Gus et al., 2003; Domuta et al., 2012).

The alternative (conservative) soil minimum tillage and no-tillage systems require a reduced intervention on the soil, keeping the vegetable scraps at the soil surfaceat least 50-60% with a mulch role in protecting the soil. The soil is thus protected from the surface erosion, the soil aggregates are stabilized, the organic materials and the fertilization levelsh all grow, the soil compaction and the CO_2, emissions are reduced, the biodiversity rises (Lazureanu et al., 1997; Jitareanu et al., 2006; Marin et al., 2015). The vegetable scraps left on the soil surface protect it and under the action of micro- and macroorganisms in the transformation process contribute to the improvement of soil structure (Ulrich et al., 2006; Wozniak et al., 2014).

The application of conservative soil tillage alternatives is conditioned by the adoption of a new fertilization system, as well as by their optimization in relation with the local pedo-climate conditions. In order to choose the best technological variant one must take into account the soil technological characteristics: texture, humidity, field exposure, macro and microclimate, the humus content etc., but also the climate conditions of the agricultural year and the capacity of the technology applied to capitalize these resources (Stefanic et al., 1997; Moraru and Rusu, 2010; Szajdak and Rusu, 2016).

In the Transylvanian Plain an interaction of a big number of limiting factors for agricultural technologies is recorded, of which two prevail. The first is the thermal background at its level of low temperature and with high time variations and the second is the hill orography of the land with a lot of soils degraded by erosion (Rusu et al., 2009; 2014; Chetan et al., 2015; 2016). They impose restrictions regarding the crop structure and systems of agricultural machines to ensure the application of a conservative technology.

The paper presents the results of the research made under the conditions from Agricultural Research and Development Station Turda (ARDS Turda), situated in the Transylvanian Plain, the influence of the soil tillage system, the fertilization system and the agricultural year, the soil humidity, the production and economic efficiency in winter wheat crop.

MATERIALS AND METHODS

The research start from the idea of optimizing the existing possible relation among the soil tillage system, crop structure, water accumulation and preserve in the soil for a longer period of time, accesible to crop plants as well as the productions which can be madeat a lower price. These researches have been made during a trifactor experience, during 2014-2016, the experimental field is a 3 year rotation crop: soy-winter wheat - maize.

The experimental factors were:

A - the soil tillage system: a_1 - conventional systems with plowing (CS); a_2 - no-tillage systems (NT).

B - the fertilization system: b_1- $N_{60}P_{40}$ (in sowing); b_2 - $N_{60}P_{40}$ (in sowing) + N_{40} (in spring at the wheat vegetation).

C - agricultural year: c_1 - 2014; c_2 - 2015; c_3 - 2016.

Sowing was made with Directa - 400 sower, at 18 cm among the lines, the incorporation depth of the seed is 5 cm; the sowing thickness was 550 germinable grains/m^2; the biological material used isthe type of winter wheat Andrada (created at ARDS Turda). The experience was placed on a verticphaeosiom type of soil (SRTS, 2012) with the following characteristics (MESP, 1987): pH 7.00; humus 3.40%; total nitrogen 0.226%; phosphorus 73 ppm; potassium 295 ppm, determined on the 0 - 30 cm depth.

In order to determine the soil humidity (U, %) the gravimetric method was used. The soil samples were taken 3 times, on the depth of 1 m, graduallyfrom 10 to 10 cm, with Theta drill probe. The access ible humidity reserve (Ra, m^3/ha) was determined on the depth 20; 50; 100 cm.

Taking the wheat samples was made by meeting the methodology rules of the experimental technique. This operation consisted of the following steps: taking the protective tapes from around the experiences;

taking the front and side margins of the experimental variants (the front deletions were 1 m and the side ones were 0.60 cm), taking into account the working width of the harvester of experimental parceling. The harvest surface of the experimental parceling was 28 m^2.

The economic efficiency of the variants researched was determined according to the number of technological works applied, the fuel consumption (based on the characteristics of the agricultural machines and equipment used) and material used reported per hectare.

The experimental data was processed by analyzing the variant (PoliFact, 2015) and setting up the limit differences (LSD, 5%, 1%, 0.1%).

RESULTS AND DISCUSSIONS

The experience was set up on a fertile soil but also with susceptibility of quick subsidence at the passing of big agricultural aggregates or when it is worked mechanically under conditions of high humidity. The soil physical characteristics influence directly its fertility, which in its turn, has a powerful influence on the water, air and nutrition regime from the soil.

The analysis of the evolution of climate factors and their reporting in relation to the experimental results obtained aim to identify the best measures to adapt to the climate changes recorded, both worldwide and locally. An analysis of the evolution of the thermal and rainfall regimeat ARDS Turda (altitude of 427 m) during the last 60 years, respectively since 1957, when the station was set up and up to nowis presented next. The thermal and rainfall regime during 1957-2016, at ARDS Turda, is presented in Figure 1 and Figure 2. The research area is characterized by a multiannual average temperature of 9.1°C and multiannual average rain of 518.6 mm. But during the last 15 years one can notice a clear tendency of high temperatures and a drop of the rain recorded. The climate changes recorded, as well as the unpredictable ones in the future imposea rational choice of the biological material which is going to be cultivated and the application of adequate technologies to the new climate conditions.

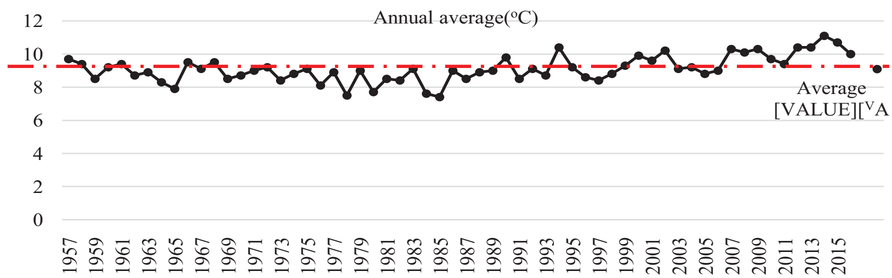


Figure 1. The thermal regime ARDS Turda, 1957-2016

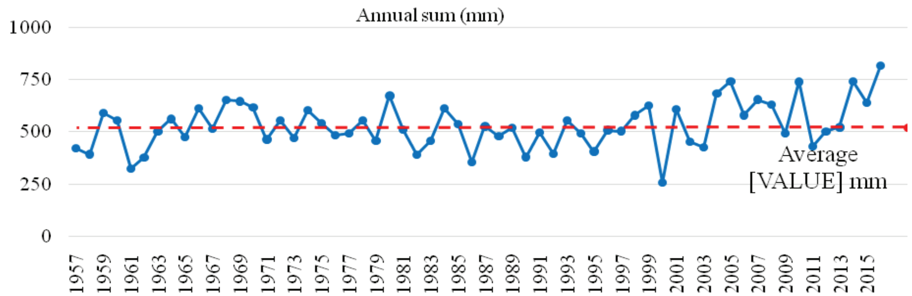


Figure 2. The rainfall regime ARDS Turda, 1957-2016

What was specific for the three years taken into account in the study (2014, 2015, 2016) was the unequal distribution of rain, there was a long period of pedological drought followed by heavy rain.

The 2014 was a good year for agricultural crops from the point of view of the climate, the alternation of months with normal temperatures from a thermal point of view and the warm ones was good for the vegetation steps. The rainfall in 2014 with the annual sum of 741.5 mm, was high in quantity, especially during the summer, even if the number of rainy days was smaller.

The 2015 was characterized as a hot and rainy year. The year average was 10.6^{o}C, that is 1.5^{o}C more than the multiannual average in 60 years. Rainfall in this year exceeded by 122.4 l/m^2 the value of 518.8 l/m^2, the multiannual average in 60 years. The amount registered was 641.2 l/m^2.

2016 is a hot year, with a deviation of + 0.9^{o}C compared to the multiannual average, with an annual average temperature of 10^{o}C. From the rainfall regime point of view, 2016 with 816.8 l/m^2 and a deviation of + 288 l/m^2 compared to the multiannual average is characterized as an excessively rainy year.

The choice of the best soil tillage system with the specific technology works applied for the winter wheat must ensure the accumulation and preserve in the soil of the entire quantity of water coming from the rainfall during summer and autumn. Following the results obtained during 2014-2016, regarding the humidity existing in the soil in winter wheat crop, one has noticed that there are certain differences among soil tillage systems.

In the NT system, the accessible water reserveis kept better in the soil even during drought, the depth water rises through capillaries to the radicular area paying off for the lack of water due to drought. Restoring the water reserve from the soil, as one can notice in Figure 3, is more difficult than in the case of CS, but the loss of water from the classical systemis as rapid. Restoring the water reserve during 2015, 2016 had to suffer due to short heavy rain when leaks from slopes were bigger than the infiltrations.

The results obtained show the insignificant influence of the factor tillage system in the forming of the wheat crop (figure 4), the difference between the two systems CS and NT is only 34 kg/ha. In exchange, one can notice the significantly positive influence of the technology with two fertilizations ($N_{60}P_{40}$ + N_{40}) in the achievement of wheat grain production (Figure 5).

Expressing the production potentialof Andrada winter wheat typeis mostly influenced by the year factor (Figura 6). We can notice the strongly significant negative influence of 2015 by the production achieved, that is 6175 kg/ha. 2016 had a strong positive influence upon wheat production, it was 6519 kg/ha with a difference of 307 kg/ha compared to 2014 taken as a mark, when 6212 kg/ha were produced.

The fuel consumption is different at each crop technology and the economic efficiency differs according to the soil tillage system. The aim of applying NT, which replaces the classical system is to reduce the fuel consumption and of course, the costs for the achievement of the agricultural production.

By applying CS a higher number of passing with equipment on the soil surface is made especially for the preparation of the germinative bed, three technological works are necessary, after which there is still the straw baling after the harvest and their transport from the field. To these works are added others specific for the crop: sowing, crop maintenance and harvesting, which leads to a fuel consumtion of 110 liters/ha at a cost of 630 lei/ha.

The technology differences of the NT system reduce the soil degradation process caused by the compaction phenomen on at repeated passings with heavy machines on the soil surface, a fuel savings is made for the set up of a hectare of wheat crop of approximately 50%, being necessary a consumption of only 55 liters/ha at a cost of 315 lei/ha.

Due to the high costs of materials necessary for the crop set up (especially pesticides) and up to the harvest (including freeing the land by straw baling with the classical system) the economic efficiency results more from the fuel savings (Table 1) the total result on NT technology is a saving of 19.2%.

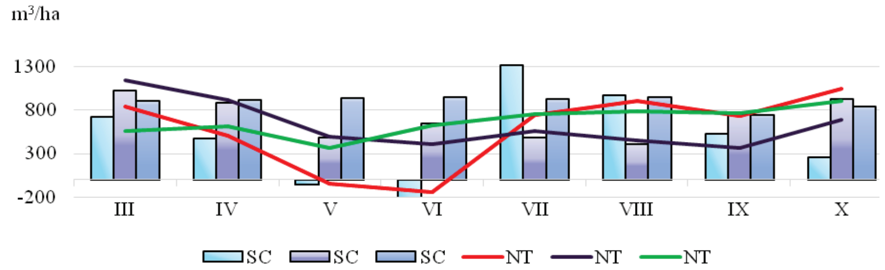
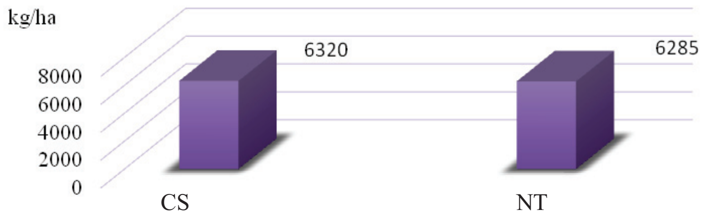


Figure 3. The influence of the tillage system in wheat cropon the soil water preserve (m^3/ha), 2014-2016

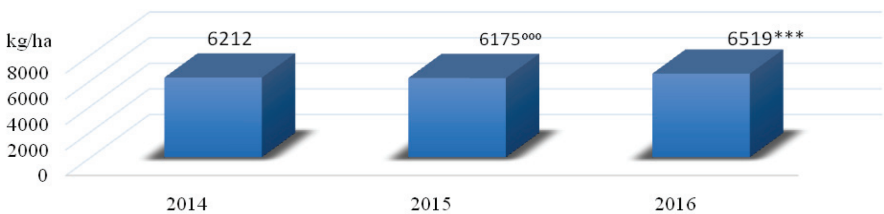


DL (5%) = 74; DL (1%) = 171; DL (0.1%) = 313

Figure 4. The influence of the soil tillage system on wheat production 2014-2016

DL (5%) = 30; DL (1%) = 69; DL (0.1%) = 220

Figure 5. The influence of the fertilization levelon wheat production 2014-2016



DL (5%) =16; DL (1%) = 23; DL (0.1%) = 34

Figure 6. The influence of the year on wheat production, 2014-2015

Table 1. Efficiency of crop technologies for the set up of 1 ha wheat

Consumption	CS	NT	Difference to NT ±
Fuel, l/ha	110	55	- 55
Price, lei/ha	630	315	- 315
Materials (wheat seed, pesticides, chemical fertilizers etc.)	1537	1437	- 100
Total, lei/ha	2167	1752	- 415

CONCLUSIONS

The higher values of the water preserve accessible in the soil were determined in the CS system, but at the same time here there is a faster loss compared to the NT system, where the water accumulation in the soil is made more difficult, but it is lost slower.

The soil tillage system doesn't have a significant influence on the wheat production, the difference between the two systems is only 34 kg/ha.

The additional wheat fertilization (with N_{40}) brings a production increase of 111 kg grains/ha.

The agricultural year through the climate conditions (temperature and rainfall) influences significantly the wheat production, the production increase made reaches up to 307 kg/ha during the rainy year 2016, compared to 2014, taken as a mark.

By applying the conservative no-tillage system a saving per hectare of 19.2% is made.

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REFERENCES

Calegari A., Alexander I., 1998. The effects of tillage and cover crops on some chemical properties of an oxisol and summer crop yields in southwestern Parana, Brazil. Advences in GeoEcology, 31: 1239-1246.

Chetan F., Chetan C., Rusu T., Simon A., 2015. Effects of the winter wheat cultivation in tillage system without plowing on the soil properties, ARDS Turda, 2005-2014. ProEnvironment, 8(22): 119-125.

Chetan F., Rusu T., Chetan C., Moraru P. I., 2016. Influence of soil tillage upon weeds, production and economical efficiency of corn crop. AgroLife Scientific Journal, 5(1): 36-43.

Cociu A., Cizmas G. D., 2013. Effects of stabilization period of conservation agriculture practices on winter wheat, maize and soybean crops, in rotation. Romanian Agricultural Research, 30, 171–181.

Dinca L., Sandoiu D. I., Stefanic G., Ciontu C., 2013. Modification of some chemical and physiological characteristics of reddish preluvosol, produced by the system of soil basic tillage and fertilization. RomanianAgricultural Research, 30, 2067-5720.

Domuta C., Sandor M., Ciobanu Gh., Samuel A., Ciobanu C., Domuta A., Borza C., Domuta Cr., Brejea C., Gatea M., 2012. Influence of the crop system on soil erosion and on the soil physical properties under the Romanian north-western area conditions. Journal of Environmental Protection and Ecology, 13 (2): 736–745.

Gheres M., 2007. Consideration on the impact of agricultural technologieson soil compaction. In soil compaction - processesand consequences, Ed. Risoprint Cluj-Napoca, 149-157.

Gus P., Rusu T., Bogdan I., 2003. Conventional and unconventionalsoil tillage systems. Ed. Risoprint Cluj-Napoca, 204.

Jitareanu G., Ailincai C., Bucur D., 2006. Influence of tillage systems on soil physical and chemical characteristics and yield in soybean and maize grown in the Moldavian Plain (North - Eastern Romania). In Soil Management for Sustainability, 370-379.

Lazureanu A., Manea D., Carciu Gh., 1997. Influence ofsoil tillage and chemical fertilizationupon the production of grain maize cultivated at theDidactic Station Timişoara. Alternatives in Soil Tillage, 1: 23-30.

Marin D.I., Rusu T., Mihalache M., Ilie L., Nistor E., Bolohan C., 2015. Influence of soil tillage system upon the yield and energy balance of corn and wheat crops. Agrolife Scientific Journal, 4(2): 43-47.

Moraru P.I., Rusu T., 2010. Soil tillage conservation and its effect on soil organic matter, water management and carbon sequestration. Journal of Food, Agriculture & Environment, vol. 8 (3-4), 309-312.

Rusu T., Gus P., 2007. Soil compaction - processesand consequences. Ed. Risoprint Cluj-Napoca, 276.

Rusu T., Albert I., Bodis A., 2007. Ecotechniqueof field crops. Ed. Risoprint Cluj-Napoca, 191.

Rusu T., Gus P., Bogdan I., Moraru P. I., Pop A. I., Clapa D., Marin D.I., Oroian I., PopL. I., 2009. Implications of minimum tillage systems on sustainability of agricultural production and soil conservation. Journal of Food, Agriculture & Environment, 7(2): 335-338.

Rusu T., Moraru P.I., Coste C., Cacovean H., Chetan F., Chetan C., 2014. Impact of climate change on climatic indicators in Transylvanian Plain, Romania. Journal of Food, Agriculture & Environment, 12(1): 469-473.

Rusu T., Bogdan I., Marin D.I., Moraru P.I., Pop A.I., Duda B.M., 2015. Effect of conservation agriculture on yield and protecting environmental resources. Agrolife Scientific Journal, 4(1): 141-145.

Stefanic G., Irimescu M., Spanu I., 1997. Influence of mellowing mode and soil basic works on the soil vital state. Alternatives in Soil Tillage, 1: 123-130.

Szajdak L.W., Rusu T., 2016. Free sulfuric amino acids and rhodanese in soils under rye cropping and crop rotation. [In:] Bioactive Compounds in Agricultural Soils. Ed. Szajdak L.W. Springer International Publishing Switzerland, 91-122. DOI: 10.1007/978-3-319-43107-9_4.

Ulrich S., Hofmann B., Tischer S., Christen O., 2006. Influence of tillage on soil quality in a long term trial in Germany. Soil Management for Sustainability, 110-116.

Wozniak A., Makarski B., Stepniowska A., 2014. Effect of tillage system and previous crop on grain yield,

grain quality and weed infestation of durum wheat. Romanian Agricultural Research, 31: 1-9.
MESP, 1987. Pedologic Studies Elaboration Metodology. Pedologic and Agrochemical Ins. Bucharest. Vol. 1-3.
PoliFact, 2015. ANOVA and Duncan's test pc program for variant analyses made for completely randomized polifactorial experiences. USAMV Cluj-Napoca.
SRTS, 2012. Romanian System of Soil Taxonomy. Ed. Estfalia, Bucharest.

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INFLUENCE OF DIFFERENT TILLAGE SYSTEMS ON THE BEHAVIOR OF A CORN HYBRID CULTIVATED IN THE AREA GĂLĂȚUI-CĂLĂRAȘI

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Abstract

This paper present the results obtained for the corn crop grown in 2016 under the pedological and climatic conditions of South Romania, Călărași County. The research aimed to analyze the influence of different soil tillage systems on the development and yield of a hybrid corn belonging to the FAO group 350. The variants studied were part of the conventional tillage system (20 cm plowing, 30 cm plowing) and minimum tillage system (30 cm scarification, 40 cm scarification, 20 cm Tiger 3 MT, 30 cm Tiger 3 MT). Under the influence of different soil tillage systems, the highest grain yield (8,065.3 kg/ha) was obtained at 30 cm plowing, with plants characterized by a height of 220.5 cm, and a LAI of 2.50. The lowest grain yield was generated by the tillage 20 cm Tiger 3 MT and had a value of 4775.7 kg/ha.

Key words*: conventional tillage, minimum tillage, corn yield, LAI.*

INTRODUCTION

Corn is one of the most important cereal crops, and due to its many uses and to the possibility of being cultivated in different climatic conditions is ranked second in the world, by area cultivated (184.8 million ha), after wheat (Roman et al., 2011; FAO, 2014).
Plants' development, corn's yields and weeds' level of development are directly influenced by tillage (Cociu., 2011; Rusu et al., 2013; Aikins et al., 2012 cited by Ion et al., 2015; Chețan et al., 2016).
The need to reduce input costs, along with the necessity to preserve soil water and other soil resources, determined the extension of research regarding the use of minimum tillage systems in corn's production technology (Hatfield, 1994; Gus et al., 2003; Li and Mu, 2006 Jităreanu et al., 2006; Marin et al., 2011; Gao et al., 2012; Moraru and Rusu, 2013).
Nevertheless, although the use of minimum tillage system ensures a lower consumption of energy, the yield generated can be smaller than the corn yield generated when using a conventional tillage system (Rusu et al., 2009; Gus et al., 2011; Marin et al., 2011; Rusu., 2014; Marin et al., 2015).
Thus, field experiences conducted in Romania, by Rusu et al., (2009) showed that the corn yield generated by the minimum tillage system represented 92.1% to 97.9% of the yield generated by the conventional tillage system.

MATERIALS AND METHODS

The research was conducted in 2016, in Călărași county, village Gălățui (N - 44 15'56 "E - 27° 6'55") at an altitude of 12 m above sea level.
The area is part of Mostiştea Plain, a subdivision of the Romanian Plain. In terms of climate, the area is characterized by a multi-annual thermal regime with values around 11°C and an average annual hydric regime of 500 mm.
The experimental surface was organized by a block design with three replications, using the following experimental variants:
Conventional tillage system:
- V_1 - 20 cm plowing
- V_2 - 30 cm plowing

Minimum tillage system:
- V_3 - 30 cm scarification
- V_4 - 40 cm scarification
- V_5 - 20 cm Tiger 3 MT
- V_6 - 30 cm Tiger 3 MT

An early corn hybrid (FAO 350 - DKC 4590) was used as a biological material, and the previous crop was winter wheat.
Fertilization was made using a complex of macro-elements (NPK) in a dose of 50 kg a.s./ha of each element, applied before sowing.
The sowing was carried out on 9th of April with SPC8 sowing-machine, at a distance of 70 cm between rows, providing a density of 60,000 plants harvested per hectare. Crops maintenance consisted in a pre-emergent application of herbicides (immediately after sowing) using the commercial product ADENGO in a dose of 0.40 l/ha, and a post-emergent use of the commercial herbicide ELUMIS, in a dose of 1.5 l per ha, carried out during the 7-8 leaf stage (61 days after sowing).

RESULTS AND DISCUSSIONS

Soil tillage influence on corn height (cm), Gălățui, 2016

Plants height under the influence of different tillage systems was evaluate when corn plants had the most intense growth. This was determined as shown in Table 1, at 57 days after sowing (June 4th), 61 days after sowing (June 18th) and 85 days after sowing (July 2), when 96% of plants' height was reached.
At 57 days after sowing (Figure 1 - left) the average plant high of the studied tillage systems was 42.5 cm and differences between tillage types were already visible.
Thus, plants height ranged from 37.2 cm (- 12.8% compared to control - 20 cm plowing) obtained at 20 cm Tiger 3 MT to 48.1 cm (+ 6.4% compared to control) recorded at 30 cm plowing.

Table 1. Corn plants' height development in 2016

Variants	Date					
	June 4th (cm)	%	June 18th (cm)	%	July 2 (cm)	%
20 cm plowing *(Ct)*	**45.2**	**100**	**84.5**	**100**	**213.2**	**100**
30 cm plowing	48.1	106.4	109.5	129.6	220.5	103.3
30 cm scarification	39.6	87.6	75.0	88.8	188.3	88.3
40 cm scarification	42.5	94.0	79.5	94.1	210.4	98.7
20 cm Tiger 3 MT	37.2	82.3	62.5	74.0	176.8	82.9
30 cm Tiger 3 MT	39.4	87.2	66.5	78.7	182.6	85.6
Avg. variants	**42.0**	**92.9**	**79.6**	**94.2**	**198.6**	**93.1**

At 85 days after sowing (July 2, Figure 1 - right), plants average height was 198.6 cm, the highest plants being recorded for 30 cm plowing (220.5 cm), with 3.3% higher than the height of plants obtained for the control tillage (20 cm plowing). The smallest plant height, 176.8 cm, was obtained when using 20 cm Tiger 3 MT tillage, the height value being 17.1% lower than plants' height obtained for the control tillage (20 cm plowing).

Figure 1. Corn crop at Gălățui (Călărași):
Left - June 4th; Right - July 2; (original photo)

Soil tillage influence on corn leaf area index (LAI), Gălățui, 2016

In 2016, average LAI of corn cultivated at Gălățui (Călărași) under different tillage systems was 2.01 (Tabel 2).

Table 2. Soil tillage influence on corn leaf area index (LAI)

Variants	LAI	%	Diff.	Signf.
20 cm plowing *(Ct)*	**2.31**	**100**	**Ct**	**-**
30 cm plowing	2.50	108.2	0.19	***
30 cm scarification	1.79	77.5	- 0.52	Ooo
40 cm scarification	2.24	97.0	- 0.07	Ns
20 cm Tiger 3 MT	1.44	62.3	- 0.87	Ooo
30 cm Tiger 3 MT	1.80	77.9	- 0.51	Ooo
Avg. variants	2.01	87.2	- 0.30	Ooo
LSD 5% = 0.07; LSD 1% = 0.10; LSD 0.1% = 0.14				

The highest LAI value recorded was 2.50, obtained for 30 cm plowing, this value was 8.2% higher than the value generated by the control tillage (20 cm plowing), the difference being statistically assured.
The lowest LAI value was recorded at 20 cm Tiger 3 MT, 1.44 respectively, being 37.7% smaller than the value obtained in control. The LAI difference between 20 cm plowing (control) and 20 cm Tiger 3 MT was strongly negative.

Soil tillage influence on corn yield, Gălățui, 2016

The conventional tillage system (20 cm plowing, 30 cm plowing) assured, in the field conditions of Gălățui, an average corn yield of 7,753.5 kg/ha, while the minimum tillage system generated an average corn yield of 5,920.7 kg/ha (Table 3).

The corn yield in minimum tillage system was lower compared to the yield obtained in the conventional tillage system. Thus, the yield for the minimum tillage system accounted for 76.4% of the yield recorded in the conventional tillage system. The yield difference obtained as a result of applying minimum tillage, compared to conventional tillage (control), was – 1,832.7 kg/ha, which is very significant in statistical terms.

Table 3. Corn yield conventional tillage vs. minimum tillage, 2016

Variants	Kg/ha	%	Diff. kg	Signf.
Conventional tillage	**7,753.5**	**100**	**Ct**	**-**
Minimum tillage system	5,920.7	76.4	1,832.7	ooo
Average	6,837.1	88.2	-916.4	oo
LSD 5% = 357.2 kg/ha; LSD 1% = 655.5 kg/ha LSD 0.1% = 1450.5 kg/ha				

In the soil and climatic conditions of the research area, for the agricultural year 2015 - 2016, date in Table 4 highlights that the tillage system affects the grain yield of corn.

The best corn yield of 8,065.3 kg/ha was obtained for 30 cm plowing, with a distinctly significant yield increase of 8.4% compared to the yield obtained in control tillage (20 cm plowing), with a value of 7,4441.6 kg/ha. Increased production resulting from 30 cm plowing was statistically assured.

Table 4. Corn yield influenced by different tillage systems, 2016

Variants	Kg ha^{-1}	%	Diff.	Signf.
20 cm plowing *(Ct)*	**7,441.6**	**100**	**Ct**	**-**
30 cm plowing	8,065.3	108.4	623.7	**
30 cm scarification	5,863.5	78.8	-1,571.1	ooo
40 cm scarification	7,631.2	102.5	189.6	ns
20 cm Tiger 3 MT	4,775.7	64.2	-2,665.9	ooo
30 cm Tiger 3 MT	5,412.5	72.7	-2,029.1	ooo
Avg. variants	6,531.6	87.8	-910.0	ooo
LSD 5% = 250.0 kg/ha; LSD 1% = 345.6 kg/ha; LSD 0.1% = 477.7 kg/ha				

Regarding the minimum tillage system works, they recorded lower yields compared to conventional tillage (20 cm plowing), and differences were in most cases statistically assured. Thus, for the 20 cm scarification tillage the yield was with 1,571.1 kg/ha lower than the yield obtained for the control variant, the difference being highly significant in statistical terms.

Regarding the 30 cm scarification tillage, yields for this tillage type was slightly higher compared to Control (20 cm plowing), with a difference of +189.6 kg/ha, but the yield increase was not statistically assured. For the soil tillage using 20 cm Tiger 3 MT the yield obtained had a value of 4,775.7 kg/ha, with 2,665.9 kg smaller than the yield obtained for 20 cm plowing (control), the statistical difference being highly significant. The 30 cm Tiger 3 MT tillage generated a corn yield of 5,412.6 kg/ha, representing 72.7% of the yield obtained for 20 cm plowing (control). Thus, the yield obtained for this tillage system was - 2,029.1 kg/ha smaller than the yield obtained for Control (20 cm plowing), the difference between the two variants being statistically.

CONCLUSIONS

The influence of different tillage systems on the behavior of the corn hybrid researched in the soil and climatic conditions of Gălăţui area is reflected by differences in plants' development and in grain productions obtained depending on the applied soil tillage, as follows: plants' height recorded the best value (220.5 cm), for 30 cm plowing (conventional system), with 3.3% higher than the height obtained for the control tillage; Leaf area index ranged from 1.44 (minimum system - 20 cm Tiger 3 MT) to 2.50 (30 cm plowing - conventional system); corn yield recorded values between 4,775.7 kg/ha (-35.8% compared to 20 cm plowing-control), when applying soil tillage 20 cm Tiger 3 MT, and 8,065.3 kg/ha (+8.4% compared to 20 cm plowing- control) when applying 30 cm plowing.

REFERENCES

Aikins S.H.M., Afuakwa J.J., Owusu-Akuoko O., 2012. Effect of four different tillage practices on maize performance under rainfed conditions. Agric. and Biology Journal of North America, 3(1), p. 25-30.

Chetan F., Rusu T., Chetan C., Moraru P.I., 2016. Influence of soil tillage upon weeds, production and

economical efficiency of corn crop. Bucharest - AgroLife Scientific Journal, Vol. 5, No. 1, p. 36-43.
Cociu A., 2011. Soil properties, winter wheat yield, its components and economic efficiency when different tillage systems are applied. Romanian Agricultural Research, 28, p. 121-130.
Gao S., Tong X., Wu L., 2012. Environmental constraints and transformation of China's export structure. Journal of Food, Agriculture and Environment, 10 (1), p. 919-922.
Gus P., Bogdan I., Rusu T., 2003. Conventional and unconventional soil tillage systems. Ed. Risoprint, Cluj-Napoca.
Guş P., Teodor R., 2011. Unconventional soil tillage systems, agrotechnical and economical alternative for durable agriculture. In Soil Minimum Tillage Systems. 6-th International Symposium, Ed. Risoprint, ISSN 2247-7525, Cluj-Napoca, p. 11-23.
Hatfield J.L., Stewart B.A., 1994. Crop residue management. Adv. Soil Sci. Lewis Publ., Boca Raton, FL. HEARD.
Ion V., Băşa Gh.A., Dumbravă M., Epure L.I., Dincă N., Toader M., 2015. Grain yield and yield components at maize under different preceding crops and soil tillage conditions. Bucharest - AgroLife Scientific Journal, Vol. 4, No. 2, p. 27-32.
Jităreanu G., Ailincăi C., Bucur D., 2006. Influence of Tillage Systems on Soil Physical and Chemical Characteristic sand Yield in Soybean and Maize Grown in the Moldavian Plain (North-Eastern Romania). International Symposium, Soil Management for Sustainability, Advances in GeoEcology, Germany, Ed. Catena Verlag, 38, p. 370-379.
Li R., Mu X., 2006. Challenges and Conservation Measures: Water Resources of the North China Plain.
Marin D.I., Mihalache M., Ciontu C., Bolohan C., Ilie L., 2011. Influence of soil tillage of pea, wheat, and maize crop in the Moara Domnească-Ilfov area. 5th International Symposium - Soil Minimum Tillage System, Cluj-Napoca, Ed. Risoprint, p. 111-118.
Marin D.I., Rusu T., Mihalache M., Ilie L., Nistor E., Bolohan C., 2015. Influence of soil tillage upon production and energy efficiency in wheat and maize crops. Bucharest - AgroLife Scientific Journal, Vol. 4, No. 2, p. 43-47.
Moraru P.I., Rusu T., 2013. Effect of Different Tillage Systems on Soil Properties and Production on Wheat, Maize and Soybean Crop. World Academy of Science, Engineering and Technology International Journal of Biological, Biomolecular, Agricultural, Food and Biotechnological Engineering Vol. 7, No. 11, p. 1027-1030.
Roman Gh.V., Tabara V., Robu T., Pirsan P., Stefan M., Axinte M., Morar G., Cernea S., 2011. Fitotehnie-Cereale si leguminoase pentru boabe. Vol. I, Ed. Universitara, ISBN - 978-606-591-276-2.
Rusu T., Bogdan I., Moraru P.I., Pop A.I., Oroian I., Marin D.I., Ranta O., Stanila S., Gheres M., Duda M., Mogosan C., 2013. Influence of minimum tillage systems on the control of *Convolvulus arvensis* L. on wheat, maize and soybean. Journal of Food, Agriculture & Environment, 11(2), p. 563-566.
Rusu T., Guş P., Bogdan I., Moraru P.I., Pop A., Păcurar I., Clapa D., Marin D.I., Pop L.I., 2009. Effect of Minimum Tillage Systems on the Soil Conservation and Sustainability of Agricultural Production. Journal of Agricultural Machinery Science, 5 (3), p. 241-245.
Rusu T., 2014. Energy efficiency of conservative tiilage system in the hilly areas of Romania. Middle East Journal of Scientific Research 22(11) p. 1700-1706. Water for Irrigated Agriculture and the Environment, 38-42.
***FAO, http://www.fao.org/faostat/en/#data/QC.

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MODIFICATION OF CARBONATED CHERNOZEM AGROCHEMICAL INDICES UNDER INFLUENCE OF SYSTEMATIC APPLICATION OF MINERAL FERTILIZERS IN MOLDOVA

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Abstract

The paper presents the main agrochemical indexes changes: humus content, nitrate nitrogen reserves, mobile phosphorus and exchangeable potassium content in chernozem carbonated (calcareous) from south of Moldova in the period 1965 - 2015. Statistically processed data allowed to determine the dynamics of nitrogen indices with different norms: 0 - 60 - 90 - 120 - 180 kg/ha on various phosphorus funds: 1.0 - 1.5 - 2.5 - 3.5 mg/100 g of the soil. On the control variant was established that humus content decreased from 3.8% to 3.4%, nitric nitrogen reserves in soil layer of 1 m under winter wheat and maize were 67 - 102 kg/ha and decreased at the harvest to 42 - 84 kg/ha. Mobile phosphorus content decreased from 1.5 to 1.2 mg/100 g soil. Potassium exchangeable content remained at a high level of 27 - 32 mg/100 g soil. The systematic application of mineral fertilizers showed the following changes of agrochemical indices: the initial humus content was 3.8% and decreased to 3.3%, nitrate nitrogen reserves were 112 - 161 kg/ha in the spring and decreased insignificantly at harvest with 7 - 19 kg/ha. The mobile phosphorus content varied in dependence of applicable fertilizes norms. The exchange able potassium content slightly increased - on average by 2 mg/100 g soil.

Key words: *soil, fertilizers, field crops, nutritive regime, agrochemical indices.*

INTRODUCTION

In conditions of Moldova the main natural factors limiting harvests of the crop plants are humidity (atmospheric precipitation) and effective fertility of soils. Depending on the amount of annual rainfall and cultivation area in Moldova can be obtained 3.0 - 7.0 t/ha of winter wheat and 3.5 to 9.0 t/ha of maize grain.

From the account of soils natural fertility can be obtain 2.6 t/ha of winter wheat, 3.3 t/ha of maize grain. Potential harvest of precipitation achieved only 35 - 40%. An increase the crop with 25 - 35% can be obtain from account of mineral fertilizers effective application.

According to the last agrochemical soil mapping conducted in 1990 by State Agrochemical Service, about 41% of farmland in the country was characterized by a low humus content and only 20% was optimal level. Nitrification capacity of soils was low on the 80% of agricultural surface. The content of mobile phosphorus was low and very low on the 25%, moderate - 34% and optimal, high and very high level only on the 40% of the area. The potassium content was optimal, high and very high degree on the about 90% of surveyed agricultural land.

Currently, the soil effective fertility state is considerably worsened, because in the last 25 years the organic fertilizers practically were not applied and the application of the mineral fertilizers do not exceed 30 kg per ha, the share of leguminous crops that capturing the biological nitrogen from atmosphere decreased by 4 - 5 times. As a result the balance of humus and nutrients content is deeply negative in all agricultural soils. Harvests of the majority crops are small, although in some years with abundant precipitations during the summer, the productivity on the hectare rises from account of intensive mineralization of organic matter.

At present the average dose of NPK fertilizers applied in Moldovan agriculture is about 50 kg per ha, or 60 thousand tons of fertilizers per whole agricultural area.

For increasing the soil fertility and raising crop yields to European standard is required to apply annually about 230 - 300 thousand tons of mineral fertilizers in active substance, but not 60 thousand tons as at present.

MATERIALS AND METHODS

The research was conducted at the long term experience of Pedological Experimental Station from Grigorievca village, Căușeni district, founded in 1961 on the chernozem carbonated (calcareous) from the south of Moldova. Experience consists of four fields, each field consists of 16 variants in four repetitions. In the experience is grown winter wheat in crop rotation with the following crops: peas, winter wheat, grain maize, winter barley and sunflower. According to the general scheme of experience the mineral nitrogen nutrition have following levels: 0 - 60 - 90 - 120 - 180 kg/ha on the phosphorus fund (determinate after Macighin method): 1.0 - 1.5 - 2.5 - 3.5 mg per 100 g of soil (Andries, 2011).

It was carried out the systematization and generalization of data on nutrient dynamics in carbonated chernozem of long term experience with application of mineral fertilizers in the years 1986 - 2015. For this purpose were collected the soil samples from each experimental plot in 16 variants and 4 repetitions on 4 crop fields.

In the collected soil samples were determined the major agrochemical indices: humus content - Tiurin method, nitrate nitrogen content – Gradval - Leaju method, mobile phosphorus in ammonium carbonate extract - Macighin method, exchangeable potassium by flame photometry - Maslov method.

RESULTS AND DISCUSSIONS

Humus is the main index of soil fertility on that depends largely agrochemical, agro-physical and biological soil properties. Founder of genetic pedology V.V. Dokuceaev investigated soils of Moldova in 1881, established that Moldavian chernozems contained 4 - 7% of humus. After a century period the research conducted by I.A. Krupenikov at the same objects, revealed considerable decline in soil organic matter up to 2 - 4%. Research conducted by A.Ursu on the chernozem from Soroca district over 135 years after V.V. Dokuceaev have established a decrease in organic matter content about 2.36% (Ursu, 1988, 2003).

Losses of organic matter for 100 years constituted about 41% on average. Studies by V.Cerbari demonstrated that arable ordinary chernozem from commune Băneşti, district Teleneşti have the humus content of 4.46% or 30% less than in the fallow chernozem (Cerbari, 2000).

The systematic application of mineral fertilizers in field crop rotation helps to offset the loss of organic matter in soils with applying the high quantity (30-40% compared to control) of plant debris.

Following investigations it was established that within 50 years the humus content in the control variants was significantly decreased. On the carbonated chernozem losses were: 0.52% or 0.011% annually (Figure 1).

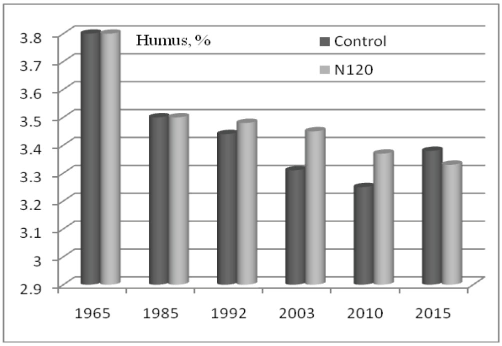

Figure 1. Dynamics of humus content in carbonated chernozem

Soil dehumification rhythm was different per periods. In the first 20 years the rhythm decline of dehumification was more intensive. The humus content in the carbonated chernozem was reduced from 3.8 to 3.4% (Table 1).

Table 1. Modification of organic matter content (%) in carbonated chernozem in the period 1965-2015

Soil	Variant	**1965**	**1985**	**1992**	**2003**	**2010**	**2015**
Cher-nozem carbo-nated	Control	3.80	3.50	3.44	3.31	3.25	3.38
	N_{120}	-	3.50	3.48	3.45	3.37	3.33

Since 1985 the humus losses were very small, but the pace of humification was stabilized at a insignificant quantity.

Nitrate nitrogen reserve was calculated on the field with winter wheat and maize. Reserve of nitrate nitrogen to control variant in the spring, under winter wheat was 67 kg/ha and at harvesting was reduced to 42 kg/ha.
Variants fertilized with nitrogen it is higher compared to control, because the preceding remaining reserves in soil. At harvest nitrate nitrogen reserves decrease, but remain high in the variants with high doses of 120 - 180 kg N/ha (Table 2).

Table 2. Modification of the nitrate nitrogen content in carbonated chernozem (kg/ha)

Soil	Variant	Spring		Harvesting	
		winter wheat	maize	winter wheat	maize
Cher-nozem carbonated	Control	67	102	42	84
	N_{60}	96	115	43	109
	N_{120}	102	138	81	138
	N_{180}	112	161	105	142

Nitrate nitrogen reserves on the witness variant under maize before sowing was 102 kg/ha in the carbonated chernozem, at the harvest its reserves insignificant decreased. Systematically fertilized variants with nitrogen before sowing, led to high content of nitrate nitrogen reserves in the 1 m of soil layer 112 - 161 kg/ha. At the maize harvesting faze the nitrogen reserves remain highly, especially on the variants with highly doses of nitrogen application.
From the obtained results, it appears that the systematic application of nitrogen fertilizers in the doses above 90 kg/ha on the carbonated chernozem in crop rotation led to the accumulation of nitrate nitrogen in the soil, that is gradually washed down in the profile, becoming a source of environment pollution.
Mobile phosphorus content is a basic characteristic of soil fertility. Chernozems of Moldova is characterized by a low content of mobile phosphorus.
During intensive agricultural chemicalization into the soil were incorporated 1143 kg/ha of phosphorus (P_2O_5) fertilizers. As a result at the end of 90s of last century, according to the last agrochemical mapping cycle the content of mobile phosphorus in soils of Moldova was increased by 2.0 times. The sharp reduction of fertilizer application after 1992 (up to 25-50 kg/ha), including phosphorus (up to 1-2 kg/ha) have led to reduced the amount of mobile phosphor in the soils (Ţîganoc, 2003). The reserve of mobile P_2O_5 was exhausted in the study years 2012 - 2014.
Therefore, the periodic determination of mobile phosphor content in the soils is a necessity for knowing the assurance level of plant in this nutrient. Changes of mobile phosphor content in soil over 50 years is shown in Table 3.

Table 3. Modification of the mobile phosphorus content in carbonated chernozem (mg/100g soil)

Soil	Variant	**1965**	**1985**	**1992**	**2010**	**2015**
Cher-nozem carbonated	Control	1.5	1.4	1.5	1.2	1.2
	Fertilized	3.3	2.9	2.0	3.2	2.3

From the obtained data it was evident that mobile phosphorus content decreased from 1.5 to 1.2 mg/100 g soil in the control variant (Figure 2).

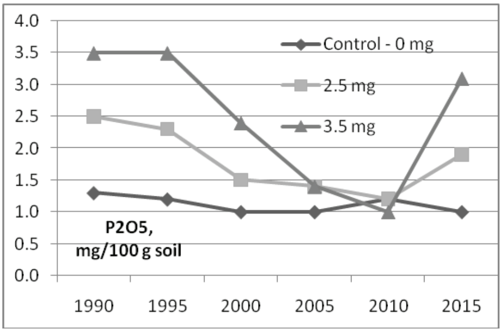

Figure 2. Dynamic of mobile phosphorus content in carbonated chernozem

Therefore, declining of phosphorus rhythms in the soils are not previously forecasted, but are much smaller. Rates of mobile phosphorus content decrease slowly at low concentrations. In support of this hypothesis the obtained harvests in the years 2013 and 2014 was very high to majority crops cultivated in the country, although the phosphorus fertilizers have not been applied in the soils from 90s.
Exchangeable potassium content in the soils is determined to optimize plant nutrition with this element by applying differentiated fertilizers. Moldovan soils are formed on the rocks with minerals rich in potassium, therefore its characterized by a relatively high content of exchangeable potassium. It has been established that potassium content in soils of Moldova depends largely on mineral and size composition.

Generally, the exchangeable potassium content in the soils of Moldova is 17 - 30 mg/100 g soil or 1.4 - 2.3% from the total content. The systematic application of fertilizers in the period 1965 - 1990 led to the formation of a positive balance of potassium in soils and increase its content by 1 - 2 mg K_2O/100 g soil (Burlacu, 2004).

For maintaining the exchangeable K_2O content at the optimal levels is recommended the application of organic and mineral fertilizers. Research has shown that over 50 years, the exchangeable potassium content at the witness variant of the investigated soil was changed slightly, although with crop harvest was exported from soil about 4.5 - 5.0 t/ha of potassium (Figure 3).

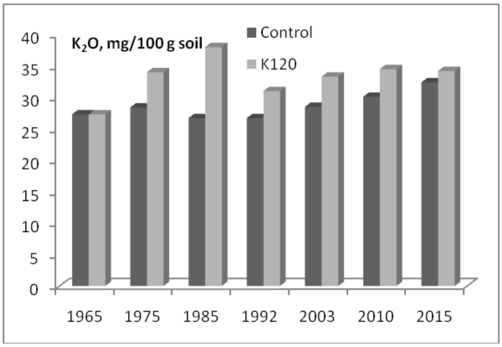

Figure 3. Dynamic content of exchangeable potassium in the carbonated chernozem

The exchangeable potassium content in carbonated chernozem is 27 - 32 mg/100 g soil. The obtained results demonstrate the high capacity of investigated calcareous chernozem in maintaining a dynamic equilibrium between different forms of potassium in the soil (Table 4).

Table 4. Modifying the content of exchangeable potassium in carbonated chernozem (mg/100 g soil)

Soil	Variant	**1965**	**1975**	**1985**	**2003**	**2010**	**2015**
Cerno-ziom carbo-nated	Control	27.3	28.4	26.7	28.5	30.1	32.4
	K_{120}	-	34.0	38.0	33.3	34.5	34.2

Systematic application of potassium fertilizers in crop rotation resulted in a slight increase of potassium in soil. During of 50 years the potassium content from fertilizers account was increased by 2 mg in chernozem carbonated. The same significant changes were recorded in soils of other experiences and in cycles of agrochemical mapping carried out in our country in 90 years.

CONCLUSIONS

The research was conducted during the years 1965 - 2015 and indicate the dynamic changes of nutritive regime parameters in chernozem carbonated as a result of systematic and lengthy application of mineral fertilizers in field crop rotation.

At the control variant was established that the humus content has decreased from 3.8% to 3.4%, nitric nitrogen reserves in 1 m of soil layer in the spring period at the winter wheat and maize were 67 - 102 kg/ha and at harvest period these indices decreased to 42 - 84 kg/ha. The content of mobile phosphor decreased from 1.5 to 1.2 mg/100 g soil, and the exchangeable potassium content remains at the same level 27 - 32 mg/100 g soil.

The systematic application of mineral fertilizers showed the following changes of agrochemical indices: humus content decreased to 3.3%, nitric nitrogen reserves under winter wheat and maize in the spring faze were 112 - 161 kg/ha. Phosphorus mobile content varied in dependence of fertilization norms and the exchangeable potassium content slightly increased on average by 2 mg/100 g soil.

REFERENCES

Andries S., 2011. Agrochimia elementelor nutritive. Eficacitate și ecologia solurilor. Pontos, Chișinău, 223.

Burlacu I., 2004. Deservirea agrochimică a agriculturii în Republica Moldova. Pontos Chișinău, 195.

Cerbari V., 2000. Sistemul informațional privind calitatea învelișului de sol al Republicii Moldova (banca de date). Pontos, Chișinău, 83-375.

Ursu A., 2003. Cernoziomul de la Soroca – 135 ani după Dokuceaev. Buletinul Academiei de Științe a Republicii Moldova, 2(291): 120-123.

Țîganoc V., 2003. Transformarea rezervelor de fosfor mobil în solurile Republicii Moldova. In: Lucrările conferinței internaționale științifico-practice. Solul - una din problemele principale ale secolului XXI. Pontos, Chișinău, 283-294.

Ursu A., 1988. Solurile Moldovei. Vol.3, Chișinău, Ştiinţa, 336.

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CURRENT STATE OF HUMUS IN ARABLE CHERNOZEMS OF MOLDOVA

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Abstract

The paper aimed to present current state of humus in arable typical chernozems from the Republic of Moldova. They occupy a significant area in the country's land fund, about 70%. The research was conducted in the North of Moldova. Typical chernozems in natural state are the most fertile soils from our country. They have a very deep humus profile. Soils in natural state are very rich in humus that decreases gradually with depth, in our case from 6.86% in upper horizon to 0.12% in Ck horizon. Humus reserves of typical fallow chernozem are 472 t/ha in humiferous profile.
Long-term involvement in agriculture, furthermore, insignificant and insufficient fertilization with organic fertilizers since '90 years, led to their degradation and negative humus balance. According to our research, these soils lost about 2.12% of humus from 0-25 cm layer that represents 34 percent from its initial amount. Humus reserves of arable typical chernozem decreased by 52 t/ha in comparison with fallow soil.
Analysis of humus composition of researched soils revealed that fallow and arable typical chernozems possess humus of humate type that is characteristic for this soil type. Therefore, agricultural use did not change the humus type of soils.

Key words*: humus, humic acid, fulvic acid, soil quality, typical chernozem.*

INTRODUCTION

The main natural resource of the Republic of Moldova is soil cover. In its composition, chernozems are predominant soils (70%). Inefficient use of these resources has led to degradation of physical, physico-chemical and biological properties of soils used in agriculture.
In the last 20 years, the amount of organic fertilizers introduced into the soils reduced dramatically. As a result, humus balance in arable soils became negative. Humus reserves reduces annually by 1 tonne per hectare (Ursu, 2015).
At the same time, humus plays an essential role for soil fertility, soil water and air regimes, soil properties such as structure, bulk density, porosity; it is the main source of nutritive elements for plants growing etc.
In this context, the paper presents a study of humus state of typical chernozems in the Northern part of the Republic of Moldova in order to reveal actual problems and find possibilities of its remediation.
Typical chernozems occupy 282,000 ha or 8.34% of the territory of the country. The characteristic areal of the soils is northern part of Moldova (forest-steppe region) with altitudes about 180 - 200 m, but also they are found in the central part of Moldova with altitudes 160 - 220 m (Ursu, 2011).

MATERIALS AND METHODS

The research was conducted in the Northern part of the Republic of Moldova – the region characteristic for typical chernozems, with moderately warm, semi humid climate, number of sunny days per year – 290 - 300, average annual temperature – 8 - 8.5°C, average annual precipitation – 550 - 600 mm, evaporability – 700 - 800 mm, growing season – 167 - 176 days.
The object of study was arable loamy-clayey typical chernozem used in agriculture for a long time (Figure 1). Coordinates of the main soil profile: latitude - 47°51.288'; longitude - 27°073', absolute altitude - about 212 m.
Arable soil was compared with a fallow chernozem never used in agriculture, situated on a slope about 5 - 10 (Figure 2). Coordinates of the main soil profile: latitude - 47°51.313'; longitude - 27°45.266', absolute altitude – 176 m.

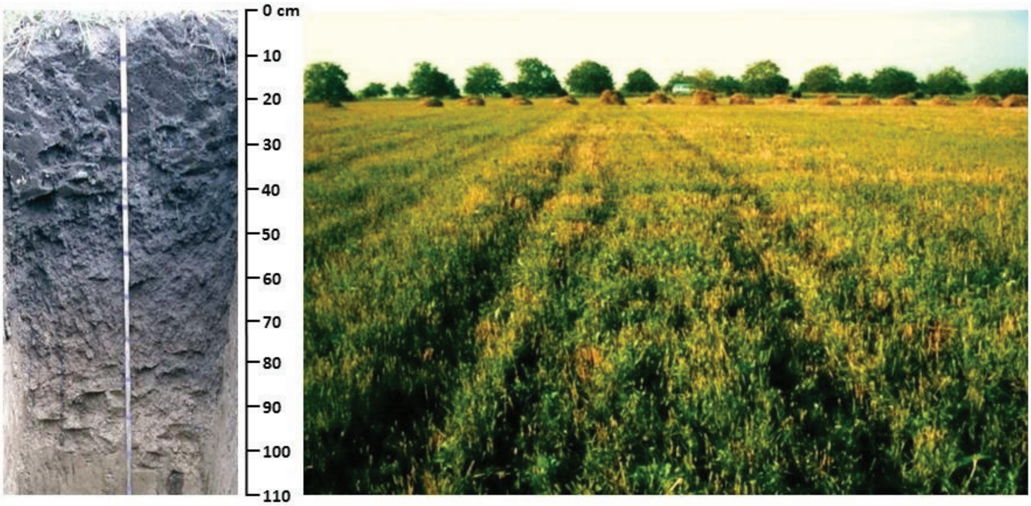

Figure 1. Soil profile of arable loamy-clayey typical chernozem and its agroecosystem

Figure 2. Soil profile of fallow loamy-clayey typical chernozem and its natural ecosystem (steppe)

In the field, for each studied variant, were set up five profiles in the form of a square with sides of 50 m with a main profile in the center and four secondary profiles at the peaks of the square.

Laboratory tests were performed according to the standard methods approved in the Republic of Moldova: particle size analysis by Kacinski method; organic matter content by Tiurin method; humus reserves by calculus; soil bulk density by core method. Humus composition was determined in two characteristic profiles of arable and fallow chernozems by Kononova and Belicikova method.

RESULTS AND DISCUSSIONS

Natural conditions in the North of Moldova contributed to formation of very rich, fertile soils in this area – typical chernozems.

Typical chernozems in natural state are characterized by a high humus content and a thick humus-rich profile.

Arable typical chernozem studied in the research was formed on loamy-clayey loess deposits and inherited their loamy-clayey texture from mother rock (Figure 3).

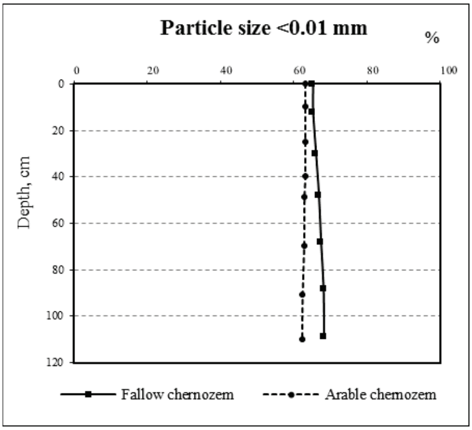

Figure 3. Soil texture of arable and fallow chernozems

Fallow typical chernozem also formed on loamy-clayey loess deposits up to 80 - 90 cm, situated deeper on compacted marine clay. That specific feature influenced thickness of soil profile in negative way, as a result it is by 3 - 4 cm thinner than at arable soil and makes in average 88 cm.

Arable typical chernozem is characterized by a very deep humus profile, with an average thickness of 91 cm (Figure 4).

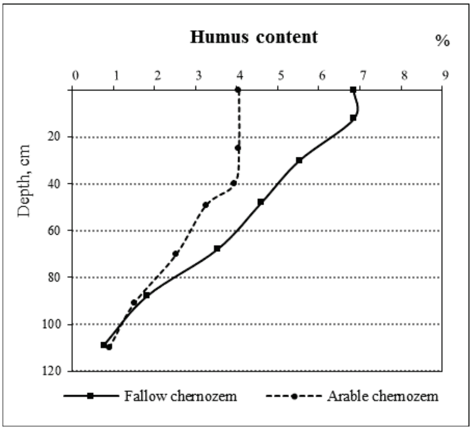

Figure 4. Humus content in arable and fallow chernozems

Variation curve of humus content corresponds to the soil type (Figure 4). Humus decrease in soil profile is gradual: in arable chernozem from 4.05 ± 0.13% in Ahp1 layer to 0.46% in Ck horizon; in fallow chernozem from 6.86±0.57% in Aht1 horizon to 0.12% in Ck horizon.

Because of use in agriculture, arable typical chernozem lost 2.12% of humus from 0 - 25 cm layer or 1.60% from 0 - 50 cm layer. Humus content in the 0-25 and 0 - 50 cm layers of arable soil, compared to the fallow soil, reduced respectively by 34 and 29 percent from initial amount.

According to the classes of humus content used in the Republic of Moldova (Andries, 2007), humus content in the layers 0 - 25 cm and 25 - 50 cm of arable chernozem is moderate. Fallow chernozem is characterized by high humus content in upper horizons.

Humus reserves in soil humiferous profile (soil horizons with humus content higher than 1%) of fallow chernozem are 472 t/ha. It should be remarked that 67% of humus reserves are concentrated in the first 50 cm of typical chernozems. Long-term use of arable chernozem in crop rotations with a high proportion of row crops and the lack of organic fertilizers conducted to decrease of humus reserves in soil humiferous profile. Now humus reserves of arable chernozem are 375 t/ha, that is 52 t/ha lesser in comparison with the fallow soil. It is not possible to determine exactly the period of time when arable chernozem from our research lost that amount of humus. But it is known that since 1990 the amount of organic fertilizers introduced into the soils of our country decreased dramatically and since 1993 humus balance in soils is negative (Cerbari, Taranu, 2015).

Analysis of humus composition of researched soils (Table 1) reveals that fallow and arable typical chernozems possess humus of humate type (the humic acid/fulvic acid ratio > 1), that is characteristic for this soil type.

Therefore agricultural use did not change the humus type of soils.

The obtained data are similar with results obtained by Evdokimova's and Tişchina, 1999 and Cernova et al., 2003.

Comparatively small value of ratio HAs: FAs in Aht1 horizon (0-10 cm) of fallow typical chernozem can be explained by the presence in this layer of a large amount of organic matter half humificated with a higher content of fulvic acids.

Table 1. Humus composition of fallow and arable typical chernozems

Genetic horizon and depth, cm	Total C, %	Humic subs-tances	Humic acids (HAs)	Fulvic acids (FAs)	Humin	HAs:FAs
		C, % / % from total carbon				
Arable loamy-clayey typical chernozem						
Ap1 (0-21 cm)	2.30	1.11 / 48.3	0.73 / 31.8	0.38 / 16.5	1.25 / 51.7	1.9
Ah (40-49 cm)	1.80	0.82 / 45.6	0.51 / 28.3	0.31 / 17.3	0.98 / 54.4	1.7
Bh1 (49-70 cm)	1.50	0.63 / 42.0	0.39 / 26.0	0.23 / 16.0	0.87 / 58.0	1.7
Fallow loamy-clayey typical chernozem						
Aht1 (0-10 cm)	3.58	1.71 / 47.8	1.02 / 28.5	0.69 / 19.3	1.87 / 52.2	1.5
Aht1 (10-30 cm)	3.14	1.40 / 44.6	0.88 / 28.0	0.52 / 16.6	1.74 / 55.4	1.7
Ah (30-50 cm)	2.48	1.09 / 44.0	0.67 / 27.0	0.42 / 17.0	1.38 / 56.0	1.6
Bh1 (50-70 cm)	2.06	0.93 / 44.2	0.57 / 27.7	0.36 / 16.5	1.13 / 55.8	1.6

CONCLUSIONS

Typical chernozems of the Republic of Moldova have a very deep humus profile. Soils in natural state are very rich in humus that decreases gradually with depth, in our case from 6.86% in upper horizon to 0.12% in Ck horizon. Humus reserves of typical fallow chernozem are 472 t/ha.

Long-term involvement of soils in agriculture in combination with lack of organic fertilizers conducted to decrease of humus content in arable soils. Arable typical chernozem lost 2.12% of humus from 0 - 25 cm layer, that represents 34 percent from its initial amount. Humus reserves of arable typical chernozem decreased by 52 t/ha in comparison with fallow soil.

Humus composition was not affected by use in agriculture and significant changes were not registered.

REFERENCES

Andries et. al., 2007. Instructiuni metodice privind cartarea agrochimica a solurilor. Chisinau, Pontos, p. 36.

Cerbari V., Marius T., 2015. Agricultura verde – sansa de salvare a cernoziomurilor Moldovei de degradare. Agricultura Moldovei. nr. 9-10, 2015, p. 13-19.

Cernova O.V., Râjova I.M., Viunenko A.V., 2003. Sravnitelinaea haracteristica gumusnogo sostoeaniea telinnyh I pahotnyh cernoziomov privoljskoi stepi. Sbornik dokladov naucino-practiceskoi konferentsii, Kursk, p. 199-203.

Evdokimova T.I., Tişchina A.V., 1999. Izmeneniea svoistv cernozioma tipicinogo pod vlieaniem seliskohozeaisvennogo ispolizovaniea. Pocivovedenie (5), p. 652-660.

Ursu A., 2011. Solurile Moldovei. Chisinau, Stiinta, p. 324.

Ursu A., 2015. Solurile Moldovei: probleme actuale de folosire si protejare. Buletinul stiintific al Muzeului National de Etnografie si Istorie Naturala a Moldovei. Vol. 2 (15), p. 12-16.

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ERODABILITY OF SOILS IN THE RECEPTION BASIN "NEGREA"

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Abstract

This article is the result of research on soils in Negrea village of Hancesti District concerning the erodability of the terrain. The purpose of this article it is researched territory division of the estate blacks in 6 classes with varying degrees of erodability (presented in accordance N. Florea etc. - very low, low, moderate, strong, very strong, excessive) and the elaboration a map on soils erodability. A first step in harnessing the data (because, for the first time in the Republic of Moldova was determined erodability of soils) was the primary analysis of data obtained in the field, as well as statistical methods. Erodability values of soils in reception basin "Negrea" were calculated based on their characteristics parameters which influence erosion, according to the formula proposed by P. Stanescu (Stanga, 2005) - erodability of soils was estimated based on analytical data humus content, clay content and bulk density of investigated soils. It has been demonstrated that the high risk of erosion is induced medium textures - in the horizon from the surface with a fine texture in the substrate fact that no longer allows infiltration of rain water in depth and, consequently, the more rapidly organization surface runoff that practices the soil particles.

The results of calculation of erodability of the soils in the village Negrea are presented in tables 1and 2. Generally, most reception basin soils because of silty clay loam texture, sandy and low humus content the erodability is characterized by large and are vulnerable to erosion processes. The knowledge of erodability degree is necessary for agricultural activity of farmers.

Key words: *erodability, reception basin, intensity of erosion processes, value of erodability, Negrea village.*

INTRODUCTION

Republic of Moldova is the region where natural conditions (climate, topography, rainfall and other factors) give rise to inevitable erosion and soil cover status and physical indicators and morphometric characteristic determines the intensity of this destructive process. Status of soil quality, effective fertility level, depends largely on crop productivity, development of the zootechnical sector, the ecological and welfare of the population of the republic.

Erodability of soil is a „measure of the ease with which soil can be eroded by the action of water runoff, expressed by the amount of material removed from the soil under standard conditions climate, slope, land use etc." (Cojocaru, 2015; Lupascu et al., 1998).

In other words, *erodability may be considered of vulnerable to soil erosion*, vulnerability given its intrinsic properties and relationships as it is with other factors erosion. Production erosion is modulated by a number of factors, whose share in erosion risk estimation is different depending on the intensity with which manifests itself in a particular field unit.

Erodability is an accumulation of erosion processes in the analyzed area (washing the surface, ravines, torrential, landslides, mudflows, collapses of shores) and classes of erodability shows the potential intensity (from lowest to highest) of erosion.

Theoretically, the entire territory that was analyzed is erodible, differing only the intensity of this potentialities, from the sloping horizontal surfaces, from the lowest to the highest degree of erodability varying from one area to another depending on several determinant factors. For example, small slopes give the land a small degree of erodability.

Lands covered with pastures are more erodible than those covered with vines or forest. Fragmented lands will also be more prone to erosion than unfragmented land and so on.

The purpose of this article it is researched territory division of the estate Negrea in 6 classes with varying degrees of erodability (very low, low, moderate, strong, very strong;

excessive). In the finally will be exposed erodability map of soils (Cojocaru, 2015).

Negrea village residents must know predisposition to land erosion and properly plan and organize administrative actions (where are necessary land stabilization works and where no etc.).

Also, knowing the degree of erodability could be necessary for agricultural activities. Finally, the present study may be consulted by the Municipality, companies or individuals in order to organize their activities.

Currently major attention is paid to improving techniques and tillage systems in reducing energy consumption, reducing human impact on soil stabilization, optimizing its physical and humic substances, preventing the erosion process.

Researches previously conducted both at home and abroad were focused on the link between the intensity of occurrence of erosion processes, physical-geographical natural conditions, the factors - relief, climate, soil cover at the level of subtype and vegetation (crop residues, coverage degree of the soil surface by plants).

Soil degradation processes, including by erosion, are conditioned both by natural conditions and human activity as well.

Among the natural factors that influence degradation of soils is mentioned next: climatic conditions; the geomorphological construction (relief); texture and parent rock composition (Cojocaru, 2015).

Hincesti district is located in the center of Moldova on an area of 1483.4 km^2.

It borders the Ialoveni, Cimislia, Leova, Nisporeni and the neighboring country of Romania.

Also Negrea village is located in Central Moldova in the middle part of the reception basin (hydrographic) of the river Lapusnita (Krupenikov et al., 2001).

Approximate distance from the Negrea village to the main cities is as follows: Hancesti - 23 km, Chisinau - 60 km. The altitudinal deployment and variation of natural and anthropogenic conditions (slope, land use, human impact etc.) require differences in the degree of erodability of the land.

We can say that economic development is based on sustainable principles advantageous in regarding the all-natural components: air, water, soil, forests and subsoil resources.

MATERIALS AND METHODS

One of the peculiarities of surface erosion is that it has a large expansion in space and simultaneously carries on extensive areas of land. Another feature is that the phenomenon becomes sensitive only after a long period of time when the process with all the cortege of concentration, has already occurred. Gradually, fertile and humus-rich horizons are washed as the process continues. Remove the parent material surface rock infertile or parent if the process continues its unfettered development.

Soil erosion in its many forms and features is the consequence of the direct precipitation impact on the soil. Therefore, referring to two factors - rainfall and soil - it requires analysis and their knowledge in terms of their interdependence - cause - effect. From ordinary observations known to be, rains that fall in a given area cause or do not, erosions. Between rains which determines nevertheless, the triggering erosion phenomenon are the rainfall which generates great loss of soil and other, losses is much less, although the conditions of the soil are the same (Cojocaru, 2015).

According to prof. Motoc M. (1963) is the first, which groups soils from Romania according to their resistance to erosion in classes and categories (Table 1). And classes described in groups depending on soils on how in which erosion process changes depending on the genetic horizons, while resistance categories represents the degree of resistance which the soil is opposed of erosion (assessment is done within the class).

Motoc M. et al., distribute the properties of soil which determines the erosion process into two categories (Motoc et al., 1975, 1976, 2000): properties that influence the rate of infiltration by changing the ratio leakage/infiltrations, and therefore the intensity of the erosion process (1); properties that directly determine soil resistance to the action of dislocation and transport exercised by rain and leaking liquid (2). Erodability of the soil thus becomes the product of the two categories of properties results.

Erodability values of soils in the reception basin „Negrea” were calculated on the basis of their characteristics parameters which influence erosion, according to the formula proposed by P. Stanescu (quoted by Stanga, page 187), using humus content, clay content and their apparent density (Stanga, 2005).

$$S = \frac{(100-A)}{(A+n*h)*D}, \qquad (1.1)$$

where: S - erodability index;
A - clay content (%);
h - humus content (%);
D - bulk density (g/cm^3);
n=15 for A=12-32%; n=10 for A=33-45%.

The formula proposed by P. Stanescu is simple and has been successfully used in the calculation of values of soils erodability (Cojocaru, 2015; Stanga, 2005).
The appreciation belonging of soils to different classes of erodability was performed according to the classification presented in Table 1.

Table 1. The classes of erodability of soils according to Florea N. and others (Florea et al., 1987)

Name	Limits
is not the case	0
very small	< 0.6
small	0.6-0.7
moderate	0.7-0.8
strong	0.8-0.9
very strong	0.9-1.0
extremely strong	> 1.0

RESULTS AND DISCUSSIONS

In the slope arable lands of the reception basin from the village Negrea are affected by caused erosion, in general of concentrated leaking under the influence of torrential rains. Farmers, a long time irrational methods used for the cultivation of sloping land, which not only contributed to the outbreak of soil erosion as well as decrease soil fertility.
Anthropogenic factors main to degradation of soil cover are training the maximum territory in the plowing, cutting strips of forest, agricultural work along the slope, placing incorrect road network, insufficient protection of soils with vegetating share exaggerated crop hoes in the crop rotations, soil compaction by heavy mechanisms, failure to comply with agrotechnical for erosion control.
Agricultural activities, without taking into account the peculiarities of soil, relief, lead to continued decline in soil fertility and their degradation. The intensity of agricultural activities in different periods for different usage differs point of view quality and quantity and is varied.
The Universal soil losses equation (USLE) soil erodability factor, K, represents possible losses of soil depending on their specific characteristics. So then the risk erosion for reception basin „Negrea” soils can be appreciated both by calculation using of soil values of specific indices developed in the mathematical formulas for determining erodability and by direct measurement of solid and liquid leaks from a certain area of land, imitating the artificial rainfall precipitation of a certain intensity (Cojocaru, 2015).
The results of the investigations of soil conditions in Romania (Ionita et al., 1985; Motoc et al., 1975, 1979, 2000; Stanga, 2005) under conditions analog of soil, climate and relief on the Tutovei hillsides and including the Falciu hills, was established that the erodability of soils correlates the very well with: content of sand; of dust; clay; organic matter, etc. So now, for the calculation of erodability is necessary determining by pedological researches of soils properties that influence this factor. For lands used for arable after grubbing of vines in the middle part of the territory of reception basin „Negrea” were investigated characteristics the following units of soils (ordinary chernozem) in the framework of delluvial - erosion slope located in the central part of the northwest exhibition of the slope: not eroded (located on the water pinnacle); poorly eroded; moderately eroded; highly eroded and typically delluvial (Cojocaru, 2015).
The purpose research carried out in the village Negrea it was in erodability of soils calculation based on the values for each soil profile characteristics studied and appreciation leakage control plots of the influence of the degree of erosion on the water and soil losses.
Depending on the humidity and essential properties of soil can be distinguish four main mechanisms that contribute to dislodge of soil particles, then facilitating their transport (Emerson, 1967; Florea et al., 1987): the explosion of the structural aggregates by

compression of existing air in the soil pores at the time of rapid moisture (1); mechanical disaggregation under the influence of raindrops (2); micro-breaking by differentiated inflating (3); physico-chemical dispersion (4).

Micro-terracing of slopes under multiannual plantations and other anti-erosion measures in the past the total use of the territory of reception basin under orchards and vineyards led to a decrease the washing processes of soil on the slopes (Krupenikov et al., 2001; Lupascu et al., 1998). The passage of arable lands without being undertaken measures to combat the erosion process increased soil losses.

The calculation results of erodability of investigated soils in the middle part of reception basin „Negrea" are presented in Table 2.

According to calculations, erodability of surface layers of not eroded ordinary chernozems, with varying degrees of erosion and typically delluvial is the following:

- *not eroded* - moderately to small (moderate humus content, satisfactory hydro-stability of the structure);
- *poorly eroded* - moderately (moderate to submoderat humus content, unsatisfactory hydro-stability of the structure);
- *moderately eroded* - moderately (submoderat humus content, unsatisfactory hydro - stability of the structure);
- *highly eroded* - big (small humus content, unsatisfactory hydro-stability of the structure);
- *typically delluvial* - big to very big (dusty-sandy, loam texture, small humus content, unsatisfactory hydro - stability of the structure).

In the village Negrea after grubbing of orchards and vineyards and arable land uses it is absolutely necessary to plan and implement complex measures for combating of soil erosion.

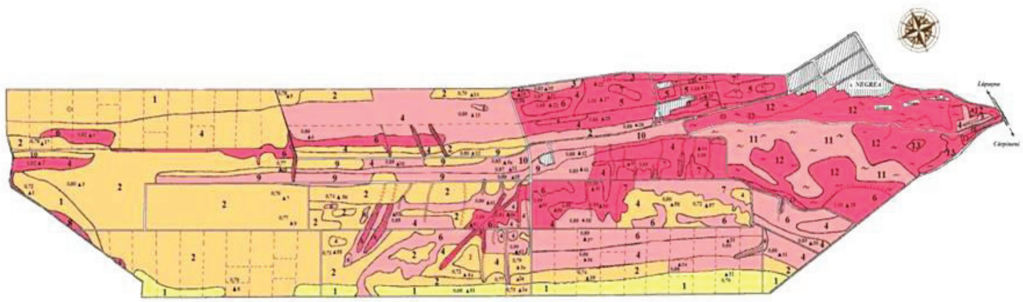
Overall, according to the received results, most soils in the reception basin because of clay-loam, dusty sandy texture, and low humus content are characterized by moderately and big erodability and finally are vulnerable to erosion processes.

From the data of the Table 2 follows that to increasing the degree of soil erosion and deterioration of physical, chemical and physico-mechanical properties, of their values erodability shall be increased accordingly.

The big erodability of typically delluvial soils is due to the high content of fractions of sand and coarse dust in the of their granulometric composition.

Table 2. Erodability index values of the horizons investigated soils

The depth (cm)	**The erodability value**	**Class of erodability**
No. 1a profile. Not eroded ordinary cernoziom, humiferous moderately with profound strong humiferous profiles, poorly carbonate, clayey-loam, sloppy		
0 – 20	0.73	moderately
20 – 35	0.61	small
No. 2a profile. Poorly eroded ordinary cernoziom, humiferous moderately with profound moderately humiferous profiles, poorly carbonate, clayey-loam, sloppy		
0 – 20	0.77	moderately
20 – 35	0.61	small
No. 3a profile. Moderately eroded ordinary cernoziom, humiferous submoderat with profound moderately humiferous profiles, poorly carbonate, clayey-loam, sloppy		
0 – 20	0.79	moderately
20 – 35	0.62	small
No. 4a profile. Highly eroded ordinary cernoziom, humiferous poorly with semi-profound humiferous profiles, moderately carbonate, clayey-loam, sloppy		
0 – 20	0.81	big
20 – 35	0.71	moderately
No. 5a profile. Typically delluvial soil, humiferous submoderat, poorly carbonate, silty, with buried soil of the deeper than 70 cm and summary humiferous profile of very powerful deeply		
0 – 20	0.83	big
20 – 35	0.85	big



Conventional signs	The value of erodability	The class of erodability
	< 0.6	very small
	0.6-0.7	small
	0.7-0.8	moderately
	0.8-0.9	Big
	0.9-1.0	very big
The total area of the reception basin „Negrea" - 343 ha		

Figure 1. The soils erodability map of the reception basin "Negrea" (*developed by the author in accordance with existing methodology*) (Cojocaru, 2015; Florea et al., 1987; Stanga, 2005)

Such are observed very good on the map of soils erodability from the reception basin „Negrea" (Figure 1), developed based on the erodability calculation for all soil profiles located in the process of conducting pedological studies in the field.

The determination of erodability of the investigated soils was possible due to the appreciation necessary indices for calculating.

Erodability categories reflect the reality on the ground at a time, for example (Emerson, 1967; Motoc et al., 1979, 2000; Florea et al., 1987; FAO, 1984):

- *the first category of erodability* - are without lands vulnerable to erosion, agricultural use or as a support for the urban center itself;
- *the second category of erodability* - are lands with small vulnerability to erosion;
- *the third category of erodability* - are lands with average vulnerability to erosion. Characterize various forms of relief (slopes, pinnacles, aprons, valleys). The slopes are also varied, and manner of usage varies from one situation to another (shrubs, pasture, vineyards, crops, building space);
- *the fourth category of erodability* - are lands with high vulnerability to erosion;
- *the fifth category of erodability* - are highly erodible lands. Agricultural activity cannot be practiced. The potential use as vineyards or orchards would be possible only in alternation with forest plots and only by strong consolidation works.

In these conditions, it is likely that investment is never diminished. Therefore, to stop the active erosion and prevent degradation of the future, the most recommended way to use is to stabilize by plantations of trees.

CONCLUSIONS

Republic of Moldova is the region where natural conditions (climate, topography, rainfall and other factors) give rise to inevitable erosion and soil cover status and physical indicators and morphometric characteristic determines the intensity of this destructive process.

Erodability is an accumulation of erosion processes in the analyzed area (washing the surface, ravines, torrential, landslides, mudflows, collapses of shores) and classes of erodability shows the potential intensity (from lowest to highest) of erosion.

Soil degradation processes, including by erosion, are conditioned both by natural conditions and human activity as well.

Theoretically, the entire territory that was analyzed is erodible, differing only the intensity of this potentialities.

Fragmented lands will also be more prone to erosion than unfragmented land and so on.

The purpose research carried out in the village Negrea it was in erodability of soils calculation based on the values for each soil profile characteristics studied and appreciation leakage control plots of the influence of the degree of erosion on the water and soil losses.

The big erodability of typically delluvial soils is due to the high content of fractions of sand and coarse dust in the of their granulometric composition.

Negrea village residents must know predisposition to land erosion and properly plan and organize administrative actions (where are necessary land stabilization works and where no etc).

REFERENCES

Cojocaru O., 2015. Combaterea eroziunii solurilor bazinului de recepţie „Negrea" din zona colinară a Prutului de Mijloc. Teza de doctor. Chișinău, p. 83-105.

Emerson W.W., 1967. A classification of soil aggregrates based on their coherence in water. Australian Journal of Soil Research, 5: p. 47-57.

Ioniță I., Ouatu O., 1985. Contribuţii la studiul eroziunii solurilor din Colinele Tutovei. Rev. Cercet. Agron, Iași, 3 (71): p. 58-62.

Lupaşcu G., Parichi M., Florea N., 1998. Dicţionar de ştiinţa şi ecologia solului. Ed. Universităţii. „Al. I. Cuza", Iaşi, 404 p.

Moţoc M. et al., 1975. Eroziunea solului şi metodele de combatere. Ed. Ceres, Bucureşti, 301 p.

Moţoc M., Stănescu P., Taloiescu I., 1979. Actual conceptions regarding erosional phenomenon and it control. Institute for Soil Science and Agrochemistry. Agriculture Library. Bucharest, p. 77-86.

Moţoc M., Morărescu V., 2000. Unele probleme privind erodabilitatea solului în cazul eroziunii în suprafaţă. În: Ştiinţa Solului, seria III, nr. 1, vol. XXXIV, Bucureşti.

Florea N. et al., 1987. Metodologia elaborării studiilor pedologice. Partea I. Colectarea şi sistematizarea datelor pedologice. Bucureşti, 191 p.

Florea N. et al., 1987. Metodologia elaborării studiilor pedologice. Partea III. Indicatorii ecopedologici. Bucureşti, 226 p.

Krupenikov I., Andries S., 2001. Recomandări privind ameliorarea solurilor erodate prin aport de material pământos. Chișinău, p. 3-13.

Stângă I.C., 2005. Metode indirecte de calcul al erodabilităţii solului. Factori şi procese de pedogeneză. 4 S. nouă, Iaşi, p. 183-192.

Stângă I.C., 2005. Relaţii între erodabilitatea solurilor şi proprietăţile fizico-mecanice ale acestora. În: Factori şi procese de pedogeneză. 4 S. nouă, Iaşi, p. 247-253.

***FAO, 1984. Provisional methodology for assessment and mapping of desertification. Food and Agriculture Organization of the United Nations and United Nations Environment Programme, Rome, Italy, p. 25-79.

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IMPROVEMENT OF Ca AND Mg UPTAKE BY APPLICATION OF DOLOMITE AND DOLOMITE + LEONARDITE

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Abstract

This study was carried out as a pot experiment to determine the effects of dolomite alone or together with leonardite on Ca and Mg uptake of pepper plants. The doses of 8 and 16 g.pot^{-1} of dolomite which were equivalent to 4000 and 8000 kg.ha^{-1} incorporated to soil as either alone or together with 8 and 16 g.pot^{-1} of leonardite. Each pot fertilized by 200 mg.kg^{-1} N, 150 mg.kg^{-1} P_2O_5 and 150 mg.kg^{-1} K_2O. Results revealed that application of neither dolomite nor dolomite + leonardite applications were effective on root dry matter development; however, 4000 kg.ha^{-1} dolomite + 4000 kg.ha^{-1} leonardite incorporation yielded the highest shoot dry weight. Ca concentrations of plants were increased by increasing doses of dolomite and leonardite. Dolomite incorporation alone at the dose of 4000 kg.ha^{-1} improved plant Mg concentration, all other applications was reduced plant Mg contents compared to non-treated (NT) variant. Zn and Mn concentration were also measured in this study. Zn concentration was 96 mg.kg^{-1} at non-treated variant which was reached its highest value as 221 mg.kg^{-1}Zn at 4000 kg.ha^{-1} dolomite dose. The lowest obtained value within the dolomite and dolomite + leonardite applied pots was 143 mg.kg^{-1}Zn which was still 49% higher than NT. Mn concentration was gradually increased by increasing dose of both applications, starting from 80 mg.kg^{-1}Zn in NT to 192 mg.kg^{-1}Mn at the highest application doses of dolomite and dolomite + leonardite. Stimulating effect of leonardite was observed in shoot dry wegiht, Ca, Cu and Mn concentration whereas Mg and Zn concentration was diminished by leonardite addition to the dolomite.

Key words*: dolomite, leonardite, calcium, magnesium, plant nutrition.*

INTRODUCTION

Calcium and magnesium deficiencies are two common problems on greenhouse vegetable production especially in alkaline soils. Addition of the deficient nutrients to soil and increasing the availability of existing elements via organic matter incorporations are the two of the possible approaches to improve plant nutrition. Organic matter incorporation has an indirect effect as stimulating biological activity of the soils which Turgay et al. (2004) reported higher CO_2 formation in leonardite application. Microorganisms in soils are releasing phytohormones, small molecules or volatile compounds, which may act directly or indirectly to regulate plant growth. Humic substances have beneficial effects on plants by improving soil fertility by influencing nutrient uptake (Trevisan et al., 2010). Visser (1985) reported 200 times more microorganism number in case of 30 mg L^{-1} humic and fulvic acid (HFA) applications.

Mg deficiency leads to prevent photosynthates transport from leaves to roots (Cakmak et al., 1994) which may cause less root development, consequently insufficient micronutrients uptake. Moreover, crop tolerance to the stresses factors increasing by Mg; therefore, Mg demand is depended by growth conditions (Gransee and Fuhrs, 2013). The deficiency of Ca causes physiological disorder as blossom end rot, whereas, increasing Ca concentration increased leaf and fruit Ca contents (Bar-Tal et al., 2001). Kirkby and Pilbeam (1984) reported the cause of Ca deficiencies as poor Ca distribution rather than restriction of Ca uptake. Bar-Tal et al., (2001) reported less blossom end occurrence in case of frequent irrigation along with Ca fertilization.

In this research dolomite as Ca and Mg containing natural material was used to provide those two elements to the soil. Leonardite was selected as bio-stimulant agent to improve availability of Ca and Mg.

MATERIALS AND METHODS

The experiment was carried out under greenhouse conditions as a pot experiment using the soil that taken from the Suleyman Demirel University Research Farm. Three kg of soil placed to each pot. The texture class, organic carbon contents, total organic nitrogen, $CaCO_3$ content, pH and salt contents of the experimental soils were SiC, 0.64%, 0.029%, 25%, 8.1 and 0.015%, respectively.

The detail of applications and doses are presented in Table 1.

Table 1. Detail of applications

Abbreviation	Description
NT	Non-treated – control
D1	8 g of dolomite to each pot which equivalent to 4000 kg ha^{-1}
D2	16 g of dolomite to each pot which equivalent to 8000 kg ha^{-1}
DL1	8 g dolomite + 8 g leonardite which equivalent to 4000 kg ha^{-1} dolomite + 4000 kg ha^{-1} leonardite
DL2	16 g dolomite + 16 g leonardite which equivalent to 8000 kg ha^{-1} dolomite + 8000 kg ha^{-1} leonardite

Prior transferring the seedlings, dolomite or dolomite + leonardite incorporated to each pot homogenously.

The CaO, MgO and Fe_2O_3 contents of the dolomite were 32%, 21% and 0.28 whereas the humic + fulvic acid content of leonardite was 40%. Each pot fertilized by with 200 mg kg^{-1} N, 150 mg kg^{-1} P_2O_5 and 150 mg kg^{-1} K_2O using ammonium nitrate, NH_4NO_3, $NH_4H_2PO_4$ (Mono Ammonium Phosphate) and potassium sulphate K_2SO_4 fertilizers.

At the end of 2 months growing period, shoot and root were removed, washed thoroughly by demineralised water. Before grinding, plant materials are dried out at 65 °C until they reach constant weight.

Dry biomass development as root and shoot were weighed using analytical balance. The Ca, Mg, Zn, Cu and Mn concentrations were determined using atomic absorption spectrophotometer following the procedures described by Kacar and Inal (2010). Moreover, the total element uptake from the soil was calculated for every single element considering biomass development and plant nutrient concentrations (Jarrell and Beverly, 1981). Those values are presented in related figures as a line chart.

RESULTS AND DISCUSSIONS

The root and shoot biomass developments were presented in Figure 1. No statistical differences observed among root dry weights ($p>0.05$), whereas the shoot weights are statistically influenced from the applications ($p<0.05$). The highest shoot weight determined in DL1 application. Shoot weight was not affected from D1 application which no differences were observed between NT and D1. However, when leonardite accompany to dolomite (DL1), synergistic effects become visible; therefore shoot dry weight reached the highest value. Although it is not statistically significant, increasing leonardite dose reduced shoot weight when D2 and DL2 are compared. The negative effects of higher levels of leonardite in certain circumstances are reported earlier (Leventoglu and Erdal, 2014; Erol and Coskan, 2016).

The results in Figure 1 proved once again that the higher dose of leonardite application is either limiting the beneficial effects of leonardite or even cause adverse effects. On the other hand, leonardite incorporation was sustained shoot/root ratio (Table 2) which was diminished by high dose of dolomite application.

Cakmak et al. (1994) used shoot/root ratio to evaluate plant nutritional status, they reported close relationship between shoot/root dry weight ratios and relative distribution of total carbohydrates (sugars and starch) in shoot and roots.

The main purpose of this experiment was to improve Ca and Mg uptake which both are causing deficiency problems in greenhouse vegetable production especially in the high relative humid conditions. A number of factors are affecting Ca and Mg uptake, which the main challenge is sustaining availability of the nutrients.

The Ca and Mg concentrations as well as their uptake amount are presented in Figures 2 and 3 respectively.

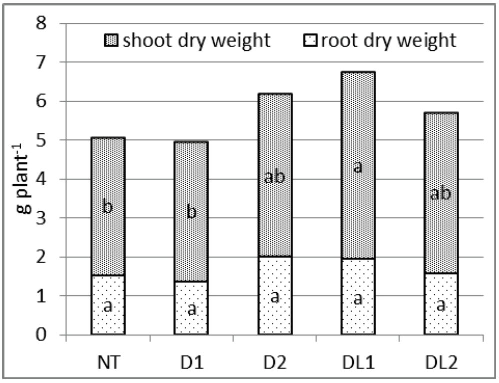

Figure 1. Root and shoot biomass development

Table 2. Shoot: root ratio of pepper plant

	NT	D1	D2	DL1	DL2
S:R ratio	2.26	2.59	2.05	2.44	2.57

Dolomite applications alone were not effective as dual applications of dolomite and leonardite. Although the highest solely dolomite applications dose slightly improved Ca concentration, the lowest dolomite application without leonardite (D1) did not improved Ca in the plant. The highest Ca concentration observed at the highest combination of dolomite and leonardite (DL2); however, DL1 application provided the highest Ca uptake. These results clearly proved that the dolomite can be used as a Ca source, but the higher dose of application may further increase pH, that resulting micronutrient deficiency. To overcome this phenomenon leonardite can be used to enhance Ca uptake at lower dolomite applications. The mechanism of this enhance effect of leonardite is not clear; however, Sozudogru et al. (1996) reported no effects of leonardite on Ca uptake. Positive effect in this study can be associated with improved soil microorganisms where Visser (1985) reported 200 times more microorganism number in case of 30 mg L^{-1} HFA applications.

As clearly seen in Figure 3, increasing dolomite doses - reduced Mg uptake, and leonardite application did not alter this effect. The highest Mg concentration was reached in D1 application, whereas the lowest was in D2 which the plant Mg concentration was even lower than the non-treated variant. The reason of negative effect of increasing dolomite dose most likely associated with pH increment due to the liming effect. When Ca and Mg results considered together, it is hard to recommend optimum dose for both -nutrients uptake; however, if the dolomite application is the only option available, the lower doses along with leonardite applications are seem to be more promising practice.

The Zn, Cu and Mn concentration as well as uptake amounts are presented in Figures 4, 5 and 6, respectively. The idea behind Zn, Cu and Mn evaluation was to determine possible negative impact of dolomite incorporation on uptake of these micronutrients due to the pH increas. Zn deficiency is one of the most common nutrition disorders due to two third of the soils in Turkey has Zn insufficiency problem (Eyuboglu et al., 1998). Results revealed that all applications improved Zn concentration and Zn uptake compared to control. This was not expected because of dolomite incorporation to soil is increasing pH (Toth, 2010), and Zn availability is reducing 100 times by increasing pH at 1 unit (Havlin et al., 1998). Contrary to results presented here, Toth (2010) reported either no influence or reduction on Zn concentration by means of dolomite applications. Although the increment in zinc concentration as a result of dolomite application was gradually decreased, yet Zn concentrations were higher even in 8000 kg ha^{-1} dose than the control. The tested dose of 8000 kg ha^{-1} was possibly higher than the highest dose that farmers follow in Turkey. Considering the Zn uptake, any of D1, D2 or DL1 applications may be recommended in fertilizer program.

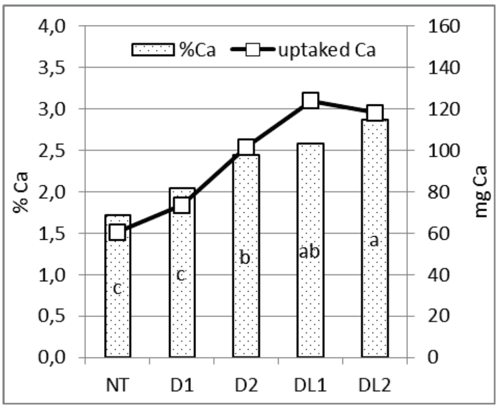

Figure 2. Ca concentrations and Ca uptake

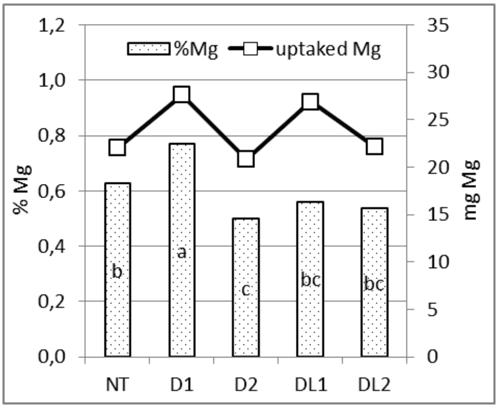

Figure 3. Mg concentrations and Mg uptake

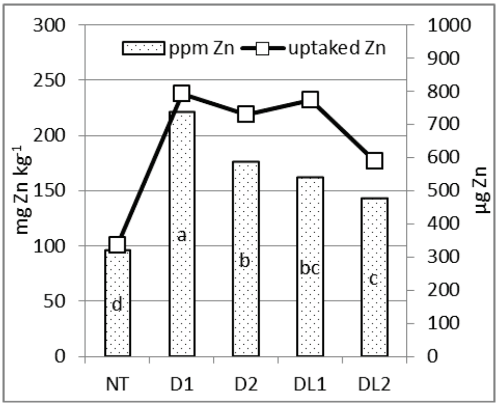

Figure 4. Zn concentrations and Zn uptake

Similarly to Zn concentration, Cu concentration (Figure 5) was positively influenced from dolomite applications; however, no tendency as a function of dolomite dose was observed. All applications were improved Cu uptake of the plants, whereas the lowest Cu concentration was in NT. While the highest value obtained in DL2, no differences was exist between D2 and DL1 variants.

The copper element has a distinctive feature among the all elements analysed. Copper accumulation has recently been mentioned in the soil in Turkey due to the fact that it is cheap and allowed in organic farming; therefore, it is the most used substrate as a fungicide in the region. In this research the Cu values determined within the adequate Cu threshold values of 25-75 mg Cu kg^{-1} which Jones (2012) reported. But DL2 application increased both Cu contents and Cu uptake by 67% and 94% respectively. Taking this into consideration, it is concluded that the application of dolomite does not cause Cu toxicity in the short term, but caution should be exercised when applying dolomite in areas containing high Cu contents. On the other hand, plants are more resistant to Cu deficiency comparing to Zn and Mn (Yu and Rengel, 1999). Cu uptake was in accordance of Cu concentration, besides Cu uptake was more influenced in leonardite + dolomit applied pots.

Mn content (Figure 6) was the only element showing tendency. Both increasing doses of dolomite and dolomite + leonardite, increased Mn concentration as well as Mn uptake. Leonardite has the stimulation effect on Mn uptake as expected whereas dolomite + leonardite applications provided the higher Mn nutrition. The relations between the parameters are presented in Table 3. Strong relation was determined between Mn and Ca concentrations ($p<0.001$). Increasing root dry weight was increased shoot dry weight whereas Ca concentration was positively influenced from shoot dry weight ($p<0.01$). The other relations were found to be insignificant ($p>0.05$).

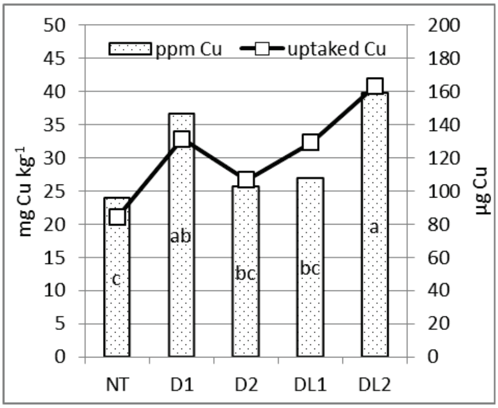

Figure 5. Cu concentrations and Cu uptake

CONCLUSIONS

No doubt dolomite was the one of the potential Ca and Mg source for plant production considering the results presented here. However, most probably due to the further increasing pH in alkaline soils, higher dose of dolomite is preventing uptake of zinc which is already one of the nutritional disorders in Turkey. In this research dolomite application improved Ca uptake in every additional dose, while Mg concentration was negatively affected by increasing amount of dolomite. The highest Mg concentration was achieved on the lowest dolomite dose. Even in this lower dose, leonardite incorporation was further reduced Mg concentration. Leonardite was considered as an agent to stimulate nutrient uptake by improving soil biologic activity; nevertheless, it was not encourage Mg uptake. Consequently, to improve Mg uptake the lower dolomite dose should be recommended whereas the higher dolomite + leonardite doses should be selected for stimulate Ca uptake.

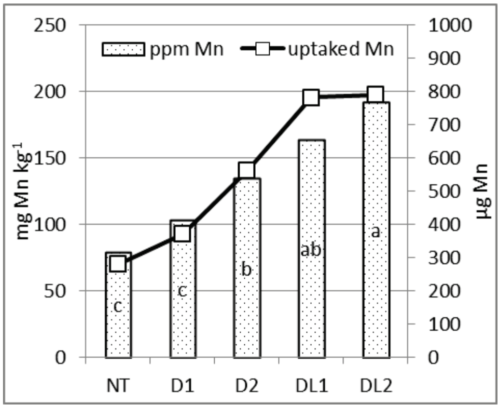

Figure 6. Mn concentrations and Mn uptake

Table 3. Correlation coefficients between the parameters tested

	mg Cu kg^{-1}	*mg Mn kg^{-1}*	*mg Zn kg^{-1}*	*%Mg*	*%Ca*	*shoot dry w.*
mg Mn kg^{-1}	0.2824					
mg Zn kg^{-1}	0.3854	0.0953				
%Mg	0.2910	-0.4256	0.3436			
%Ca	0.4087	0.8475 ***	0.0707	-0.3466		
shoot dry w.	0.2584	0.3835	0.1104	-0.3405	0.5576 **	
root dry w.	-0.1668	0.2111	-0.0779	-0.4194	0.3433	0.6225 **

** $p<0.01$ *** $p<0.001$

REFERENCES

Bar-Tal A., Keinan M., Aloni B., Karni L., Oserovitz Y., Gantz S., Hazan A., Itach M., Tratakovski N., Avidan A., Posalski I., 2001. Relationships between Blossom- End Rot and Water Availability and Ca Fertilization in Bell Pepper Fruit Production. Acta Hortic. 554, p. 97-104.

Cakmak I., Hengeler C., Marschner H., 1994. Partitioning of Shoot and Root Dry Matter and Carbohydrates in Bean Plants Suffering from Phosphorus, Potassium and Magnesium Deficiency. J. Exp. Bot. 45 (9): p. 1245-1250.

Erol H., Coskan A., 2016. Effect of Humic + Fulvic Acid Application at Different Doses on Biological Activity of Different Region Soils. Scientific Papers. Series A. Agronomy, Vol. 59, p. 69-74.

Eyuboglu F., Kurucu N., Talaz S., 1998. General Situation of Plant Available Micronutrients Elements (Fe, Cu, Zn, Mn) of Turkish Soils. The Republic of Turkey, Soil and Fertilizer Research Institute, Ankara (in Turkish).

Gransee A., Fuhrs H., 2013. Magnesium mobility in soils as a challenge for soil and plant analysis, magnesium fertilization and root uptake under adverse growth conditions. Plant and Soil 368: p. 5-21.

Havlin J.L., Beaton J.D., Tisdale S.J., Nelson W.L., 1998. Soil Fertility and Fertilizer, An Introduction to Nutrient Management. 6th Edition. Pearson Education Inc. ISBN: 9780136268062.

Jarrell W.M., Beverly R.B., 1981. The Dilution Effect in Plant Nutrition Studies. Advances in Agronomy, 34: p. 197-224.

Jones Jr. J.B., 2012. Plant Nutrition and Soil Fertility Manual, Second ed. CRC Press. ISBN 9781439816097.

Kacar B., Inal A., 2010. Plant Analyses, Nobel Academic Press. ISBN: 9786053950363 (in Turkish).

Kirkby E.A., Pilbeam D.J., 1984. Calcium as a plant nutrient. Plant, Cell & Env. 7: p. 397-405.

Leventoglu H., Erdal I., 2014. Effect of High Humic Substance Levels on Growth and Nutrient Concentration of Corn under Calcareous Conditions. Journal of Plant Nutrition, 37: p. 2074-2084.

Sozudogru S., Kutuk A.C., Yalcin R., Usta S., 1996. Humik Asitin Fasulye Bitkisinin Gelisimi ve Besin Maddeleri Alimi Uzerine Etkisi. Ankara Universitesi Ziraat Fakultesi Yayin No: 1452. Bilimsel Arastırma ve Incelemeler: 800, Ankara.

Toth T., 2010. Effect of Zinc and Dolomite Treatments on the Chemical Composition of Acid Sandy Soil and Bean Crop. Communications in Soil Science and Plant Analysis, 41: p. 2568-2576.

Trevisan S., Francioso O., Quaggiotti S., Nardi S., 2010. Humic substances biological activity at the plant-soil interface-From environmental aspects to molecular factors. Plant Signaling & Behavior 5:6, p. 635-643.

Turgay O.C., Tamer N., Türkmen C. ve Karaca A., 2004. Gidya ve Ham Linyit materyallerinin Topragin Biyolojik Ozelliklerine Etkisini Degerlendirmede Toprak Mikrobiyal Biyokutlesi. 3. Ulusal Gubre Kongresi Bildiri Kitabi, 1. Cilt, s; p. 827- 836, Tokat.

Visser S.A., 1985. Physiological Action of Humic Substances on Microbial Cells. Soil Biology and Biochemistry, 17(4): p. 457-462.

Yu Q., Rengel Z., 1999. Micronutrient Deficiency Influences Plant Growth and Activities of Superoxide Dismutases in Narrow-leafed Lupins. Ann. Bot. 83(2): p. 175-182.

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ADMINISTRATION OF ALGAL BIO-FERTILIZERS TO CULTIVATION OF TOMATOES (*Lycopersicum esculentum* L.) UNDER GREENHOUSE CONDITIONS

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Abstract

The paper aimed to present the results of studying the administration of algal bio-fertilizers to cultivation of tomatoes (Lycopersicum esculentum L.) under greenhouse conditions. In the experiments were involved algae cyanophytes Anabaena variabilis and Nostoc gelatinosum, which are deposited in pure collection in laboratory of "Phycology". During the experiments was monitored soil pH, plant growth, the productivity of tomatoes and the total N from soil layer. Administration of algal bio-fertilizers Anabaena variabilis ensures the accumulation of more high levels of nitrogen in the soil, compared to other experimental variations. Bio-fertilizers administration contributes to stimulating growth of the stem height of tomato plants, increasing the number of seedlings of tomato to a 1 to 2.30 times and productivity tomatoes from 1.73 to 3.40 compared to the group in which was not given algal biomass. The highest results of tomatoes productivity were attested in variant with administering bio-fertilizers based of Nostoc gelatinosum biomass.

Key words*: algal bio-fertilizers, blue-green algae, productivity, nitrogen fixation, tomatoes.*

INTRODUCTION

According to the statistical report presented by the Food and Agriculture Organization of the United Nations (FAO) the index of fruit and vegetables production has increased worldwide. If in 1980 the fruit production index reaches about 58, then in 2000 it was 86 and in 2014 reached 127. At the same time, worldwide, is observed a significant increase the quantity of fertilizers, such as nitrogen (in 2009 to 64.9 kg/ha and a. 2014 to 85.8 kg/ha), phosphorus (in 2009 to 25.9 kg/ha and 2014 to 33.2 kg/ha), potassium (in 2009 to 18.2 kg/ha and 2014 to 20.4 kg/ha) (FAO, 2015). This worldwide increase the of fruit and vegetables production is due to the application of advanced technologies for cultivation, chemical fertilizers, seeds and transgenic seedlings that contributes to achieving harvest, but in many cases influences negative on the human body.

In such conditions it is necessary to develop and implement in practice new bio-fertilizers that would help to improve the harvest and soil quality and stimulate crop plants growth.

Bio-fertilizers are defined as preparations containing living cells or latent cells of efficient strains of microorganisms that help crop plants uptake of nutrients by their interactions in the rhizosphere when applied through seed or soil. They accelerate certain microbial processes in the soil which augment the extent of availability of nutrients in a form easily assimilated by plants (Vessey, 2003). Bio-fertilizers are considered natural fertilizers made up of inoculum of organisms from bacteria, algae, fungi or combination of them, contributing to increasing availability of nutrients (Sahu, 2012).

Bio-fertilizers have been used in agriculture since ancient times and is mentioned in the writings of the classics of Greece and Rome, describing agricultural practices that improve harvest. The old civilization Maya manage the waters of Mexico, creating wetlands to maintain a complex mixture of algae cyanophytes and other microorganisms, which were used in order to increase the content of nutrients in the soil (Morrison et al., 2003; Malusa et al., 2016). At the moment, several species of algae are widely applied in agricultural practice as bio-fertilizers, which have bio-stimulating effect of crop plants growth.

The application of alga bio-fertilizers is effective and necessary because to their management is amended the structure of the soil. Is eliminated growth stimulating substances such as hormones (auxins and gibberellins). The use of bio-fertilizers adds to the maintenance of water in the soil due to the gelatin and reduced the salinity. Administration of algae contributes to increasing the concentration of phosphorus and nitrogen from the soil by fixing nitrogen from the atmosphere and organic acid excretion (Wilson, 2006).

A practical interest is using the algae as bio-fertilizers in the cultivation of tomatoes. Some researchers conducted in this regard have shown beneficial effects on marine algae *Nannochloropsis* biomass administration as bio-fertilizers in the cultivation of tomatoes. So, in batches with administration of algal bio-fertilizers was registered a lower growth of plant height, a lower harvest but of high quality, also and obtaining fruit with a more high sugar and carotenoids (Grunertae, 2016).

MATERIALS AND METHODS

In the experiments were involved algae cyanophytes *Anabaena variabilis* and *Nostoc gelatinosum*, which are deposited in pure culture collection in laboratory of "Phycology". These experiments were conducted in greenhouses, Company SRL „AŢ-Zim", which are located near the village Bardar, district Ialovei, Republic of Moldova. The research was conducted during the spring and summer. In experiments were used the following experimental groups: 1- administration of *Anabaena variabilis* living biomass (3 kg/ha), 2 - administration of *Nostoc gelatinosum* living biomass, 3 - control version where was not given algal biomass. Algal biomass was crushed, diluted in drinking water and administered to the surface of soil. Each experimented variant occupies an area of 20 m^2. Algae inoculation was made on the 15th day after planting seedling tomato sorts "Admiral". During the experiments was monitored plant growth, the quantitative analysis of tomato harvest, the total N in 0-20 cm soil layer (using the method colorimetric) (Минеев, и др., 2001) and soil pH (potentiometric method) (Терпелец и др., 2010). Soil moisture during the experiments varied from 16.07 to 22.79%.

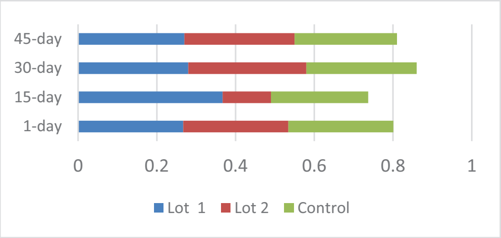

Figure 1. Changes of total nitrogen in the soil to the administration of algal bio-fertilizers, %

RESULTS AND DISCUSSIONS

As is known nitrogen-fixing algae are able to fix nitrogen when it is in deficiency and to consume when they are in sufficient quantities (Dobrojan et al., 2010; Stratulat, 2012).

Analyzing the changes in dynamics of total nitrogen in the soil, we note that both versions with administration of algal bio-fertilizers and also in control, the amount of nitrogen is not stable, which indicates that the consumption and nitrogen fixation is produced. In lots with administration of algal bio-fertilizers is attested the highest amounts of nitrogen in the soil compared with controls.

Administration of algal bio-fertilizers *Anabaena variabilis* ensures the accumulation of more high levels of nitrogen in the soil, compared to other experimental variations. At the same time, particularly in versions 1 and 2 the total soil nitrogen is accumulating after being consumed and produced, which demonstrates once again the contribution of algal bio-fertilizers in the soil with nitrogen refilling. This tendency indicates that nitrogen consumption by tomato plants is initiated the process of biological nitrogen fixation carried out by algal bio-fertilizers.

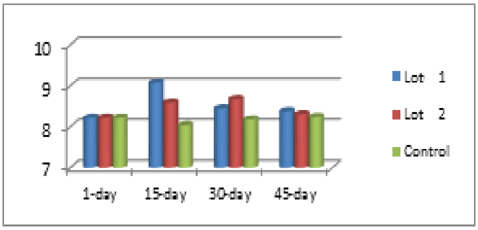

Figure 2. Changing the soil pH in the administration of nitrogen-fixing algae

Soil pH has changed over the period of analysis especially in the versions with administration of bio-fertilizers and version control modifications are not essential. During the experiments it is observed that the pH of the soil tends to easy basification, especially versions with administration of bio-fertilizers. In groups 1 and 2 soil pH is slightly higher than in the control sample, in the period from the 15th until the 45th day. Values soil pH varies from one period to another and from one variant to another. However, the highest values of soil pH are observed in the group with bio-fertilizers administration consists of algae *Anabaena variabilis* biomass. This may be caused by accumulation of inorganic nitrogen in the soil.

Table 1. Influence of algal bio-fertilizers on tomato plant size, cm

Experimental lots	Analysis days; days of the administration of algal bio-fertilizers			
	15	30	45	60
Lot 1	26.01±1.39	48±4.15	79±5.93	128±8.25
Lol 2	22.11±1.43	48±4.44	76±7.30	129±9.25
Control	18±0.90	34±1.49	62±8.44	124±8.02

The analysis of increasing process found that the length of the stem shows some differences depending on the experimental variants, which shows the positive influence that manifests algal bio-fertilizers on growth processes of tomatoes. In the period from the 15th until the 45th day, the plants from variants with administration of algal bio-fertilizers are longer than those in the control group. The tallest plants were attested in lots 2 and 1, which reached values of 128±8.25 to 129±9.25 cm, being with 4-5 cm higher compared to control variant. Thus, we can conclude that administration of algae as bio-fertilizers contribute to boosting growth of tomato stems from 4.03 to 3.22% compared to the control group (Table 1).

Table 2. The influence of algal bio-fertilizers on the number of tomatoes on one plant

Experimental lots	The analyzed period (60th day after the administration of algal bio-fertilizers)
Lot 1	13±2.59
Lot 2	18,46±2.33
Control	8±1.39

Number of fruit presents a critical indicator of the productivity of tomatoes. Thus, the result of determinations made at the 60th day of analysis is observed that the administration of bio-

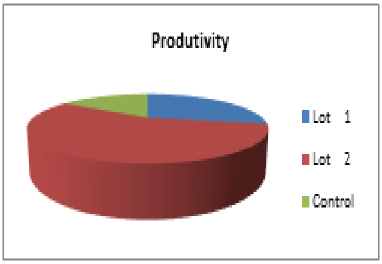

Figure 3. Productivity of tomatoes, kg/m^2

fertilizers, number of tomatoes to a seedling is higher than the control group. The highest number of fruit is found in the lot 2 (18.46±2.33) which is 1.42 times higher than in group 1 and 2.30 times higher compared to the control group.

Algal bio-fertilizers administration influence on the productivity of tomatoes. In the groups with bio-fertilizers administered the amount of tomato obtained from an area of 1 m^2 is 1.73 to 3.40 times higher than in the control variant. The highest results of tomatoes productivity were attested in variant with administering bio-fertilizers based of *Nostoc gelatinosum* biomass.

CONCLUSIONS

Administration of algal bio-fertilizers contributes to the accumulation and stabilizes the nitrogen in the soils involved in the cultivation of tomatoes. The soils algalization with bio-fertilizers contributes to slight change of soils pH to slightly alkaline direction. Bio-fertilizers administration contributes to stimulating growth of the stem height of tomato plants, increasing the number of seedlings of tomato to a 1 to 2.30 times and productivity tomatoes from 1.73 to 3.40 compared to the group in which was not given algae biomass. The most efficient algal bio-fertilizers from those tested, proved to be *Nostoc gelatinosum* biomass.

REFERENCES

Dobrojan G., Dobrojan S., Stratulat I., 2012. Modificarea azotului la cultivarea algei *Anabaenopsis* sp. pe mediul nutritiv Drew. Conferința Internațională a Tinerilor Cercetători.ed. a X-a, 77.

Grunertae O., Coppensa J., Van Den Hendeb S., Vanhouttec I., Boona N., Haesaertd G., Gelderc L.De., 2016. The application of microalgae as a slow-release fertilizer: tomato cultivation as a model. International Tomato Conference, p. 1-8.

Malusà E., Pinzari F., Canfora L., 2016. Effi cacy of Biofertilizers: Challenges to Improve Crop Production. Microbial Inoculants in Sustainable Agricultural Productivity, Vol. 2, Functional application, p. 17-40.

Morrison B.A., Cozatl-Manzano R., 2014. Initial evidence for use of periphyton as an agricultural fertilizer by the ancient Maya associated with El Eden wetland, Northern Quintana Roo, Mexico. In: Fedick S., Allen M., Jimenez-Osornio J., Gomez-Pompa A. (eds.) The Lowland Maya area: three millennia at the humanwildland interface. CRC Press, New York, 635.

Sahu D., Priyadarshan I., Rath B., 2012. Cyanobacteria - as potential biofertilizer. CIBTech Journal of Microbiology, Vol. 1 (2-3), p. 20-26.

Stratulat I., Dobrojan S., 2012, Studiul procesului de fixare biologică a azotului atmosferic la cultivarea algei *Nostoc flagelliforme* pe unele medii nutritive. Conferinţa internaţională a tinerilor cercetători, a X-a., 83.

Vessey J.K., 2003. Plant growth promoting rhizobacteria as biofertilizers. Plant Soil, p. 571-586.

Wilson L.T. 2006. Cyanobacteria: A Potential Nitrogen Source in Rice Fields. Texas Rice, p. 9-1.

Минеев В.Г., Сычев В.Г., Амельянчик О.А., и др., 2001. Практикум по агрохимии, 2-е издание, переработанное и дополненное. – М,, Из.: Московского Государственного Университета, 689.

Терпелец В. И., Слюсарев В. Н., 2010. Учебно-методическое пособие по изучению агрофизических и агрохимических методов исследования почв. - Краснодар: КубГАУ, 65.

***Food and Agriculture Organization of the Unite Nations, 2015. FAO Statistical Pocketbook 2015. FAO, 236.

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EFFECT OF VERMICOMPOST OBTAINED FROM KITCHEN WASTES ON CORN GROWTH AND MINERAL NUTRITION

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Abstract

In this study, it was aimed to invesitigate the effect of vermicompost obtained from home originated organic wastes on plant growth and mineral nutriton of corn plant under green house condition. Vermicompost were given to the soil at the rates of 0, 5, 10, 20 and 40 t.ha^{-1}. Study was planned according to the randomized parcels with 4 replicates and study lasted two months. At and of the experiment, plant dry weights, N, P, K, Ca, Mg, Fe, Cu, Zn and Mn concentrations were determined. Depending on the applied vermicompost application, plant dry weights increased up to 20 t ha^{-1} vermicompot doses but then decreased. Plant nutrient concentrations such as N, P, Fe, Mn and Cu did not change but Ca concentration decreased. However, K, Mg and Zn concentrations in leaves increased with vermicompost doses. Although, most of the leaf nutrient concentrations were not affected positively with vermicompost doses, about all nutrient uptakes showed increases with the doses of vermicompost.

Key words: *kitchen wastes, plant nutrition, soil fertility, vermicompost.*

INTRODUCTION

Keeping soil fertility is one of the most important subjects for high yield with high quality plant production. Fertile soils are the soils that contain sufficient amount of nutrient ready for plant uptake when they need. Nutrient supplying capacity of the soils can decrease with the time depending on nutrient uptakes by the plants.

Furthermore, soil nutrient concentrations diminish due to the factors such as leaching, fixation, and denitrification.

Plant nutrient requirement changes depending on the plant varieties. While in the fertile soils, nutrient requirement of the plants can be met from the soils, in unfertile soils, these requirements should be met with fertilizers.

Soil organic matter with positive role on soil physical, chemical and biological properties is an important soil component (Doan et al., 2013; Doan et al., 2014; Uz et al., 2016). Additionally, soil organic matter being a main source of N and some other nutrients has an irreplaceable importance for soil fertility. The amount and properties of organic matter are important soil characters.

Chemical fertilizers are the most effective sources to compensate nutrient deficiency in the soils. However, uncontrolled and unconscious use of chemical fertilizers gave rise to some environmental problems. Therefore, nowadays, increasing interest for environmentally friendly sources to increase soil fertility properties as soil amenders or direct nutrient suppliers has been recorded. Some alternative sources such as compost, vermicompost, biochar etc. are being used to increase plant nutritional status (Aggelides and Londra, 2000; Aynacı and Erdal, 2016). These sources may play role in soil fertility directly as nutrient sources or indirectly as soil amenders. This study aimed to determine the effects of vermicompost made of kitchen wastes on plant growth and mineral nutrition of corn plant under greenhouse condition.

MATERIALS AND METHODS

Vermicomposts were given to the soil at the rates of 0,5, 10, 20 and 40 t.da^{-1}. Study was planned according to the randomized parcels with 4 replicates under greenhouse conditions during two months. Corn plant was used as plant material. Before sowing, 200 ppm N (as ammonium nitrate),100 ppm P (as triple super phosphate) and 100 ppm K (as potassium sulphate) were added as basal fertilization and mixed to the soil with vermicompost. During the experiment, plants were irrigated with tap water. Physical and chemical properties of the experimental soils are given in Table 1.

In order to determine soil available nutrients, P extracted with $NaHCO_3$ (Olsen et al., 1954), K, Ca, and Mg extracted with NH_4AOC (Jackson, 1967) and Mn, Zn, Fe, and Cu extracted with DTPA (Lindsay and Norvell, 1969). P measurement was done using spectrophotometer; others were measured with Atomic Absorption Spectrophotometer. Soil texture was determined using hydrometer (Bouyoucos, 1954) and $CaCO_3$ content was measured with calcimeter (Allison and Moodie, 1965). pH was determined using pH meter in suspension of soil and water at the rates of 1/2.5. Soil organic matter (OM) was determined based on Walkley and Black (1934).

Plants were harvested above ground the soil after the experiment period. Then, they were washed toughly with tap water, dilute acid (0.2 N HCl) and distilled water. Afterwards samples were dried, grounded and wet digested with microwave oven. Total nitrogen was analyzed according to Kjeldahl method. Phosphorus concentrations of samples were determined with a spectrophotometer (Shimadzu UV-1208) at 430 nm according to the vanadomolybdo phosphoric acid method. Potassium, Ca, Mg, Fe, Cu, Zn, and Mn concentrations were determined using atomic absorption spectrophotometer.

All data concerning the growth, nutrient concentrations and nutrient uptakes of corn plant were submitted for statistical analyses using MSTAT program for one-way analysis of variance applied to determine any significant difference at 0.05%.

Table 1. Characteristics of the experimental soils

Texture	pH	OM (%)	$CaCO_3$ (%)	Plant available nutrients (mg kg^{-1})							
				P	K	Ca	Mg	Mn	Zn	Fe	Cu
Loam	7.8	3.7	25	108	443	7445	185	6.2	1.3	10.4	2.7

RESULTS AND DISCUSSIONS

Effect of vermicompost obtained from kitchen wastes on plant growth and nutrient concentrations

Vermicompost application doses increased plant dry weight significantly. As it seen from Figure 1, plant dry weights increased from 7.93 g pot^{-1} to 23.43 g pot^{-1} with 20 t ha^{1} **vermicompost** doses (VC doses).

Increase of VC doses levels up to 40 t ha^{-1} resulted in a sharp decrease of plant dry weight. Leaf N levels varied between 2.27% and 2.42%, but leaf N concentrations of corn were not affected from the VC doses.

Leaf K and Mg concentrations of leaves significantly varied with the doses. While all doses had the same effect on leaf K concentrations comparing to control, only the highest VC doses significantly varied from other doses in terms of Mg concentrations.

Leaf Ca concentrations decreased with the VC doses. As indicated in Figure 2, leaf micro element concentrations such as Fe, Mn and Cu were not affected from VC doses.

But leaf Zn concentrations showed significantly increment at the highest vermicompost dose comparing to other application levels.

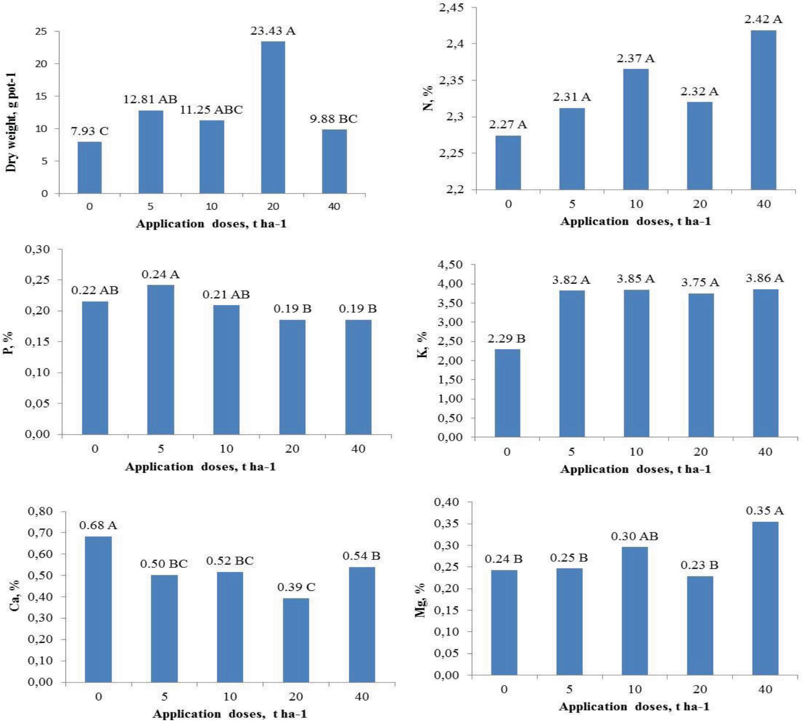

Figure 1. Effects of vermicompost on dry weight and N, P, K, Ca, and Mg concentrations of corn

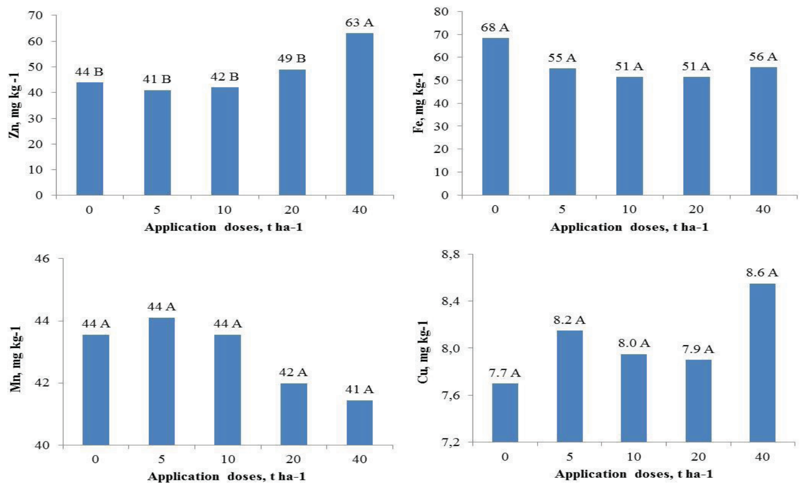

Figure 2. Effects of vermicompost on Zn, Fe, Mn, and Cu concentrations of corn

Effect of vermicompost obtained from kitchen wastes on nutrient uptake of corn plant

Plant N, P, K and Mg uptakes from the soils increased with the VC doses. But the nutrients such as N, P and K showed decrease after the dose of 20 t ha^{-1}. Ca uptake of corn did not show any changes depending on the vermicompost application doses (Figure 3). All micro element uptakes significantly varied with the doses of vermicompost. However, as in macro element uptakes, Fe, Mn, and Cu uptakes began to decrease with the increase of application levels to the 40 t ha^{-1} (Figure 4).

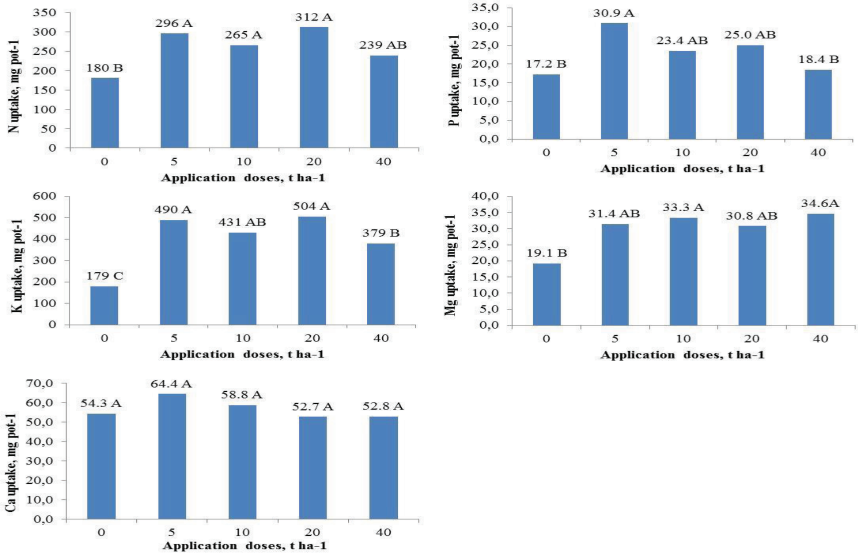

Figure 3. Effects of vermicompost on N, P, K, Ca, and Mg uptakes of corn plant

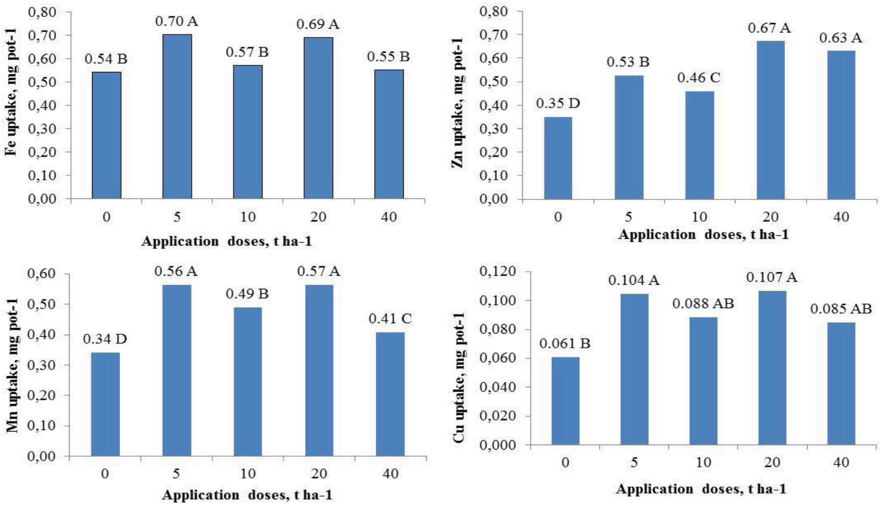

Figure 4. Effects of vermicompost on Fe Zn, Mn, and Cu uptakes of corn plant

Increases in plant dry weight with compost or vermicompost applications are common findings (Loecke et al., 2004; Sardoei, 2014; Aynacı and Erdal, 2016). This situation was expressed with directly or indirectly positive effect of organic matter on plant growth with vermicompost application. As indicated previous studies, vermicompost can increase soil fertility by means of different ways and thus plant growth and dry matter increase (Nagavallemma et al., 2004; Gutiérrez-Miceli et al., 2007; Joshi and Vig, 2010). On increase yield, slow release of nutrients during the plant growth and decreasing of nutrient loss by means of leakage may have effect as indicated by Cantanazaro et al. (1998). In the other study, it was found that vermicompost application led to pH decrease resulting in corn plant dry matter increase (Sharma et al., 2005). However, increase of vermicompost over the 20 t ha^{-1} resulted in dry matter decrease. This may be due to the negative effect of over organic matter and its products such as humic materials (Leventoglu and Erdal, 2014). As indicated in previous studies, higher levels of organic matters can bind soil nutrients as unavailable forms, thus plants cannot grow better (Leventoglu and Erdal, 2014). Vermicomposts have large particulate surface areas that provide many microsites for microbial activity and for the strong retention of nutrients (Shi-wei and Fu-zhen, 1991). Some researchers recorded that there had been some growth improving products such as hormone like substances, cytokinins, auxins and humates produced with some microorganism and earthworms (Krishnamoorthy and Vajrabhiah, 1986; Tomati et al., 1988; Tomati et al., 1990; Atiyeh et al., 2002). Vermicompost contains most nutrients in plant-available forms such as nitrates, phosphates, and exchangeable calcium and soluble potassium (Edwards, 1998). These properties of vermicomposts might be the reason of leaf nutrient increase. Also, increasing effect of vermicompost on soil nutrient availability might lead to increase in plant mineral nutrition.

Nutrient uptake of corn is closely related with plant dry weight and plant nutrient concentrations. As known, nutrient uptakes by plants increase with the increase of dry weight and plant nutrient concentrations. However, nutrient uptakes decreases with the decrease of dry weight and plant nutrient concentrations. Therefore, the factors leading to increase in dry weight and nutrient concentrations increase plant nutrient uptakes; on the contrary, the factors leading to decrease in dry weight and nutrient concentrations decrease plant nutrient uptakes.

CONCLUSIONS

In conclusion, plant growth and mineral nutrition of corn plant positively affected by vermicompost obtained from kitchen wastes generally. But the 40 t ha^{-1} dose of vermicompost had negative effect of corn growth on the soil used for this experiment. Futhermore, effects of the doseges, between 20 t ha^{-1} and 40 t ha^{-1}, on plants growth and mineral nutritions need to be examined.

REFERENCES

Aggelides S.M., Londra P.A., 2000. Effects of Compost Produced from town wastes and sewage sludge on the physical properties of a loamy and clay soil. Bio resource Technology, 71(3), 253-259.

Allison L.E., Moodie C.D., 1965. Carbonate. In: C.A. Black et al (ed.) Methods of soil analysis, Part 2. Agronomy 9:1379-1400. Am. Soc. of Agron., Inc., Madison, Wisconsin, U.S.A.

Atiyeh R.M., Lee S.S., Edwards C.A., Arancon Q., Metzger J.D., 2002. The influence of humic acid derived from earthwormprocessed organic wastes on plant growth. Bioresource Technology 84: 7–14.

Aynacı D., Erdal İ., 2016. Effect of home-originated waste compost on growth and nutrient concentration of corn and pepper. SuleymanDemirel University, Journal of Natural and Applied Sciences, 20 (1): 123-128.

Bouyoucos G.L., 1951. A Recalibration of the hydrometer for making mechanical analysis of soil. Agron. J. 43:434-437.

Cantanazaro C.J., Williams K.A., Sauve R.J., 1998. Slow release versus water soluble fertilization affects nutrient leaching and growth of potted chrysanthemum. Journal of Plant Nutrition 21:1025-36.

Doan T.T., Jusselme D.M., Lata J.C, Nguyen B.V, Jouquet P., 2013. The earthworm species Metaphireposthuma modulates the effect of organic amendments (compost vs. vermicompost from buffalo manure) on soil microbial properties: A laboratory experiment. European Journal of Soil Biology, 59:15-21.

Doan T.T., Bouvier C., Bettarel Y., Bouvier T., Henry-des-Tureaux T., Janeau J.L., Lamballe P., Nguyen B.V., Jouquet P., 2014. Influence of buffalo manure, compost, vermicompost and biochar amendments on bacterial and viral communities in soil and adjacent aquatic systems. Applied Soil Ecology, 73:78-86.

Edwards C.A., 1998. The use of earthworms in the breakdown and management of organic wastes. In: Earthworm ecology. CRC Press LLC, Boca Raton, 327–354.

Gutiérrez-Miceli F.A., Santiago-Borraz J., Molina J.A.M., Nafate C.C., Abud-Archila M, Llaven M.A.O., Rosales R.R., Dendooven L., 2007. Vermicompost as a soil supplement to improve growth, yield and fruit quality of tomato (*Lycopersicum esculentum*). Bioresource Technology, 98(15): 2781-2786.

Jackson M.L., 1967. Soil chemical analysis. Prentice Hall of India Private Limited, New Delhi.

Joshi R., Vig A.P., 2010. Effect of vermicompost on growth, yield and quality of tomato (Lycopersicumesculentum L). African Journal of Basic & Applied Sciences, 2(3-4): 117-123.

Krishnamoorthy R.V., Vajrabhiah,S. N., 1986. Biological activity of earthworm casts: an assessment of plant growth promoter levels in casts. Proceedings of the Indian Academy of Sciences (Animal Science), 95: 341-351.

Leventoglu H., Erdal İ., 2014. Effect of high humic substance levels on growth and nutrient concentration of corn under calcareous conditions. Journal of Plant Nutrition, 37(12): 2074-2084.

Lindsay W.L. Norvell W.A., 1969. Development of a DTPA micronutrient soil test. Soil Science Society of American Proceeding, 35: 600-602.

Loecke T.D., Liebman M., Cambardella C.A., Richard T.L., 2004. Corn response to composting and time of application of solid swine manure. Agronomy Journal, 96: 214-223.

Nagavallemma K.P., Wani S.P., Lacroix S., Padmaja V.V., Vineela C., Rao M.B., Sahrawat K.L., 2004. Vermicomposting: Recycling wastes into valuable organic fertilizer. Global Theme on Agroecosystems Report no. 8.

Olsen A., 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate US Dep. of Agri. Circ. 939 Washington DC.

Sardoei A.S., 2014. Vermicompost effects on the growth and flowering of marigold (Calendula officinalis). European Journal of Experimental Biology, 4(1): 651-655.

Sharma S., Pradhan K., Satya S., Vasudevan P., 2005. Potentiality of earth worms for waste management. The Journal of American Science, 1(1): 4-16.

Shi-Wei Z., Fu-Zhen H., 1991. The nitrogen uptake efficiency from 15N labelled chemical fertilizer in the presence of earthworm manure (cast). In: Veeresh, G.K., Rajagopal, D., Viraktamath, C.A. (Eds.), Advances in Management and Conservation of Soil Fauna. Oxford and IBH publishing Co, New Delhi, Bombay, pp. 539–542.

Tomati U., Grappelli A., Galli E., 1987. The presence of growth regulators in earthworm-worked wastes. In: Bonvicini Paglioi, A.M., Omodeo, P. (Eds.), On Earthworms. Proceedings of International Symposium on Earthworms, Selected Symposia and Monographs, Unione Zoologica Italiana, 2. Mucchi, Modena, pp. 423–435.

Uz İ., Sonmez S., Tavali I. E., Citak S., Uras D.S., Citak S., 2016. Effect of vermicompost on chemical and biological properties of an alkaline soil with high lime content during celery. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 44(1): 280-290.

Walkley A., Black I.A., 1934. An examination of the degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil science, 37(1): 29-38.

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SUNFLOWER CAN TAKE EXCESS BORON FROM DIFFERENT BORON SUPPLIES WITHOUT GROWTH LOSE AND NUTRITIONAL DISORDERS

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Abstract

One of the aims of this study was to determine the effect of different boron sources on boron nutrition and growth of sunflower plant. Also it was aimed to examine the sunflower response to the over leaf boron concentrations. For this, 7 boron sources; Anhydrate borax ($Na_2B_4O_7$), Boric acid (H_3BO_3), Etibor-48 (Powder; Borax pentahydrate, $Na_2B_4O_7$. 5 H_2O), Boron oxide (B_2O_3), Etidot-67 ($Na_2B_8O_{13}.4H_2O$), Borax ($Na_2B_4O_7.10H_2O$) and Etibor-48 (Granule; Borax pentahydrate, $Na_2B_4O_7.5H_2O$) were applied to 4 kg soil containing pots at the rates of: 0 (control), 5, 10 and 20 mg B kg^{-1}. Plants were grown under greenhouse condition until the flower bud period, and then plants were harvested and analyzed for nutrients. According to the results, leaf B concentration of sunflower increased up to 718 mg.$kg^{-1}$with the boron applications. All boron sources increased the leaf boron concentration and the means were recorded as 105, 170, 250 and 483 mg.kg^{-1} respectively. Sunflower growth and mineral nutrition were not affected negatively by the over leaf B concentrations.

***Key words**: boron sources, boron nutrition, boron toxicity, plant growth, sunflower.*

INTRODUCTION

Despite intensive researches have been made on the understanding of metabolic functions of boron (B) in plants for a long time, it is well known that B plays important roles on cell wall structure, lignification, carbohydrates metabolism, RNA metabolism, IAA metabolism, phenol metabolism, pollen germination, fruit set, structural and functional properties of biological membranes (Kacarand Katkat, 2010; Marschner, 2011).

Although, B has many functions on plant metabolism, many plants require quite low amount of B comparing the many other nutrients.

One of the most pronounced properties of B is that there is a narrow gap between the deficiency and toxicity levels in plants. It is true for B-sensitive plants, but it is not correct to generalize for all plants (Marschner, 2011).

Although, there is a little border between deficiency and toxicity levels in low-B requiring plants such as soybean, it is not valid for B-tolerant plants (Chepman et al., 1995). As in other nutrients, nutrient uptake and usage by the plants differs with many factors including genetically properties.

Nutrient uptake ability of plants can vary depending on the different plant species even they are grown in the same condition.

This variation can occur between the varieties of a plant species too.

In different studies these differences were emphasized and diversities of plants in terms of B uptakes were expressed (El-Sheikh et al., 1971; Paull et al., 1988; Paull et al., 1991; Taban and Erdal, 2000).

In a study conducted on the classification of plants demand in terms of B uptake capacity, plants were collected under 3 groups as: B demand is low (soil B:< 0.1 mg kg^{-1}), B demand is medium (soil B:0.1-0.5 mg kg^{-1}) and B demand is high (soil B:> 0.5 mg kg^{-1}) and sunflower took place in the high B demanding plants group (Berger, 1949; Kacarand Katkat, 2010; da Silva, 2016).

Asad et al. (2002) indicated that the youngest leaf B concentrations should be 25 mg kg^{-1} for 75 days sunflower plants to reach maximum shoot dry weight. In some other studies, it was implied that 32 - 35 mg kg^{-1} and 46 - 63 mg kg^{-1}

B is needed for maximum growth for different aged sunflower plants (Blamey et al., 1979; Rashid and Rafique, 2005).

According to the Bergman (1992), the youngest maturated leaf B concentrations should be 31-140 mg kg^{-1} for healthy sunflower growth. In a study worked on B toxicity in sunflower, it was found that B concentration of leaf increased up to 1870 mg $kg^{-1}$and the critical concentration of B toxicity was determined as 1130 mg kg^{-1}. Also in this study only 25% yield decrease was reported with 1870 mg kg^{-1} (Blamey et al., 1979).

In several studies, critical levels for B toxicity in sunflower leaves have been recorded as 100-700 mg kg^{-1}, >500 mg kg^{-1}, 925 mg kg^{-1} and 1150 mg kg^{-1} (Blamey, 1979; Aitken and McCallum, 1988; Cerda et al., 1981; Bergmann, 1992).

As B fertilizer, different B sources can be used. Although, borax ($Na_2B_4O_7 \cdot 10H_2O$), sodiumpentaborate ($Na_2B_4O_7$ 5 H_2O), boric acid (H_3BO_3) are the most used B fertilizer, some other B containing materials such as anhydrite borax (Na2B4O7) are used for fertilization purposes on different plants (Demirtaş, 2006; Kacar, 2013).

One of the aims of this study was to determine the effect of different B sources on B nutrition and growth of sunflower plant.

Also it was aimed to examine the sunflower response to the over leaf B concentrations.

MATERIALS AND METHODS

Study was conducted under greenhouse condition. As plant material, sunflower was growth until the flower bud period in 4 kg soil containing pots as 4 replications. Seven B sources were tested to see and compare the effects on plant growth, B nutrition and some other nutrient concentrations. B sources and some properties were given in Table 1 (Anonymous, 2016).

Four levels of B as: 0 (control), 5, 10 and 20 mg B kg^{-1} were given to the pots before sowing together with the 300 mg kg^{-1} N (as ammonium nitrate), 200 mg kg^{-1} P (as triple-superphosphate) and 150 mg kg^{-1} K (potassium sulphate) basal fertilizers.

The experimental soil was loamy (Bouyoucos, 1951) having pH 8.0 (1:2.5 soil to water ratio), 1.5 % $CaCO_3$, 1.1 % organic matter (Jackson, 1962), 13.6 mg kg^{-1} $NaHCO_3$ extractable P (Olsen et al., 1954), 115, 684, 37.5 mg kg^{-1} 1N NH_4OAC exchangeable K and Ca and Mg (Knudsen et al., 1982).

DTPA extractable Fe, Cu, Zn and Mn concentrations (Lindsay and Norwell, 1978) were 3.1, 0.64, 1.39 and 12.3 mg kg^{-1}, respectively. Soil B concentration extracted with 0.01M $CaCl_2$ was 1.1 mg kg^{-1}. Soil P concentration was determined with a spectrophotometer; K, Ca, Mg, Fe, Cu, Zn and Mn concentrations were measured with AAS and B concentration was determined with ICP (Kacar, 2009).

At the flower bud period, experiment was ended. Before harvesting, leaf samples were taken from the upper mostly developed leaves (Bergman 1992).

Then, whole plant was harvested above the soil. Samples were washed with top water and pure water than dried at 65^0C until the stable weight and weighted. Also, leaf samples were washed, dried and grinded for analysis.

Leaf samples were wet digested for mineral analysis. Leaf P concentrations were determined with a spectrophotometer (Shimadzu UV-1208) at 430 nm according to the vanadomolybdo phosphoric acid method. Potassium, Ca, Mg, Fe, Cu, Zn, and Mn concentrations were determined using AAS. Boron concentration of the leaf was measured with ICP (Kacarand İnal, 2008).

Analysis of variance (ANOVA) and Duncan's Multiple Range Test were conducted and least significant differences at the 5% level of probability estimated by COSTAT (CoHort Software, Washington, DC, USA) statistical program

Table 1. Some properties of B sources used for the experiment

Content	Unit	Amount
Anhydrate borax ($Na_2B_4O_7$)		
Content	Unit	Amount
B_2O_3	%	68 min.
Na_2O	%	30.27min.
SO_4	mg kg^{-1}	300max.
Cl	mg kg^{-1}	105max.
Fe	mg kg^{-1}	50max.
Boric acid (H_3BO_3)		
Content	Unit	Amount
B_2O_3	%	56.25min.
SO_4	mg kg^{-1}	500max
Cl	mg kg^{-1}	10max.
Fe	mg kg^{-1}	10max.
Etibor-48, powder (Borax pentahydrate, $Na_2B_4O_7.5H_2O$)		
Content	Unit	Amount
B_2O_3	%	47.76 min.
Na_2O	%	21.25 min.
SO_4	mg kg^{-1}	135 max.
Cl	mg kg^{-1}	70 max.
Fe	mg kg^{-1}	5 max.
Boron oxide (B_2O_3)		
Content	Unit	Amount
B_2O_3	%	98 min.
SO_4	mg kg^{-1}	500 max.
Cl	mg kg^{-1}	10 max.
Fe	mg kg^{-1}	35 max.
Etidot-67 ($Na_2B_8O_{13}.4H_2O$)		
Content	Unit	Amount
B_2O_3	%	67 min.
Na_2O	%	14 min.
Borax ($Na_2B_4O_7.10H_2O$)		
Content	Unit	Amount
B_2O_3	%	36.47 min.
Na_2O	%	16.24 min.
SO_4	mg kg^{-1}	135 max.
Cl	mg kg^{-1}	70 max.
Fe	mg kg^{-1}	10 max.
Etibor-48, granule (Borax pentahydrate, $Na_2B_4O_7.5H_2O$)		
Content	Unit	Amount
B_2O_3	%	48 min.
Na_2O	%	21.37 min.
SO_4	mg kg^{-1}	200 max.
Cl	mg kg^{-1}	70 max.
Fe	mg kg^{-1}	3 max.

RESULTS AND DISCUSSIONS

Effects of B sources and doses on plant growth

Different B sources and application doses did not affect plant growth, although some proportional increases or decreases were determined from B sources. Dry weight of above ground part of sunflower did not vary significantly with the B sources and their increasing levels. Plant dry weights showed variation between 44.1 pot-^{1} and 55.9 g pot-^{1} (Table 2).

Table 2. Effects of B sources and application doses on plant dry weights

B sources	B doses (mg kg^{-1})				
	0	5	10	20	Means
	Dry weights (g pot^{-1})				
Anhydrate borax	49.4	52.0	52.0	55.0	53.3
Boric acid	49.4	50.3	55.1	54.6	52.4
Etibor-48 (powder)	49.4	48.4	45.3	43.9	47.4
Boron oxide	49.4	47.5	44.1	45.0	45.5
Etidot-67	49.4	44.8	51.2	47.7	47.4
Borax	49.4	49.7	48.8	51.8	49.3
Etibor-48 (granule)	49.4	55.9	52.2	53.6	53.6
Means	49.4	49.8	49.8	50.2	49.9

Effects of B sources and doses on leaf B concentration

The individual effects of B sources and application doses and source x dose interactions affected leaf B concentration of sunflower significantly. Looking at the interactions, leaf B concentration showed a big variation between 105 and 718 mg kg^{-1}. Leaf B concentrations obtained from the all B sources showed increase with the doses. This tendency reflected to the means and leaf B concentrations determined from the each dose significantly varied from the others. While the lowest B concentration was measured from the control treatment, this value increased linearly with the increasing B doses. Under control treatment, leaf B concentration was found as 105 mg kg^{-1}, but this value increased 1.60, 2.38 and 4.60 times with 5,10 and 20 mg kg^{-1} application doses, respectively. According to the means, significant variations were found among the B sources (Table 3). While the lowest B concentrations were determined from the Anhydrate borax ($Na_2B_4O_7$) and Boric acid (H_3BO_3), the most effective source was the granule form of Etibor-48 ($Na_2B_4O_7.5H_2O$)

Table 3. Effects of B sources and application doses on leaf B concentrations

B sources	B doses (mg kg^{-1})				
	0	5	10	20	Means
	Leaf B concentrations (mg kg^{-1})				
Anhydrate borax	105 I*	130 GHI	191 FGH	387 BCD	203 c**
Boric acid	105 I	135 GHI	205 FGH	369 CDE	203 c
Etibor-48 (powder)	105 I	194 FGH	219 FGH	529 B	262 b
Boron oxide	105 I	187 FGH	206 FGH	438 BC	234 bc
Etidot-67	105 I	153 FGH	256 DEF	482 BC	249 bc
Borax	105 I	155 FGHI	243 DEFG	460 BC	241 bc
Etibor-48 (granule)	105 I	235 EFGH	428 BC	718 A	372 a
Means	105 *D****	170 *C*	250 *B*	483 *A*	

* Interaction effect; **source effect; ***dose effect. There is not significant difference between the values sharing the same letters.

Effects of B sources and doses on leaf mineral nutrition

The effects of different B sources and their application doses on P, K, Ca and Mg concentrations of sunflower were presented in Table 4. Boron sources and source x dose interaction significantly affected leaf P levels. Looking at the interaction leaf P concentrations were collected under two groups with the values between 0.19% and 0.28%. Similarly, also B sources were collected in two groups in terms of their effect on leaf P. On leaf K and Mg concentrations, only B sources had significant effect. Leaf K concentrations changed between 4% - 5% and Mg concentrations changed between 0.23% – 0.30%. Individual effects of sources and levels were found to be significant on leaf Ca concentrations. Leaf Ca concentrations obtained from the highest B doses (10 mg kg^{-1}) significantly decreased comparing to obtained from the other B levels. Calcium concentrations in leaves of sunflower showed significant variations between 2.11% - 2.90% under different B sources. While the highest Ca concentration was measured from the boric acid applied plants, the lowest was determined from the Etidot-67 applied parcels.

The effects of individual factors and their interaction were not significant on leaf Mn and Zn concentrations. However, source x dose interaction affected leaf Fe and Cu concentrations, significantly. When looked at the Fe and Cu values depending on the interactions, it was seen that Fe and Cu concentrations varied between 71 mg kg^{-1} - 115 mg kg^{-1} and 7.6 mg kg^{-1} - 11.4 mg kg^{-1} respectively. These variations were 104 mg kg^{-1} – 130 mg kg^{-1} and 35 mg kg^{-1} – 55 mg kg^{-1} for Mn and Zn (Table 5).

Table 4. Effects of B sources and application doses on P, K, Ca and Mg concentrations

B sources	B doses (mg kg^{-1})				
	0	5	10	20	Means
			P (%)		
Anhydrate borax	0.19 E*	0.20 DE	0.24 A-E	0.24 A-E	0.22 b
Boric acid	0.27 AB	0.27 AB	0.26 ABC	0.28 A	0.27 a
Etibor-48 (powder)	0.27 AB	0.26 ABC	0.25 A-E	0.24 A-E	0.26 a
Boron oxide	0.23 A-E	0.23 A-E	0.20 DE	0.20 DE	0.22 b
Etidot-67	0.20 DE	0.20 DE	0.20 DE	0.22 A-E	0.21 b
Borax	0.21 CDE	0.23 A-E	0.26 ABC	0.24 A-E	0.25 a
Etibor-48 (granule)	0.21 CDE	0.24 A-E	0.20 DE	0.22 A-E	0.22 b
			K (%)		
Anhydrate borax	4.2	4.6	4.6	4.9	4.60 bc**
Boric acid	5.2	5.1	4.8	4.9	5.00 a
Etibor-48 (powder)	5.0	4.8	4.8	4.4	4.75 ab
Boron oxide	4.3	4.3	4.1	4.1	4.20 cd
Etidot-67	3.9	4.0	4.0	4.0	4.00 d
Borax	4.3	4.3	5.0	4.6	4.55 bc
Etibor-48 (granule)	4.4	4.4	4.2	4.2	4.30 cd
			Ca (%)		
Anhydrate borax	2.60	2.77	2.74	2.64	2.69 bc
Boric acid	3.10	2.80	2.90	2.83	2.90 a
Etibor-48 (powder)	2.83	2.72	2.74	2.60	2.72 ab
Boron oxide	2.50	2.53	2.45	2.06	2.39 d
Etidot-67	2.08	2.14	2.09	2.14	2.11 e
Borax	2.50	2.38	2.68	2.34	2.46 cd
Etibor-48 (granule)	2.59	2.46	2.42	2.26	2.43 d
Means	2.6 *A******	2.54 *AB*	2.57 *A*	2.41*B*	
			Mg (%)		
Anhydrate borax	0.28	0.28	0.28	0.27	0.28 ab
Boric acid	0.32	0.29	0.3	0.29	0.30 a
Etibor-48 (powder)	0.29	0.28	0.29	0.26	0.28 ab
Boron oxide	0.26	0.25	0.24	0.22	0.24 cd
Etidot-67	0.23	0.23	0.23	0.23	0.23 d
Borax	0.27	0.25	0.30	0.28	0.28 ab
Etibor-48 (granule)	0.27	0.27	0.25	0.25	0.26 bc

* Interaction effect; **source effect; ***dose effect. There is not significant difference between the values sharing the same letters.

Table 5. Effects of B sources and application doses on Fe, Cu, Mn and Zn concentrations

B sources	B doses (mg kg^{-1})			
	0	5	10	20
	Fe (mg kg^{-1})			
Anhydrate borax	109 ABC*	84 E-K	87 E-K	109 ABC
Boric acid	95 C-G	100 A-D	98 B-E	90 E-J
Etibor-48 (powder)	84 E-K	89 E-K	78 G-K	71 K
Boron oxide	76 H-K	76 H-K	83 E-K	80 F-K
Etidot-67	77 G-K	83 E-K	74 I-K	115 A
Borax	87 E-K	87 E-K	113 AB	86 E-K
Etibor-48 (granule)	91 D-I	87 E-K	73 JK	94 C-G
	Cu (mg kg^{-1})			
Anhydrate borax	8.4 BCD	8.3 BCD	8.7 A-D	10.9 AB
Boric acid	10.2 A-D	11.4 A	11.1 AB	10.1 A-D
Etibor-48 (powder)	10.9 AB	10.7 AB	8.9 A-D	8.6 A-D
Boron oxide	9.6 A-D	9.4 A-D	7.9 CD	8.3 B-D
Etidot-67	8.8 A-D	9.2 A-D	8.7 A-D	8.6 A-D
Borax	7.6 D	8.6 A-D	9.9 A-D	10.5 ABC
Etibor-48 (granule)	10.2 A-D	10.4 ABC	8.8 A-D	8.9 A-D
	Mn (mg kg^{-1})			
Anhydrate borax	112	105	112	122
Boric acid	121	118	122	130
Etibor-48 (powder)	125	125	114	104
Boron oxide	117	123	104	106
Etidot-67	106	104	114	110
Borax	107	117	126	125
Etibor-48 (granule)	125	125	119	117
	Zn (mg kg^{-1})			
Anhydrate borax	40	47	45	45
Boric acid	55	47	46	43
Etibor-48 (powder)	40	43	40	35
Boron oxide	41	47	46	35
Etidot-67	42	39	36	44
Borax	45	36	47	42
Etibor-48 (granule)	49	46	43	35

* Interaction effect. There is not significant difference between the values sharing the same letters.

If an evaluation was made depending on the results obtained, there was not significant differences between the values weather obtained from the under control (–B) conditions or obtained from the B applied conditions. Because plants could take enough B from the soil and that was sufficient for sunflower growth. So, un-application of B did not result any B deficiency in plant. When considered that sufficiency range of sunflower in this period was between 35 - 150 mg kg^{-1}, plant managed to take sufficient B from the soil even under –B conditions (Jones and Wolf, 1996). In a study conducted by Aquino et al. (2013), it was indicated that sunflower leaf B concentration under –B condition reached up to 126 mg kg^{-1}, and the reason for this was explained with the high available soil B content. As seen from the soil analysis, experimental soils contain high amount of available B (1.1 mg kg^{-1}) and sunflower took the enough B for its growth (da Silva, 2016). In different studies, it is implied that sunflower takes place among the plants that are capable of higher B uptake capacity (Tanaka, 1967; Shorrocks, 1992; Souza, 2004). In a study conducted for a long time ago, it was indicated that soil should contain over than 0.5 mg kg^{-1}available B for optimum sunflower growth (Berger, 1949). Similarly, Silva and Ferreyra (1998) stated that soil B concentration should be more than 0.45 mg kg^{-1} for health sunflower growth. So, not applying of B did not border plant growth. In a study, application of 0, 1, 2, 3 and 4 kg ha^{-1} B to the B sufficient soil, did not affect sunflower growth and yield (Bonacin et al., 2009). Also, Marchetti et al. (2001) informed that B sources and doses did not affect plant height and stem diameter and this was related to B concentration of experimental soil.

Here in this study, the most attractive situation rather than B deficiency is the extreme increases of leaf B concentration with the B doses. As seen from the results, leaf B concentrations of sunflower so increased that these levels can be accepted as toxic for most of the plants. But sunflower growth were not affected negatively from these B concentrations. Demirtaş (2005) states that some of the plants don’t show characteristic B toxicity symptoms, and sunflower is one them. Blamey et al. (1997) informed the critical B toxicity level in sunflower leaves as 1130 mg kg^{-1}. In different studies, sunflower plants were indicated as high B requiring plants, so they were not affected by the high soil B (Gomez Rodriguez et al.,1981; da Silva, 2016).

Most of the other nutrients were not affected from the B levels and doses. Although, in the highest B doses leaf Ca concentrations decreased (Dechenand Nachtigall, 2006; Turan et al., 2009), all the nutrients determined in the leaf were sufficient for the optimum sunflower growth (Prado and Leal, 2006; Zobiolevd, 2010). If general evaluations were made in terms all B sources had effect on the increment of leaf B concentration. Also, plant growth was not effected negatively from the all B sources. At the same time, other nutrient concentrations obtained from the B sources were between the sufficiency ranges. As indicated previous studies some B sources such as anhydrate borax, borax pentahydrate, sodium pentaborate, solubor, boric acid etc. can be used for fertilization (Demirtaş, 2006; Gupta, 2007; Kacar, 2013).

CONCLUSIONS

As a result, all B sources increased leaf B concentrations even there were some differences among them. Sunflower took sufficient B from the soil even no fertilization was made, and the B concentration of plant increased up to 718 mg kg^{-1} with B applications. Despite the high B concentrations, sunflower growth was not affected, and the other nutrient concentrations kept their ideal concentrations. So, it can be said that all B sources can be used for B fertilization. And sunflower can be growth under high B containing soils. Also it can be said that there is not a narrow range between B deficiency and toxicity levels for sunflower.

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REFERENCES

Aitken R.L., McCallum L.E., 1988. Boron toxicity in soil solution. *Australian Journal of Soil Research* 26: 605-610.

Anonymous 2016. http://www.etimaden.gov.tr/files/files/EtiMadenSpektler2016%2002.pdf

Aquino L.A., Silva F.D.B., Berger G., 2013. Agronomic characteristics and nutritional status of irrigated sunflower cultivars. *Revista Brasileira De Engenharia Agrícola E Ambiental* 17: 551-57.

Asad A., Blamey,F.P.C., Edwards D.G., 2002. Dry matter production and boron concentration of vegetative and reproductive tissues of canola and sunflower plants grown in a nutrient solution. *Plant and Soil* 2: 243–252.

Berger K.C., 1949. Has complied tables of the boron content and requirements of various crops.*Avdan, Argon* 1.

Bergmann W., 1992. *Nutritional disorders of plants*: Development, visual and analytical diagnosis, 741. Jena, Stuttgart, New York: Gustav Fischer Verlag.

Blamey F.P.C., Asher C.J., Edwards D.G., 1997. Boron toxicity in sunflower. In *Boron in soils and plants* 145-149. Netherlands, Springer.

Blamey F.P.C., Mould D., Chapman J., 1979. Critical boron concentrations in plant tissues of two sunflower cultivars. *Agronomy Journal* 71: 243-247.

Bonacin G.A., Rodrigues T.J.D., Cruz M.C.P. et al., 2009. Morphophysiological characteristics of seed and production of sunflower as function of boron in soil. *Revista Brasileira de Engenharia Agrícola Ambiental* 13: 111-116.

Bouyoucos G.J., 1951. A recalibration of the hydrometer method for making mechanical analysis of the soils. *Agronomy Journal* 43: 434-438.

Cerda A., Salinas R.M., Romero M., 1981. Tolerancia del girasol (*Helianthus annuum* L.) al boro. In *Anales de edafologia y agrobiologia* 40: 2245-2253.

Chapman V. J., Edwards D.G., Blamey F.P.C., Asher C.J., 1997. Challengingthe dogma of a narrrowsupplyrangebetweendeficiencyandtoxicity of boron. *In Boron in Soils and Plants. Proceedings*, eds. R. W. Belland B. Rerkasem, 151-155. Dordrecht, theNetherlands: KluwerAcademicPublishers.

Da Silva F.D.B., de Aquino L.A., Panozzo L.E., Lima T. C., Berger P.G., Dias D.C.F.D.S., 2016. influence of boron on sunflower yield and nutritional status. *Communications in Soil Science and Plant Analysis 47*(7): 809-817.

Dechen A.R., Nachtigall G.R., 2006. Micronutrientes. In Mineral nutrition of plants, ed. M. S. Fernandes, 327–374. Viçosa, Brazil: SociedadeBrasileira de Ciência do Solo.

Demirtaş A., 2005. Boron in plantanditsfunctions. *Journal of theFaculty of Agriculture 36* (2): 217-225.

Demirtaş A., 2006. Boron compounds and their potential of use in agriculture. *Atatürk University, Journal of Agriculture Faculty* 37 (1): 111-115.

El-Sheikh A.M., Ulrich A., Awad S.K., Mawardy A.E., 1971. Borontolerance of squash, melon, cucumber, andcorn. *Journal of the American Society for Horticultural Science* 96**:** 536-537.

Gomez Rodriguez M.V., Gomez Ortega M., Alvarez Tinautboron M.C., 1981. Copper, iron, manganese and zinc contents in leaves of flowering sunflower plants (*Helianthus annuus*, L.), grown with different boron supplies, *Plant and Soil* 62: 461- 464.

Gupta U.C., 2007. Boron. *Handbook of plant nutrition*, Tylorand Francis group CRC Press.

Jackson M.L., 1962. *Soil chemical analysis*. Prentice-Hall, Inc., Englewood Cliffs, N.S

Jones J.B., Benjamin W., 1996. Plantanalysishandbook II: a Practical Sampling, Preparation, Analysis, and Interpretation Guide.

Kacar B. 2009. *Soil analysis*. Ankara: Nobel Press.

Kacar B. 2013. *TemelGübreBilgisi*. Ankara: Nobel Press.

Kacar B., İnal A., 2010. *Plant analysis*. Ankara: Nobel Press.

Kacar B., Katkat A.V., 2010. *Plant nutrition*. Ankara: Nobel Press.

Knudsen D., Peterson G.A., Pratt P.F., 1982. *Lithium, sodium and potassium. methods of soil analysis,* Part 2. Chemical and microbiological properties. Exchange able Cations.

Lindsay W.L., Norwell W.A., 1978. Development of A DTPA test for zinc, iron, manganese and copper. *Soil Science Society of American Journal* 42: 421-428.

Marchetti M.E., Motomya W.R., Fabrício A.C. et al., 2001. Sunflower response to sources of boron levels. *Acta Scientiarum* 23:1107-1110.

Marschner H., 2011. *Marschner's mineral nutrition of higher plants*. Academic Press.

Olsen S.R., Cole A.V., Watanable F.S., Dean L.A., 1954. *Estimation of available phosphorus in soil by extracting with sodium bicarbonate.* U.S. Dept. of Agric. Circ. 939**.** Washington D.C

Paull J.G., Cartwright B., Rathjen A.J., 1988. Responses of wheat and barley genotypes totoxicconcentrations of soilboron. *Euphytica* 39(2): 137-144.

Paull J.G., Rathjen A.J., Cartwright B., 1991. Major gene control of tolerance of breadwheat (*Triticum aestivum* L.) tohighconcentrations of soil boron. *Euphytica 55*(3): 217-228.

Prado R.M., Leal R.M., 2006. Nutritional disorders by deficiency in sunflower Var. Catissol-01. *Pesquisa Agropecuária Tropical*, 36:187-93.

Rashid A., Rafique E., 2005. Internal boron requirement of young sunflower plants: diagnostic criteria. *Communications in soil science and plant analysis* 36 (15-16): 2113-2119.

Shorrocks V.M., 1992. Boron: *A Global Appraisal of the Occurrence, Diagnosis and. of Boron Deficiency*. In Proc. Int. Symp. On the Role of Sulfur, Magnesium and Micronutrients in Balanced Plant Nutrition; Portch, S., ed.; Potash and Phosphorus Institute: Hong Kong *Correction* 39-53.

Silva F.R., Ferreyra F.F., 1998. Evaluation of boron extractors in soils of Ceará State, Brazil. *Revista Brasileira De Ciência Do Solo* 22:471-78.

Souza A., Oliveira M.F., Castiglioni V.B.R., 2004. The boron on sunflower plants. Semina, Londrina 25: 27-34.

Taban S., Erdal I., 2000. Effects of boron on growth of various wheat varieties and distribution of boron in aerial part. *Turkish Journal of Agriculture and Forestry 24*(2): 255-262.

Tanaka H., 1967. Boron adsorption by plant roots.*Plant and soil 27* (2): 300-302.

Turan M.A., Taban N., Taban, S., 2009. Effect of calcium on the alleviation o boron toxicity and localization of boron and calcium in cell wall of wheat. *Notulae Botanicae Hort iAgrobotanici Cluj-Napoca* 37(2): 99-103.

Zobiole L.H.S., Castro C., Oliveira F.A., Oliveira Júnior, A., Moreira A., 2011. Sunflower micronutrient uptake curves. *Ciência E Agrotecnologia* 35: 346-353.

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THE INFLUENCE OF CLIMATIC FACTORS IN THE PROCESS OF SOIL EROSION

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Abstract

The main consequences of ecological imbalances generated by lands erosion were consisting in decreasing or bringing back, sometimes until cancellation, the soil's capability of production, the surface and groundwater drainage system's disruption, being strongly influenced by climatic elements specific to the area. Climate represents a very important factor for the multiannual environment regime of the weather's processes and phenomena's, characteristic to Rodnei Mountains National Park, determined by solar radiation, general circulation of the atmosphere, which varies in connection to the height, positioning and configuration of the landform. The elements and evolution of the climatic changes play a very important role in the context of soil erosion. The current paper illustrates the evolution of climatic factors from the last 9 years of the studied area – Rodnei Mountains National Park, Romania. For the studied area, it was taken into account the execution of an analysis of the following climatic factors: air humidity, temperature, precipitations, the direction and speed of the wind. Through the study and research of the climatic elements, delivered by National Institute of Meteorology and Hydrology – Cluj, we can say that the temperature, precipitations, humidity, the wind direction and speed, not only favours the erosion processes, but it also accelerates their apparition, when they aren't closely watched. The analysis of every climatic factor leads to a truthful appreciation of the probability that a certain territory may be exposed to erosional processes.

***Key words**: soil erosion, climatic factors, Rodnei Mountains National Park.*

INTRODUCTION

Soil erosion is determined mostly by landform, climate (air temperature, atmosphere precipitations, air humidity, meteorological phenomena, wind and its direction), soil, solidification rock, vegetation and soil exploitation.

The elements and evolution of the climatic changes play a very important role in the context of soil degradation.

Air temperature has a big importance in the line of climatic factors that influence soil degradation, its evolution being connected to the solar radiation regime.

Given the temperature differences between the areas where pressure is higher and lower, the wind leads the air and causes multiple consequences over the terrains, especially in the areas where the wind continuously blows and in a dominant direction.

Wind erosion is intensified in the steppe and desert regions, especially where the soil's composition is of sandy conformation or composed of silt. When pursuing the wind, we have to take into account its direction, intensity and the air masses duration of movement. Due to landforms, season's succession and temperature modifications, the direction and speed of wind are visibly influenced.

Atmospherically precipitation being a hard to measure meteorological element, carries some inherent errors related mainly to the wind's action and evaporation.

It is obvious that, along with the increasing altitude and the implicit raise of solid precipitations share out of the total annual precipitations, the wind's action determines the raise of measurement errors through the reduction of the real quantity.

Air humidity is the amount of water vapours from the atmosphere and is caused by the air masses' peculiarities and by the local characteristics of the active surface.

Air humidity increases around water basis, vegetal massifs, forests, because these are sources of evaporation and evapotranspiration. By condensing water vapours give birth to clouds, liquid and solid precipitations and fog is formed.

The area for which the analysis of climatic factors was drawn is the Rodnei Mountains National Park (Figure 1), the geographical space that overlaps over the area of geographic and morphological contact of Rodnei Mountains, being an integral part of the Oriental Carpathians, from the Nordic Group.

The park's area spans over two counties: Bistrița-Năsăud (BN) and Maramureș (MM).

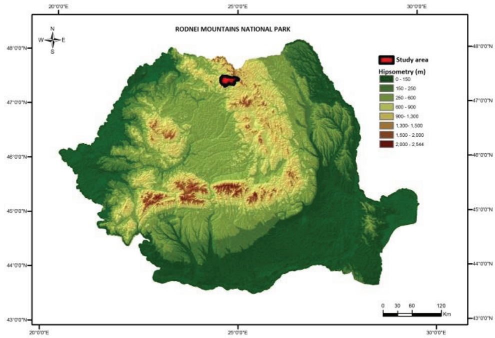

Figure 1. Study area

The surface area of Rodnei Mountains National Park is 47,177 ha (Management Plan, 2014).

MATERIALS AND METHODS

In order to get a characterization of the targeted area from a climatic point of view, we used the values recorded in the 2006-2015 span from the Iezer station (placed in the Rodnei Mountains National Park), delivered by the National Institute of Meteorology and Hydrology Cluj. These were processed in order to deliver data in connection to highlighting the climatic evolution in the studied area.

RESULTS AND DISCUSSIONS

Average annual rainfall

Rainfall represents one of the most dynamic factors that influence the erosion process.

Water drops that touch the surface of the soil detach and carry soil particles from the formation place to greater or smaller distances, depending on the kinetic energy they possess (Ceaușu et al., 1976).

Raindrops erosion appears in the moment when the rain drops, while falling, strike the soil's surface, dislodging particles, which however, get transported aerially on short distances, under 1.5 m (www.geography.ro).

Table 1. Average Monthly Precipitation 2006-2015 (l/m^2)

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Year	**Precipitation (l/sq m)**											
2006	28.1	62.7	231.7	112.1	263.4	213.3	83.2	245.3	49.6	54.8	110.1	28.8
2007	197.5	126.6	96.8	58.7	184.7	102.0	225.1	99.5	199.3	58.3	150.3	53.6
2008	72.0	50.7	231.8	165.6	203.1	143.5	272.8	105.6	102.1	121.1	84.1	77.8
2009	53.2	72.1	123.5	38.9	124.6	155.9	54.5	166.7	43.5	210.6	114.7	117.6
2010	67.4	95.5	86.8	101.9	226.5	197.8	202.5	138.8	142.3	71.9	170.0	150.8
2011	49.4	48.6	41.0	94.0	71.7	200.0	226.8	57.0	90.6	36.8	1.2	149.0
2012	106.0	73.9	44.4	125.9	158.5	196.9	114.3	79.7	79.6	117.8	79.4	73.2
2013	83.6	48.9	115.6	77.4	123.6	156.0	20.9	131.7	112.7	19.7	100.7	37.3
2014	68.2	29.5	40.4	92.5	153.0	91.3	158.1	167.9	41.1	72.8	3.9	78.9
2015	98.3	43.5	65.0	112.4	148.5	78.4	73.9	37.1	81.4	26.1	178.7	30.8

Based on the monthly values for each year, the average annual rainfall was calculated.

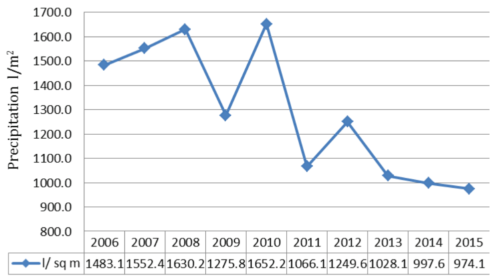

Figure 2. Average annual rainfall (l/m^2)

The maximum of average annual rainfall was registered in 2010, being 1652 l/m^2, and the minimum of rainfall is in the year of 2015, being of 974.1 l/m^2.

As a general average of the last nine years, pluviometri optimal is registered in the depressionary area (1400 m) and the beginning of the mountain stage (1900 m), being of 1000 l/m^2.

Average annual temperature

The air's temperature is the most important parameter that favours the erosion process's appearance through the snow's sudden melting. From 2006, the average annual temperature has increased slightly by 0.4°C until 2009, returning around the values of 2.3°C in 2010, expected to reach the maximum of the last 10 years of 3.9°C in the year of 2014. Still, we notice a slight warming in the last 5 years compared to the preceding years, according to Figure 3.

Table 2. Average Monthly Temperature (°C)

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Year	**Average Temperature (°C)**											
2006	-7.0	-8.3	-5.3	1.3	4.5	8.3	11.8	10.0	7.2	4.5	-1.0	-2.3
2007	-4.8	-5.1	-1.6	-0.1	8.2	10.8	12.2	12.3	5.2	2.7	-3.6	-4.3
2008	-4.7	-5.2	-4.1	0.8	5.7	10.0	10.4	11.9	5.5	3.9	0.4	-3.7
2009	-5.5	-7.5	-5.3	3.7	6.1	9.8	12.1	11.1	8.1	2.6	0.8	-4.9
2010	-8.1	-5.5	-4.5	1.0	6.4	10.2	12.3	13.1	6.0	0.4	2.2	-6.1
2011	-6.8	-6.1	-2.9	0.6	6.6	9.7	11.3	12.1	9.2	1.8	-1.1	-4.1
2012	-8.9	-10.3	-5.0	2.2	7.2	11.1	14.9	12.2	10.4	5.1	1.6	-5.7
2013	-6.8	-4.8	-4.6	2.6	8.3	10.6	11.2	12.3	3.9	4.7	1.2	-2.7
2014	-2.2	-0.2	-0.5	2.4	5.9	8.6	11.6	11.2	8.0	5.0	1.3	-4.3
2015	-4.9	-5.3	-3.4	-1.3	6.8	9.9	12.8	13.6	9.7	3.5	0.9	-2.9

The lowest temperatures are registered in the winter months, January and February, ranging between -10 and -3° C, while the maximum ones are ranged between 10 and 13° C in the summer months, from May until the end of August.

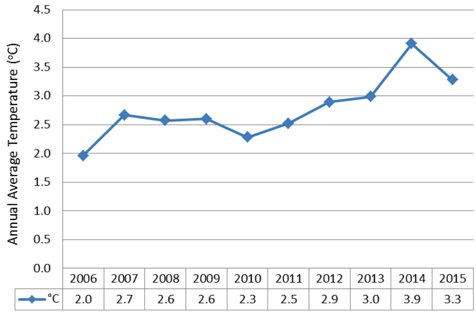

Figure 3. Average Annual Temperature (°C)

Humidity

Depending on the values of relative humidity (f), according to the World Meteorological Organization, the air is characterized from a hygrometrically point of view as: f > 100% - oversaturated; f = 100% - saturated; f = 81-90% - wet; f = 51-80% - normal; f = 31-50% - dry; f ≤ 30% - very dry.

Table 3. Humidity (%)

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Year	**Humidity (%)**											
2006	70	86	88	83	76	83	75	83	81	71	82	68
2007	89	87	75	68	79	76	75	81	85	77	89	68
2008	72	76	87	79	76	75	80	75	82	77	76	79
2009	73	88	88	71	75	82	75	78	79	83	82	83
2010	83	88	82	77	81	89	85	82	85	74	75	85
2011	84	79	78	85	84	94	86	85	81	81	69	88
2012	89	85	82	81	82	81	71	76	77	78	73	77
2013	89	78	81	82	77	85	80	78	84	75	79	65
2014	80	67	74	81	81	77	83	80	72	74	75	84
2015	81	69	81	85	83	82	79	76	83	80	78	77

The registered humidity by the Iezer Meteorological Station is presented down below according to the diagram:

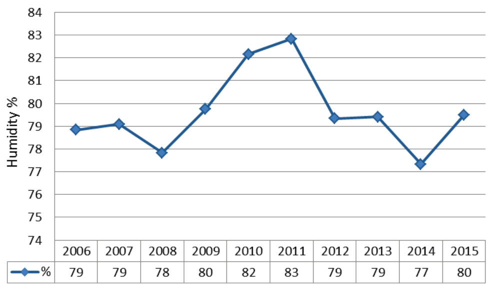

Figure 4. Average annual Humidity (%)

Following the diagram, we can say that humidity in the Rodnei Mountains National Park maintains itself at high levels, approximately around 80%, with differences dependent on altitude, vegetation, slope position, being a normal-wet humidity.

Wind speed

The winds have a higher frequency on heights, where they can reach values of over 90 km/h (25 m/s).

Table 4. Wind speed (m/s)

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Year	**Wind speed (m/s)**											
2006	3.2	3.0	5.1	2.2	3.4	2.6	1.7	2.9	3.2	2.5	4.4	3.2
2007	7.1	3.2	4.9	2.4	3.6	2.8	3.2	2.2	3.1	2.4	4.1	2.6
2008	4.4	4.6	5.2	3.5	2.7	2.3	3.6	2.7	2.1	2.2	3.3	4.4
2009	3.7	2.2	3.5	2.1	3.0	3.6	2.6	2.0	2.2	3.5	4.6	2.5
2010	2.5	2.7	4.5	2.2	3.5	2.6	1.7	3.3	2.1	1.9	6.3	3.0
2011	2.1	3.3	2.5	2.7	2.4	2.3	2.9	1.4	2.7	1.8	1.1	3.5
2012	4.0	4.1	3.7	3.3	2.9	2.7	2.6	2.0	2.7	3.7	3.1	2.8
2013	3.7	3.1	2.7	3.1	1.8	1.2	2.0	1.2	2.8	2.4	3.2	3.2
2014	3.4	3.2	2.4	2.9	1.9	1.9	2.2	2.2	2.5	2.2	2.0	3.5
2015	4.7	1.9	2.5	3.9	2.6	1.2	2.6	2.2	3.6	2.3	4.3	3.7

In high areas, we have frequent wind speeds of over 50 - 60 km/h. Generally, the average wind speed over the whole surface of the park is of 3 m/s (10.8 km/h).

Studying wind speed and direction is particularly important in the context of wind erosion. In areas where logging was performed, the wind accelerates the erosion process through decreasing soil layer, changing the physic-chemical and biological properties.

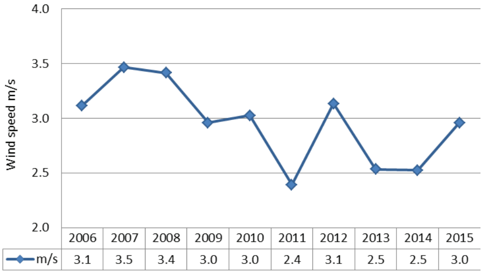

Figure 5. Wind speed (m/s)

Winds with high frequency are the SV, SE, S and then the NE, NNE şi V.

Table 5. Wind direction (%)

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Year	Wind direction											
2006	SSV	SV, VSV	SE	S, SV, NE	SV, NE	SV, ENE	ESE	SV	SSV	NE	SV, SSV	S, SV, E
2007	S	S	SV, NE	S	SV, NE	SV, V, VSV, NE	SV	SV	VSV	N	SV, V, SE	SE
2008	S, SE	S	SV	V, SV	SV, NE	SV	SSV	SV	SSV	SSE, S, SV	SV	SV
2009	SV	SV	SV	SV	VSV, V	E, S	SV, SE	E, NE	S	E	V	VSV, SV
2010	VSV, SV	SV	V	VSV, SV	VSV, SV	SV	SV	VSV, SV, S	SV	SV, SSV	S	E
2011	SV, S, VSV, SE	SE	V	SSE, SE	ESE, E	SSE, SV	SV, S	SV	SE	VSV	S	S
2012	E	SV, VSV	S	S	E, SE	SE	V	SE	VSV	V	VSV	SV
2013	SV	SE, SV	SV	SV	V	SV	S	E	SE	S, SSV	SV	VSV, S
2014	SV	VSV	SE	NE, NNE, E, ENE, SV	NE, SV	NE, NNE	SSV	SV	SV, NE	SSV	S	SV
2015	V	S	SV	S	S, SV, V	SV, SE	NE	SV	VSV	V	SSV	S, SSV

CONCLUSIONS

In order to play as faithfully as possible the situation and in achieve an interpretation as correctly as possible, we have used the climatic values registered at the closest to the area of study meteorological station (Iezer Station).

For the works designed to fight soil erosion we analyse the climate elements with values registered for a longer period of time.

Climatic elements, especially rainfall, have a major role in determining water and soil spills on mountain sides and water flows. Likewise, it contributes to sizing and applying the most corresponding works of soil protection. Regarding the climatic element - temperature, in the studied range of 2006-2015, an average temperature of 3.08°C has been registered. The wind's average speed, possessing a value of 3 m/s is classified as "weak wind" (1.8-3.3 m/s, according to the empirical scale for describing wind speeds - Beaufort scale of wind speed). The air currents that run on large areas, areas that don't have continuous vegetal coating, causes in time the erosion phenomena's apparition.

For the studied area, following the humidity analysis, an average value of over 80% has resulted, being strongly influenced by the hypsometric steps, vegetation and wind speed.

Thus, these four climatic factors offer essential information in the context of erosion.

REFERENCES

Ceaușu N., Florescu Gh., Mureșan D., Pleșa I., Popescu I., Vaisman I., 1976. Land Reclamation. Didactic and Pedagogic Publishing House, Bucharest

***Rodnei Mountains National Park, Management Plan, 2014.

***http://www.geography.ro/rapoarte/Raport_stiintific_iunie_2007-2.pdf.

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ENVIRONMENTAL IMPACT OF TRANSGENIC COTTON ON PHYSICOCHEMICAL QUALITIES OF SOIL ECOSYSTEMS IN NORTHERN KARNATAKA, INDIA

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Abstract

One of the very least understandings of ecological risk assessment is the impact of genetically modified crops on biotic and abiotic factors. Even though, farmers have adopted transgenic crops in large scale because of high yield and immediate financial gain. Key factor to be considered in the development of a genetically modified plant is the assessment of its safety. Transgenic crops may have the potential to influence the soil in which they are growing through the release of the Bt proteins in root exudates or from sloughed or decaying plant material. The present study aims to determine the impact of Bt cotton on soil physical and chemical properties of agricultural lands of three districts of Karnataka, India. About 21 parameters have been studied and determined that were significant differences in the soil nutrients such as nitrogen, potassium and other essential salts such as calcium and magnesium between transgenic and Non-transgenic cotton growing field. All results obtained in the present work suggested that there is no notable significant impact to specify any negative effects of transgenic cotton on the soil properties.

Key words: *Bt proteins, physicochemical properties, root exudates, soil ecosystem, transgenic cotton.*

INTRODUCTION

In India, cotton crop is an important agricultural crop which is playing a vital role in economy of the country through supporting millions of lives by cultivation, processing and trading of this industrial crop. India ranks second in cotton production with 6423 metric tons after China. In recent years, cotton cultivation area is fluctuating between 8-9 million hectares. Insects and pests are the most important pathogens to reduce the cotton production by infecting during various stages of growth. Loses up to 60% is caused by defoliators, tissue borers or bollworms and sap suckers. Considerable benefits such as increase in crop yield through the control of plant diseases and reduction in the use of chemical fertilizers and pesticides have been noticed by the use of transgenic crops. In recent times, several concerns remain on the impact of transgenic organisms for their adverse effect on soil ecosystem (Icoz and Stotzky, 2008). Soil biota is diverse in terms of their physiology, size and environmental requirements and that the composition and metabolic capabilities of soil biota communities underpin many soil processes. Plant-microbe interactions also play a critical role in variety of biological functions in the rhizosphere soil (Nihorimbere et al., 2011). Plant residues as well play an important role in these interactions which includes leaf litter and root exudates from Bt cotton that could potentially influence soil ecosystem functions. It is well known that Bt Cotton plants produce Bt-toxin in above-ground parts. Many researchers have suggested that Bt-toxin is also released from roots, and could bind to clay minerals in soil, raising concerns about the persistence of the toxin (Saxena and Stotzky, 2000; Knox et al., 2008; Audiseshamma et al., 2014).

Alteration in the soil ecosystem ultimately affects the microbial dynamics, availability of soil microbial diversity, soil functions such as nutrient mineralization, carbon turnover, plant growth promotions and biodegradation processes (Dunfield and Germida, 2004; Stotzky, 2004; Beura and Rakshit, 2011). Among researchers, there is a concern about the transgenic crop release of Bt toxins in to the soil environment which may reduce soil fertility as changes in chemical and biological activities. Changes in the soil ecosystems may include changes in microbial dynamics, soil biodiversity, nutrient mineralization, plant growth and biodegradation of agrochemicals because they usually produce insecticidal Cry proteins (Bt toxin) through all parts of the plant (Icoz and Stotzky, 2008). Over the last decade, many researchers carried out research on the assessment of the usage of genetically modified crops and microorganisms in agriculture promotion (Sharma and Ortiz, 2000). Biosafety assessment of genetically modified crops is very important aspect to study their impact on soil ecosystem (Bruinsma et al., 2003; Kowalchuk et al., 2003).

Impact of genetically modified (GM) crops on soil microorganism especially rhizosphere are still least understood areas in the application of GM crops. Nutrient and essential element cycling is mainly takes place due to rhizosphere microorganisms. Any changes in the rhizosphere microbial community due to Bt toxin have either positive or negative impact on plant growth and environmental health (Dunfield and Germida, 2004). Plants are releasing 20% of their assimilates to the rhizospheric soil as root exudates and at the end of plant life, the residues of crops are released to the soil, any changes in the plant exudates or plants content have direct impact on rhizosphere microbes which ultimately affect the biogeochemical cycle and soil fertility (Whipps, 1990). Hence, the present work aims at studying the impact of transgenic cotton on soil physicochemical properties in Northern Karnataka, India.

MATERIALS AND METHODS

Study area

The study was carried out in three districts of Northern Karnataka, India where cotton is intensively grown for several years. Haveri is located in the middle of the State, with 14°80' N and 75°40' E of Latitude and Longitude respectively. Dharwad is located in the northwest of Karnataka with 15°27' N Latitude and 75°05' E Longitude. Belgaum is located in northwestern part of the state at 15°87′ N and 74°50′ E of Latitude and Longitude respectively. These three districts of Karnataka are known for cultivation of transgenic cotton crops regularly.

Soil collection and physicochemical analysis

Soil samples were collected from three districts such as Belgaum, Haveri and Dharwad of North Karnataka from Bt and Non-Bt cotton crop fields. Bt cotton fields were selected where Bt crops had been planted for more than ten years which was compared with the Non-Bt fields. Before sowing and after harvest, soil samples were collected in the depth of 25, 50 and 75 cm.

Composite samples were taken from random pits on profile basis using augur, totally 108 composite soil samples were analyzed. Physicochemical properties such as pH, Ca, Mg, Cl, available potassium, nitrate nitrogen, ammonical nitrogen, available phosphate, % oxidizable organic carbon, sulfur, sodium, zinc, iron, manganous and copper were analyzed using standard protocols for Bt and Non-Bt soil samples (Jackson, 1967; Trivedy and Goel, 1986).

Statistical analysis

The statistical differences among the data were determined by independent samples test in ANOVA at the 95% confidence interval of the mean with SPSS 16.0 version. Differences were considered $p \leq 0.05$ as significant.

RESULTS AND DISCUSSIONS

Duration of Bt-cotton planting at different sampling sites in the districts of Belgaum, Haveri and Dharwad of Northern Karnataka in India is given in Table 1.

Physicochemical properties of before sowing and after harvesting of BT and Non-Bt cotton soil samples of three districts have been analyzed and the results are given in Tables 2, 3 and 4. Data from this study suggests that, among 108 soil samples collected from three districts, the pH of all the collected soil samples were alkaline in nature.

The pH of the soil is not constant, which will change over time, based on the parent material, weathering and current agricultural practices (Icoz and Stotzky, 2008).

Table 1. Details of Bt-cotton planting at different sampling sites in Northern Karnataka, India

District	Sampling site	Soil type	Years of Bt-cotton grown prior to sampling
Belgaum	Gokak	Clay loam	14
	Athani	Clay loam	
	Belgaum	Clay to clay loam	
Haveri	Hangal	Clay loam	15
	Tavarmallihalli	Clay loam	
	Haveri	Clay loam	
Dharwad	Annigeri	Clay loam	13
	Dharwad	Black soil	
	Aminbhavi	Clay loam	

Table 2. Soil properties of Bt and Non-Bt cotton growing fields before sowing and after harvest in Belgaum District of Karnataka, India

Parameters	Before sowing		After harvest	
	NBT	BT	NBT	BT
pH	$8.01^{a}\pm0.31$	$9.10^{b}\pm0.21$	$8.50^{a}\pm0.27$	$8.41^{a}\pm0.15$
Ca meq/100g	$25.21^{a}\pm1.89$	$13.41^{b}\pm0.10$	$33.54^{a}\pm0.99$	$21.99^{a}\pm1.24$
Mg meq/100g	$6.91^{a}\pm0.41$	$10.62^{b}\pm0.01$	$13.32^{a}\pm0.30$	$9.08^{b}\pm0.59$
Cl meq/100g	$7.82^{a}\pm0.55$	$8.07^{a}\pm0.51$	$6.16^{a}\pm0.67$	$7.63^{a}\pm0.70$
Available Potassium Kg/ha	$123.28^{a}\pm1.63$	$145.53^{b}\pm0.94$	$141.84^{a}\pm0.70$	$137.11^{b}\pm1.37$
Nitrate Nitrogen Kg/ha	$7.32^{a}\pm0.71$	$4.78^{b}\pm0.50$	$7.00^{a}\pm0.90$	$4.77^{a}\pm0.73$
Ammonical Nitrogen Kg/ha	$46.07^{a}\pm0.73$	$12.62^{b}\pm0.83$	$32.49^{a}\pm0.04$	$22.87^{b}\pm0.65$
Available Phosphate Kg/ha	$17.16^{a}\pm0.56$	$13.17^{b}\pm0.16$	$9.58^{a}\pm0.64$	$9.90^{a}\pm0.75$
% Oxidizable Organic Carbon	$0.34^{a}\pm0.03$	$0.52^{b}\pm0.02$	$0.53^{a}\pm0.02$	$0.49^{a}\pm0.02$
Sulfur Kg/ha	$4.09^{a}\pm0.42$	$8.02^{b}\pm0.83$	$6.32^{a}\pm0.66$	$6.37^{b}\pm0.87$
Sodium meq/100g	$0.48^{a}\pm0.04$	$0.65^{b}\pm0.04$	$0.31^{a}\pm0.02$	$0.27^{a}\pm0.02$
Zinc ppm	$1.09^{a}\pm0.19$	$0.62^{b}\pm0.02$	$1.05^{a}\pm0.17$	$0.62^{b}\pm0.11$
Iron ppm	$1.30^{a}\pm0.16$	$2.56^{b}\pm0.25$	$1.88^{a}\pm0.19$	$1.91^{a}\pm0.12$
Manganous ppm	$18.57^{a}\pm0.61$	$24.45^{a}\pm0.71$	$21.73^{a}\pm0.92$	$22.72^{a}\pm0.76$
Copper ppm	$2.78^{a}\pm0.27$	$5.12^{b}\pm0.58$	$5.70^{a}\pm0.75$	$5.61^{a}\pm0.61$

NBT: Non-Bt cotton field soil sample; BT: Bt cotton field soil sample; Same superscript in the same row under each head is not significantly different; different superscript in the same row under each head is significantly different.

Table 3. Soil properties of Bt and Non-Bt cotton growing fields before sowing and after harvest in Haveri District of Karnataka, India

Parameters	Before sowing		After harvest	
	NBT	BT	NBT	BT
pH	$9.10^{a}\pm0.13$	$8.78^{a}\pm0.25$	$8.57^{a}\pm0.12$	$8.23^{a}\pm0.10$
Ca meq/100g	$13.60^{a}\pm0.59$	$19.10^{b}\pm0.68$	$26.35^{a}\pm1.21$	$17.68^{b}\pm0.02$
Mg meq/100g	$10.28^{a}\pm0.97$	$12.29^{b}\pm0.36$	$12.47^{a}\pm0.12$	$11.56^{a}\pm0.72$
Cl meq/100g	$8.17^{a}\pm0.35$	$6.99^{a}\pm0.42$	$7.18^{a}\pm0.58$	$9.20^{b}\pm0.66$
Available Potassium Kg/ha	$235.90^{a}\pm1.40$	$203.54^{b}\pm0.10$	$172.73^{a}\pm1.39$	$198.85^{b}\pm1.09$
Nitrate Nitrogen Kg/ha	$5.64^{a}\pm0.63$	$6.35^{a}\pm0.62$	$8.61^{a}\pm0.15$	$7.17^{b}\pm0.67$
Ammonical Nitrogen Kg/ha	$15.30^{a}\pm0.85$	$12.94^{b}\pm0.86$	$33.68^{a}\pm1.31$	$37.11^{a}\pm0.70$
Available Phosphate Kg/ha	$11.58^{a}\pm0.82$	$12.27^{a}\pm0.91$	$11.28^{a}\pm0.79$	$8.70^{a}\pm0.49$
% Oxidizable Organic Carbon	$0.59^{a}\pm0.01$	$0.52^{a}\pm0.06$	$0.36^{a}\pm0.01$	$0.28^{a}\pm0.12$
Sulfur Kg/ha	$8.13^{a}\pm0.77$	$8.57^{a}\pm0.22$	$21.78^{a}\pm0.71$	$12.13^{b}\pm0.23$
Sodium meq/100g	$2.90^{a}\pm0.51$	$0.47^{b}\pm0.02$	$0.39^{a}\pm0.01$	$0.20^{b}\pm0.07$
Zinc ppm	$0.38^{a}\pm0.02$	$0.47^{a}\pm0.06$	$0.68^{a}\pm0.15$	$0.64^{a}\pm0.11$
Iron ppm	$1.76^{a}\pm0.18$	$1.86^{a}\pm0.21$	$2.18^{a}\pm0.26$	$2.11^{a}\pm0.17$
Manganous ppm	$18.57^{a}\pm0.61$	$53.65^{b}\pm1.05$	$29.47^{a}\pm0.80$	$32.27^{a}\pm1.04$
Copper ppm	$2.79^{a}\pm0.28$	$4.12^{b}\pm0.59$	$2.43^{a}\pm0.23$	$2.26^{a}\pm0.39$

NBT: Non-Bt cotton field soil sample; BT: Bt cotton field soil sample; Same superscript in the same row under each head is not significantly different; different superscript in the same row under each head is significantly different.

Table 4. Soil properties of Bt and Non-Bt cotton growing fields before sowing and after harvest in Dharwad District of Karnataka, India

Parameters	Before sowing		After harvest	
	NBT	BT	NBT	BT
pH	7.97[a]±0.35	8.32[a]±0.18	8.42[a]±0.19	8.71[a]±0.19
Ca meq/100g	20.57[a]±1.04	14.92[b]±0.84	28.77[a]±1.72	25.97[a]±1.48
Mg meq/100g	10.71[a]±0.10	14.42[b]±0.31	17.60[a]±1.16	13.67[b]±0.72
Cl meq/100g	6.86[a]±0.57	9.08[b]±0.41	6.38[a]±0.54	6.74[a]±0.59
Available Potassium Kg/ha	163.77[a]±1.16	217.93[b]±1.39	206.30[a]±1.90	254.02[b]±1.21
Nitrate Nitrogen Kg/ha	7.26[a]±0.80	6.99[a]±0.55	6.92[a]±0.60	6.85[a]±0.49
Ammonical Nitrogen Kg/ha	17.22[a]±0.71	12.41[b]±0.31	44.55[a]±1.62	22.56[a]±1.24
Available Phosphate Kg/ha	12.12[a]±0.04	13.63[a]±0.12	11.63[a]±0.13	8.88[a]±0.20
% Oxidizable Organic Carbon	0.43[a]±0.01	0.61[b]±0.06	0.45[a]±0.02	0.42[a]±0.02
Sulfur Kg/ha	7.95[a]±0.44	10.82[b]±0.84	13.42[a]±1.05	9.03[b]±0.85
Sodium meq/100g	0.53[a]±0.04	0.54[a]±0.03	0.35[a]±0.02	0.29[a]±0.03
Zinc ppm	0.52[a]±0.06	0.50[a]±0.84	0.61[a]±0.01	0.49[b]±0.10
Iron ppm	1.56[a]±0.25	2.51[b]±0.19	4.61[a]±0.80	1.98[a]±0.16
Manganous ppm	29.67[a]±1.13	28.63[a]±1.02	32.42[a]±1.09	38.48[a]±1.87
Copper ppm	4.50[a]±0.59	5.20[a]±0.59	2.51[a]±0.26	2.76[a]±0.48

NBT: Non-Bt cotton field soil sample; BT: Bt cotton field soil sample; Same superscript in the same row under each head is not significantly different; different superscript in the same row under each head is significantly different.

There is no much difference in the soil samples of three districts with respect to soil chemical properties. Results also confirmed that samples collected from three districts showed poor soil fertility. This may be due to poor cultivation practices among farmers. Results compared with Bt and Non-Bt soil samples suggests that there is no measurable impact of cultivation of Bt cotton on soil chemical parameters observed. Significant differences in many of the soil properties particularly before sowing was observed between the Bt and Non-Bt soil samples of three districts. Significance of differences was tested by using independent samples test in ANOVA.

Based on the analysis of soil samples of before sowing from Bt and Non-Bt cotton from Belgaum district shows significant difference in all the chemical properties other than chloride and manganous. After harvest of the Bt and Non-Bt cotton the soil analysis showed significant differences in magnesium, available potassium, ammonical nitrogen, sulfur and zinc. Bt and Non-Bt (before sowing) soil samples of Haveri district shows significant differences in calcium, magnesium, available potassium, ammonical nitrogen, sodium, manganous and copper. After harvest of Bt and Non-Bt cotton field soil samples of Haveri district shows significant difference in calcium, chloride, available potassium, nitrate nitrogen, sulfur, sodium and sulfur. Bt and Non-Bt (before sowing) soil samples of Dharwad district shows significant differences in calcium, magnesium, chloride, available potassium, ammonical nitrogen, % oxidizable organic carbon, sulfur and iron. Bt and Non-Bt (after harvest) soil samples of Dharwad district shows significant differences in magnesium, available potassium, sulfur and zinc.

The present work was designed to study the impact of continuous cultivation of Bt cotton for decades on soil properties. Based on the analytical and statistical results of the soil properties from Bt and Non-Bt cotton cultivated soil before sowing and after harvesting suggests that there are no much differences in chemical properties of the soil. Significant differences of some chemical compounds can be expected as a result of plant nutrient uptake and after harvesting releases of plant residues on the field. Results of this study suggested that there is negligible difference in nutrient mineralization in reference to nitrogen, potassium and phosphorous before sowing and after harvest in Bt and Non-Bt cotton fields. Moreover, overall results suggest that there is no significant adverse effect of Bt cotton on soil ecosystems.

CONCLUSIONS

The present study conclude that there were very less significant differences in essential ecosystem functions such as nutrient mineralization with reference to analyzed physicochemical parameters between Bt and Non-Bt cotton fields during before sowing and after harvesting period in three districts of Northern Karnataka, India. In conclusion, there was no alarming significant evidence to indicate any adverse effects of Bt cotton on the physicochemical properties of soil ecosystem in Northern Karnataka, India.

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REFERENCES

Audiseshamma K., Paramageetham Ch., Theja P.C., Hooda V., Babu G.P., 2014. Influence of transgenic Bt crop root exudates on rhizospheric soil microflora. International Journal of Current Microbiology and Applied Sciences, 3(5):289-294.

Beura K., Rakshit A., 2011. Effect of Bt cotton on nutrient dynamics under varied soil type. Italian Journal of Agronomy, 6:25-28.

Bruinsma M., Kowalchuk G.A., Van Veen J.A., 2003. Effects of genetically modified plants on microbial communities and processes in soil. Biology and Fertility of Soils, 37:329-337.

Dunfield K.E., Germida J.J., 2004. Impact of genetically modified crops on soil and plant-associated microbial communities. J. Environ. Qual., 33:806-815.

Icoz I., Stotzky G., 2008. Fate and effects of insect resistant Bt crops in soil ecosystem. Soil Biology and Biochemistry, 40:559-586.

Jackson M.L., 1967. Soil chemical analysis, Prentice-Hall of India, New Delhi, India.

Knox O.G.G., Gupta V.V.S.R., Roberts G.N., Downes S.J., 2008. Improving environmental loading assessments of Cry protein from GM plants based on experimentation in cotton. The Open Agriculture Journal, 2:105-112.

Kowalchuk G.A., Bruinsma M., Van Veen J.A., 2003. Assessing soil ecosystem responses to GM plants. Trends in Ecology and Evolution, 18:403-410.

Nihorimbere V., Ongena M., Smargiassi M., Thonart P., 2011. Beneficial effect of the rhizosphere microbial community for plant growth and health. Biotechnol. Agron. Soc. Environ., 15(2):327-337.

Saxena D., Stotzky G., 2000. Insecticidal toxin from *Bacillus thuringiensis* is released from roots of transgenic Bt corn *in vitro* and *in situ*. FEMS Microbiol. Ecol., 33(1):35-39.

Sharma K.K., Ortiz R., 2000. Program for the application of the genetic engineering for crop improvement in the semi-arid tropics. *In Vitro* Cellular and Developmental Biology (Plant), 36:83-92.

Stotzky G., 2004. Persistence and biological activity in soil of the insecticidal proteins from *Bacillus thuringiensis* especially from transgenic plants. Plant and Soil, 266:77-89.

Trivedi R. K., Goel P.K., 1986. Chemical and biological methods for water pollution studies. Environmental Publication, Karad, India.

Whipps J.M., 1990. Microbial interactions and biocontrol in the rhizosphere. J. Exp. Bot., 52:487-511.

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ENSURING THE SUSTENABILITY OF ARABLE CHERNOZEMS THROUGH MANAGEMENT OF THE HUMUS FORMATION PROCESS

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Abstract

The current stage of arable chernozems development is determined by the change of pedogenetic regimes as a result of agrogenic changes caused by long-term agricultural use, but also by changing the soil climate induced by climate change from the Carpatho-Danubian-Pontic space. Under such conditions it is considerably reduced the priority role of humus formation process which is responsible for the evolution of the biorutinar soil system. As a result, the chernozems in the region entered in a stagnant evolutionary phase being extremely vulnerable to various degraded processes. Certifying the chernozems sustainability can be ensured in complex technologies adaptive-landscape-improved.

Key words: *arable chernozems, biorutinar systems, humus, soil system, chernozems sustainability*.

INTRODUCTION

Through the concept, biosphere functions and ecosystems of the soil cover (Dobrovolski, 2000), the paradigm of sustainable development means ensuring enlarged reproduction of its productive function. Achieving this goal requires first, carbon sequestration and nitrogen in the humus-sphere and reducing the share of greenhouse gases, originating from functioning of the soil cover. In this context, we consider that chernozems have a special role in the Biosphere.

Although these soils account just 268 million hectares, they are most productive and have the greatest capacity to sequester carbon and nitrogen, and preserve for a long period of time (on the pedologic scale).

Another important issue inherent to carbon and nitrogen sequestration consists in ensuring the unidirectional reproduction trend of the clod-grainy chernozems structure, capable of providing stable functional regimes that would ensure chernozems sustainability conditions induced by climate change.

In this paper the biophysics framework is based on theoretic and practice presentation to ensure technologies of chernozems sustainability under climate change.

MATERIALS AND METHODS

The conceptual framework of this research methodology which targets biologization process is ensured by the natural-anthropogenic chernozems pedogenesis from the Carpatho-Danubian-Pontic space, the concept of soil resources, the concept of bioenergetic soil resources and the concept of adaptive-landscape-improved technologies elaborated in the Scientific Research Laboratory Pedogenetic Processes of Moldova State University.

This study includes researches in the field and in the laboratory through standard methods application. At the same time, a series of research were carried out within the Republic Center of Applied Pedology during the years 2003-2015 under the leadership of one of the authors of the current study. In order to identify the evolutionary trend of soil humus status indices were systematized a series of studies from the Republic Center of Applied Soil Science.

RESULTS AND DISCUSSIONS

On the basis of soil formation process, establishment and development of natural fertility stay the same biochemical processes of transformation of substances and energy, and the integration of biotic and abiotic constituents in the soil ecosystem biorutinar system.

The biochemical processes determine the circuits of carbon, nitrogen, phosphorus, sulfur and organogenic elements, but also the meaning and intensity of the pedogenetic process, controls soil evolution, fertility level, characterizes the degree of disturbance in agroecosystems under the action of natural and anthropic factors.

The current stage of natural-anthropogenic evolution of the pedogenesis process is characterized by unidirectional reduction of soil biogenesis, primarily due to reduced priority role in the process of humus formation in the soil development and their natural fertility.

The main causes of soil reduction, priority of humus formation process are:

- Perturbation, anthropogenic degradation of the pedofunctional framework (pedofunctional regimes) to achieve the process of humus formation;
- Low energy quality of humus sources, represented by organic residues;
- The deficit of the necessary biological nitrogen in order to achieve the process of humus formation;
- Accelerated intensity within decomposition process of the organic residues (in the absence of humiferous detritus) with the formation of "anthropic" humus less stable;
- Stressful state of soil biota following the "chaotic" dynamics through the composition amount and limits storage of organic waste;
- The considerable reduction of microbiotic biomass to soil from 28-30 to 1-2 t/ha as an active humus renewable source;
- Spatial incoherence of the deposition area of organic residues and the optimal conditions in the deployment of humus formation processes as a result of the intensive degradation of the arable layer;
- The decomposition and biodegradation as a result of increased humus;
- Humus losses due to water and wind erosion.

Reducing the priority role of humus formation process involves a number of quantitative changes in the evolution of the organic substance system through the stability reduction of the organic matter system as result of changing the ration between humiferous detritus and humus.

According to the researchers conducted within the biological station of Moldova State University in the typical chernozems in the areas not included in the arable circuit humiferous detritus content, consists in 8-12% of the total organic matter content in the 0-5 cm layer.

Already in the layer 15-25 cm humiferous detritus content is reduced to 3-5% from the organic substance content.

In the AmB horizon (45-68 cm) the humiferous detritus content is reduced to 1.18% of the total organic content (Table 1).

Table 1. Composition of the organic material in the fallow the arable and chernozems
(Codru, Chișinau, MSU Biological Station, 1990-1994)

Soil	Depth, cm	Content C org, total, %	Content C detritus, % from C tot	Soil	Depth, cm	Content C org, total, %	Content C detritus, % from C tot
Typic	0-5	5.81	12.0	Typic moderate	0-5	4.96	2.98
moderate deep	5-15	5.37	6.0	deep humus	5-15	4.37	1.87
humus	15-25	4.89	5.1	chernozems	15-25	3.58	1.58
chernozems	30-40	4.56	3.3	arable	30-40	2.98	1.98
fallow	45-60	3.96	1.18		45-60	2.33	1.73
Typic	0-5	5.28	8.3	Typic moderate	0-5	4.20	2.60
moderate deep	5-15	4.63	5.1	humus	5-15	3.86	1.83
humus	15-25	4.21	3.8	chernozems	15-25	3.12	1.54
chernozems	30-40	3.38	2.6	arable	30-40	2.67	2.28
fallow	45-60	2.86	1.2		45-60	2.13	1.96

In the arable layer of the typical deep humus chernozems, the humiferous detritus is reduced to 2.60-2.98% of the humiferous detritus content which increases compared with deep effervescent chernozems.

This allows us to conclude that the crops develop deeper root system. At the same time, arable soils in the AB horizon create less favorable conditions for the decomposition of vegetal debris.

Even more the plant residues of the crop plants harder are decomposed. The same laws are found in case of typical moderate humifer chernozems but with other expression value.

In the soil a unidirectional trend is established in the sense of reducing the humus content and its compliance with newly created condition by the landscape (Table 2).

Table 2. Dynamics of surfaces with different levels of humus assurance in some pedogeographic districts (% of the district)*

Pedogeographic district, no	Predominant soil	Evaluation period	Degree of humus insurance				
			Very low	Low	Moderate	Optimum	High
1.	Gray soils, argilo-clay chernozems and levigated	1965-1970	0.5	23.3	63.6	10.1	2.5
		1970-1975	1.0	18.7	57.6	17.2	5.4
		1975-1980	1.6	14.1	51.6	24.3	8.4
		1980-1985	1.8	13.3	41.2	35.6	1.1
		1985-1990	-	17.0	37.3	44.7	1.0
2.	Typic moderate humus chernozems	1965-1970	0.4	15.3	55.7	28.6	-
		1970-1975	1.5	13.4	47.6	40.3	7.2
		1975-1980	2.3	11.5	39.5	43.2	3.2
		1980-1985	1.6	15.8	45.5	34.5	2.6
		1985-1990	1.6	11.0	46.5	38.9	2.0
10.	Typic moderate humus chernozems and levigated	1965-1970	-	18.8	54.6	26.6	-
		1970-1975	2.6	21.8	50.0	15.6	-
		1975-1980	4.6	24.9	55.4	15.1	-
		1980-1985	10.2	40.2	41.8	4.8	-
		1985-1990	16.9	43.4	36.5	3.2	-
5.	Typic moderate humus chernozems and levigated	1965-1970	-	19.4	62.7	17.9	-
		1970-1975	8.3	29.1	50.1	12.5	-
		1975-1980	9.4	38.9	43.7	7.1	-
		1980-1985	12.5	44.8	38.1	4.5	-
		1985-1990	13.6	34.9	47.6	3.9	-
9.	Levigated chernozems, argilo-clay and gray soils	1965-1970	-	22.7	55.8	21.5	-
		1970-1975	4.3	28.6	50.3	16.8	-
		1975-1980	9.0	35.0	43.9	12.1	-
		1980-1985	8.5	36.2	45.3	9.8	-
		1985-1990	11.0	43.0	46.7	9.3	-
District II a	Typic low humus chernozems	1965-1970	1.4	18.7	58.5	20.3	0.6
		1970-1975	4.2	19.3	53.2	21.9	1.3
		1975-1980	6.0	19.8	46.0	23.0	5.2
		1980-1985	8.9	35.1	52.0	3.9	0.8
		1985-1990	8.1	30.9	56.5	4,5	-
District 13 b	Carbonated chernozems	1965-1970	5.0	41.5	45.1	6.6	1.8
		1970-1975	20.0	42.0	30.1	6.3	1.6
		1975-1980	22.9	42.9	27.1	5.5	1.8
		1980-1985	18.8	44.0	29.7	5.6	0.9
		1985-1990	19.4	51.5	28.0	1.0	-

*from the archive of Republic Center of Applied Pedology

Quantitative expression of its trend varies in time and space in accordance with pedogeographic conditions and concrete landscape conditions (Table 3).

The data presented in the Tables 2 and 3 highlight the fact that the intensive humus content in the chernozems, in the region, is reduced in the first 15-20 years after the intensive agricultural circuit (about 50-60 of humus losses return to this period). During this period, humus reserves are reduced as a result of mass mineralization of the humiferous detritus driven to disturbance of climate bioenergetic state of chernozems in the region. Later (around 10-15 years) humus reserves are reduced more slowly as a result of the reduction in the content of humic labile substances determined by the decrease in content of fresh energy sources in the soil, disturbing the dynamics of the formation and accumulation process of humus, worsening composition and quality of organic residues.

Table 3. State and dynamics of humus content in agrolandscape in Moldova in the period 1965-2013 (%)*

Agricultural unit	No. Field	Predominant soil	Evaluation period					
			1965-1970	1970-1975	1975-1980	1980-1985	1985-1990	2003-2013
Agrosfera BM Nisporeni	1	Typic chernozems silty clay	4.9	4.5	4.5	4.2	4.1	4.1
	2	Typic chernozems silty clay	5.1	4.7	4.6	4.4	4.1	4.1
	3	Typic chernozems with solonetz area	4.9	4.6	4.3	4.3	4.3	4.0
	4	Typic chernozems with eroded areas	3.8	3.4	3.0	3.1	3.0	2.9
	5	Typic chernozems with eroded areas	4.1	3.8	3.5	3.2	3.0	2.9
Vindex agro Orhei	1	Typic chernozems silty clay	5.3	4.9	4.6	4.3	4.2	4.0
	2	Typic chernozems loamy	5.1	4.7	4.6	4.4	4.2	4.0
	3	Typic chernozems loamy	4.9	4.6	4.3	4.6	4.3	4.0
Podgoreni, Cantemir	1	Typic low humus chernozems, low-moderate erodated	3.6	3.3	2.9	3.1	3.0	2.9
	2	Typic low humus chernozems, low erodated	3.9	3.6	3.4	3.1	3.0	3.0
	3	Typic low humus chernozems, moderate erodated	2.8	2.4	2.1	2.0	1.9	1.9
	4	Typic low humus chernozems, low-moderate erodated	3.7	3.4	3.1	3.1	3.0	2.9
Mevil-Agro, Ocniţa	1	Typic chernozems silty clay	5.7	5.3	5.1	4.7	4.5	4.4
	2	Typic levigated chernozems silty clay	5.9	5.5	5.2	5.0	5.0	4.7
	3	Typic chernozems silty clay, low-moderate erodated	5.5	4.6	4.3	4.2	3.9	3.8

*from the archive of Republic Center of Applied Pedology

Reducing humus reserves at this stage leads to the initiation of soil mass disintegration processes, which affected the reproduction process of the clod and the grainy structure; in particular of aggregate with a diameter of 3-1 mm, with an increase in aggregate content 1.0-0.25 mm. This led to intensification of both water and wind erosion.

During 40-45 years the chernozems in the region under conditions with relief elements <2° in the agricultural regime comparative with humus reserves in the fallow soils were reduced by 20-30%. In case of cereal crops humus losses make up 20-25% and in the hoeing and technical 25-30%.

In the erosion slopes humus losses reach up 30-40%. The first generalization of evolutionary laws of the organic matter system of the chernozems in the region shows that the components of the agricultural system differently influence the organic substances system (Jigau, 2016; Jigau and Tofan, 2016):

- Crop structure and the duration of their rotation influences the humus detritus content;
- The fertilization system influences the content and composition faction of labile humus;
- For the bioclimatic conditions in the Prut-Nistru space optimal values of ratio C:N=10-12:1. Lower values indicate unproductive losses of nitrogen; higher values denote nitrogen deficiency to carry out humification processes.

Tillage systems influence the content and composition of humiferous detritus and labile humus substances.

According to calculations by Masyutenko et al. (2008) within existing agricultural system under traditional crop rotation over 100 years the humus reserves in the chernozems will be reduced by 26%, over 200 years by 42% and over 500 years with 62%.

In the ameliorative crops rotation the evolution of humus means reducing humus reserves over 100 years with 12%, over 200 years with 20%, over 500 years with 29%. In the context of the exposed ones the bioenergetic state of the chernozems in the region can be evaluated by the parameters presented in the Table 4.

In the context of the parameters presented in the Table 4 their lower limits represent the value below which crops are significantly reduced and the reproductive capacity of the soil ecosystem resources.

Table 4. Bioenergetic parameters of the chernozems of the Prut - Nistru space

Fertility factors	Normative for fertility levels		
	Low	Moderate	High
Humus content in the horizon Am, %	<4	4-6	>6
Layer thickness to achieve the process of humus formation (Am+AmB), cm	<50	50-65	>65
The thickness of humus layer (A+B), cm	<60	60-80	>80
Humus reserves, t/ha layer 0-100 cm	<350	350-500	>500
Ratio C:N in composition of humus	>13:1	10-13:1	≤10:1
Ratio Cah:Caf	<1.4	1.4-2.0	>2.0
The content of mobile humus substances, mg C/100 g of soil	100-200	200-300	300-400
Variation intervals of the content of labile humus substances, mg C/100 g of soil	90-170	170-271	271-393
Limit values for accumulation of humus, %	4.0-4.5	6.5-7.0	8.0-8.5
The content of organic substances easily decomposed into the arable layer, % soil mass	0.35-0.55	0.55-0.8	0.8-1.2

Maximum values (upper limit) are the economically and ecologically justified values of reproductive activities for bioenergetic parameters. The assessment of bioenergetic parameters of chernozems in the region implies the use of two indicators: critical humus content and state allowable limit.

Critic content represent the amount of humus below which physical features (agronomic and environmental) can still be reproduced. This is 4.0%. Allowable limit of humus content (≈3%) under which a number of physical parameters (apparent density, structural-aggregate state, parameters of the porous space, hydro-physical parameters) show values that are characteristic of parental substrates (parental rocks).

In conditions when the humus content falls below the critical level in the soil evolution occurs super-cultivation state, accompanied by destructive elemental process, destructuring and intensive compacting due to intensive use under low flux condition of energy sources (humus sources).

In case when the humus content in soil falls below the allowable limits starts desertification processes in soils. In this context applying humus content and its inherent bioenergy parameters as an evolutionary indicator of chernozems, we find that the contemporary process of humus formation maintains the biogeosystem in the region in a state of energetic stagnation and retain the ability to respond to energy inputs.

This implies the conclusion that to ensure the sustainability of materialized chernozems in the extended reproduction for their bioproductive function is necessary to restore the priority role of the humus formation process.

In the context of adaptive-landscape-ameliorative technologies, based on the efficient combination of biological and technological methods that support the typogenetic processes of chernozems formation by using sources of organic matter added to the soil, implementation of ameliorative crops and conservative rotational system of soils, the use of bio and pedo-rotated fertilization system, supporting biochemical processes in soils by applying biohumic preparations.

In the sustainable management of chernozems emphasis has to be placed on management and control of substance transformation processes and interactions between them in the pedogenic process by practicing biofertilizers. These are preparations which are administered in soils in smaller amount that manure as catalysts which influence the processes of decomposition-transformation of organic and mineral substances and targeted to support the functioning process in soil microbiocenoses, efficiency, the humus formation process and the organic-mineral reactions responsible for the structural-functional soil organization.

The technologies developed in the Scientific Research Laboratory Pedogenetic Process of MSU in collaboration with SRL “AXEDUM”, the emphasis is placed on the use of Biohumus and Biovit bioorganic preparation. The latter represents the fraction of the labile humic substances resulting from technological process for obtaining Biohumus. Except compost Biohumus and Biovit represents the biologic active substances (Table 5 and Figure 1).

In the Biovit’s composition about 67-84% from the total biomass return to the active microbial biomass.

Table 5. Content of macro and microelements in Biohumus

Indices	Unit of measure	Values indices	
		In the natural	In the dry
pH	%	7.8	-
Ash content		69.7	46.6
Organic substance content		30.3	53.4
Total nitrogen content		0.88	1.55
Ammoniac nitrogen content		abs	abs
P_2O_5 content		0.97	1.70
K_2O content		1.05	1.85
$N\text{-}NO_3$ content	mg/100 g	608.7	1071.6
Calcium content	moli/100 g	19.0	-
Magnesium content		22.0	-
Mobile copper content	mg/kg	1.16	2.05
Mobile zinc content		4.30	7.60
Mobile manganese content		5.30	9.30
Mobile iron content		3.00	5.30
Colonies of microorganism/1 g		20000 billions	

The catalytic potential of Biohumus and Biovit is achieved only in the presence of fresh organic matter. It is better to use them in installments. In this respect, research has shown that the use of biohumic preparation in installments ensures that organisms that decompose humus are reduced 2-3 times (13 versus 39-44%) compared to administration of the same amount of biochemical preparation in a single rate. At the same time, their administration leads to intensification to a series of pedogenetic processes:

- Formation and accumulation of humus;
- Micro and macro-structuring of soils;
- Intense decomposition processes of organic residues and nitrification (Figure 1).

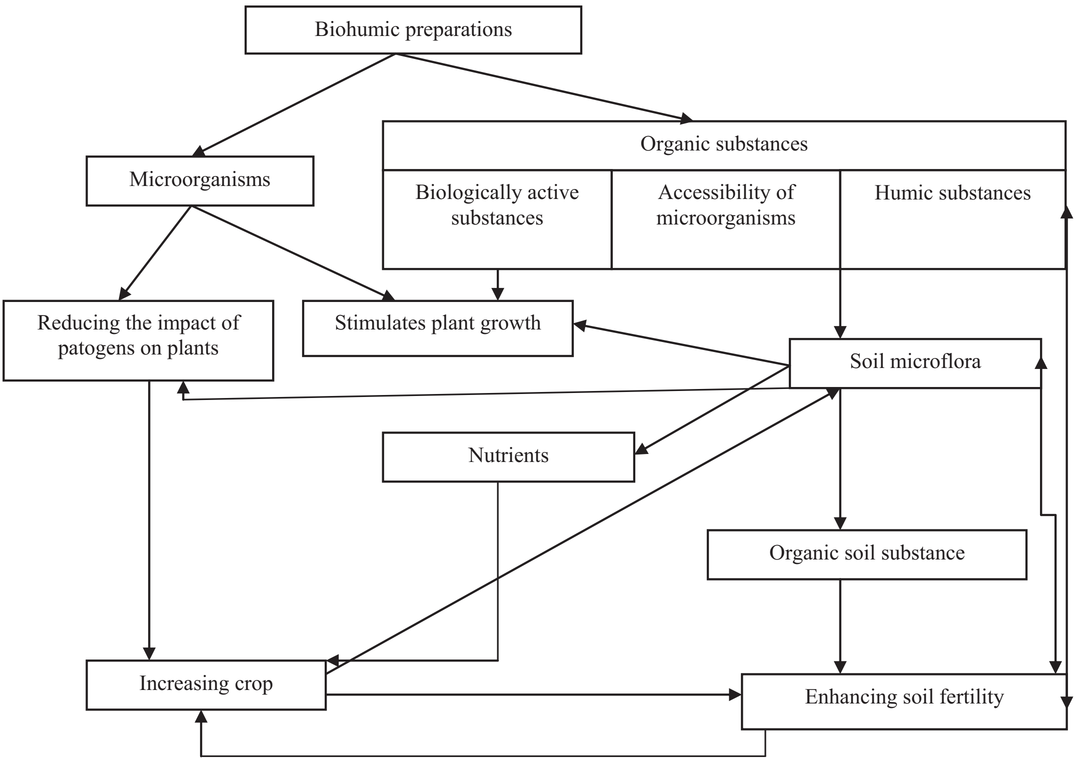

Figure 1. Mechanisms of polyfunctional action of biohumic preparation on soil-plant relations

CONCLUSIONS

The pedogenesis regimes induced in chernozems by agrogenic changes and climatic conditions in phase change have reduced the priority role of the humus formation process in the evolution of the chernozems in the space between Prut and Nistru.

This severely affects the structuring process and the extent of pedogenesis on the descendant with the concentration on the elementary processes in the agrogenic layer. Therefore, the chernozems in the region are in a stagnant evolutionary phase being extremely vulnerable to various degradative processes.

Ensuring the chernozems sustainability can be achieved within a complex technology based on typogenetic processes: humus formation and accumulation, biogenic accumulation, structuring and migration of carbonates.

REFERENCES

Jigau Gh., Tofan E., 2016. The pedofunctional framework for ensuring adaptive-landscape-ameliorative technologies. Scientific Papers, Series A, Agronomy, Vol. LIX, pp. 83-88.

Jigau Gh., 2016. Landshaftno-ekologicheskiye predposylki orosheniya chernozemov v Moldove. Lider Agro April, No. 4(66).

Masyutenko N.P., Kogut B.M., Kiseleva O.V. et al., 2008. Struktura chernozema tipichnogo i soderzhaniye organicheskogo ugleroda i labil'nykh gumusovykh veshchestv v pochvennykh agregatakh, Ros. akad. s.-kh. nauk, Vseros. nauch.-issled. in-t zemledeliya i zashchity pochv ot erozii, Pochv. in-t im. V.V. Dokuchayeva, Kursk, 34 s.

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THE INFLUENCE OF GREEN MANURE ON THE QUALITY STATE AND PRODUCTION CAPACITY OF THE CHERNOZEM CAMBIC FROM CENTRAL MOLDOVA

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Abstract

The paper presents research results regarding the influence of green manure on quality status of chernozem cambic from central Moldova and winter wheat harvest on this soil. Research has established that incorporation of two harvests of vetch green mass of 12.4 t/ha in the arable layer of chernozem cambic in the agricultural year 2015-2016 led to accumulation in the soil about 310 kg nitrogen; was synthesized about 3 t/ha of humus; was increased the labile organic matter content by 0.20% compared with witness variant; improved physical quality state of arable layer; formed a weak positive balance of organic matter and nitrogen in the soil. On the variant with application into the soil a harvest of green mass of vetch, the winter wheat harvest constituted 6.2 t/ha (growth rate 2.4 t/ha compared to control variant); on the plot with two harvests of green mass application - 7.0 t/ha (growth rate - 3.2 t/ha). Gluten content of wheat grains from variants with application of green fertilizers consists 28%, on the witness variant - 24%. Through the systematic use of green manure concomitantly with the phosphorus and potassium fertilizers in partial, the soil physical, chemical and biological quality state and agricultural productive capacity of soil can be restored gradually. In this content it is necessary to organize a system for green fertilizers use and create a seed basis of annual and perennial grasses for agricultural sector of Moldova.

Key words*: chernozem cambic, green mass, humus, quality state, vetch, winter wheat.*

INTRODUCTION

Chernozem cambic from central zone of Moldova were formed under the influence of following pedogenesis phases: *under forest vegetation* (were formed Brown soils with illuvial-cambic argillizated and heavily compacted horizon) → *under plowing* (Brown soils arable) → *under steppe vegetation* (Brown soils were evolved in chernozem cambic) → *under agricultural tillage*, from 1800s (contemporary chernozem cambic).

Chernozem cambic arable from Central Moldova inherited from the pedogenesis phases of forest vegetation the textural differentiated profile, with high content of fine clay, dominated by colloidal fraction. In conditions of the agricultural existing system these soils have undergone the intensive organic matter losses and structure destruction of humus arable layer (Leah., 2016). High content of clay, dehumification and desstructured processes led to acceleration of secondary compaction of arable layer (Canarache, 1990). The main cause of compaction resistance decrease of arable layer of investigated chernozem cambic is the insufficiently flow of organic matter in soils.

Non application of organic fertilizers into the chernozem cambic, insufficiently and inadequate use of mineral fertilizers, strong secondary compaction of arable layer leads to decrease of their production capacity by 2 time (Leah and Cerbari, 2015).

The quantities of chemical fertilizers used to field crops are small and do not provide an equilibrated balance of nutrients in the soils. The secondary production from harvesting crops is not incorporated into the soils.

A long-term favorable state of the soil physical quality can be created by the existence of a permanent flow of organic matter in arable soil layer. This constant flow can be ensured by achieving in the farming the following systemic procedures (Cerbari and Leah, 2016).

Introducing into the soil about 10-15 t/ha/year of manure. Currently, in the agricultural soils are introduced about 50 kg/ha/year of manure and about 53 kg/ha/year chemical fertilizers in active substances, 70-75% of these are nitrogen fertilizers. This fertilization level cannot ensure a profitable agriculture that would lead to the reproduction of soil fertility.

Through the repeated fallow of arable land and restoring steppe vegetation that formed chernozems. This method is acceptable, but cannot be implemented in Moldova due to lack of free land (0.4 ha of arable land per capita). Along the 15 years the humus content in arable layer was increased by 0.8%; state structure was restored to 70-80% compared to standard fallow soil (Leah, 2016).

Using the land under alfalfa/sainfoin + ryegrass over a period of 10-15 years with utilization of production as feed for livestock. This method, unfortunately, cannot have a large implementation in the Republic of Moldova, because the livestock was reduced about 6 times at last 25 years. Restoring the livestock can be create a rational co-ratio between livestock and field crops sectors and restoration of leguminous grasses in crop rotations.

Using the vetch as green fertilizer (as intermediate crop or occupied field), incorporation into the soil two harvests of winter or spring vetch as organic fertilizer, in crop rotation with 5 fields, where one field is occupied by vetch (Wiesmeier et al., 2015).

In conditions of total exclusion of annual and perennial grasses from crop rotations, non-use of organic manure as fertilizer, the only possibility to restore the organic matter flow in the soils is utilization of green manure. Through the systematic use of green manure in couple with phosphorus and potassium fertilizers in part can be restored gradually the physical, chemical and biological quality state of soil and significant increase their agricultural production capacity.

MATERIALS AND METHODS

The research subject was the chernozem cambic (leachate) of Central Moldova (from Experiment Station, com. Ivancea, district Orhei). *Purpose of research:* testing procedures to increase the organic matter flux in the soil, restoration of quality state and production capacity of arable soil layer under the influence of phytotechnical measures.

Experience variants: Control (without green manure application); Variant with application into the soil - one harvest of vetch green mass; Variant with the application of two harvests of vetch green mass.

Soil research within each experimental variant was performed by placing in the field 3 soil semi-profile up to depth of 50 cm, their morphological description, collecting samples of soil from horizons (0-10 cm, 10-20 cm, 20-35 cm) for determination of bulk density and laboratory analyzes. In performing the researches were used traditional methods of conducting the field, laboratory and office works. The results will be used to create non-polluting system of sustainable agriculture of existing crop rotations using leguminous as green manure for soil fertilization.

RESULTS AND DISCUSSIONS

To study the characteristics of fallow chernozem cambic was placed a profile in the forest protection strip founded about 60 years ago. Research conducted on the chernozems from Bălți Steppe have shown that this period is sufficient to restore the initial values of soil characteristics under steppe vegetation in condition of non using the aerial mass of grasses vegetation (Cerbari, 2010a).

Initial state of fallow cambic chernozem characteristics. For foundation of forest protection belts the soil was slopped. The horizons Ahb1 and Ahb2 were formed from the soil material of former arable layer, buried at the 25-60 cm of depth. Soil evolved on the loess clayey loamy deposits located on the Pliocene-Pleistocene alluvial deposits in the deeper of 130 cm. Soil profile is leached of carbonates up to beginning of BCk horizon - the depth of 95 cm.

The fallow chernozem cambic is characterized with loamy-clay texture throughout the profile and pronunciation of cambic horizon in Bhw1 and Bhw2. The physical clay content in the soil profile ranges from 51% in fallow layer, up to 55% in the cambic horizons and clay content at the same time - from 35% to 38%. The fallow cambic chernozem characteristics were used as a baseline for comparing it with the arable cambic chernozem (Leah, 2016).

Initial state of arable cambic chernozem characteristics. The 0-35 cm layer of arable cambic chernozem on the same field is dehumificated and destructured, lost resistance to compaction as a result of its use in agriculture.

Chernozem cambic arable has clay-loamy texture. Physical clay content in humus profile is 60-61%, in the BC and C horizons - 56-58%. The content of clay in A and B horizons varies between 39-40%, and in the B, C and C horizons - within the limits of 56-57%. Argillic alteration of upper profile is due to change of hydrothermal regime after grubbing and use of these soils on the arable.

Chernozem cambic arable are a means of production in agriculture rather difficulties. They are characterized by large amounts of inaccessible water, mechanical and thermal favorable characteristics, soils are working hard, have great capacity for swelling and shrinkage, but have good chemical qualities (cation exchange and buffering capacity, high humus content). The characteristics of arable cambic chernozem served as a relative standard to assessing their changes under the influence of phytoameliorative procedures.

Changes of the quality status and production capacity of the soil under the influence of green manure. At the end of the agricultural year 2015, after incorporation into the soil of green mass of vetch and harvesting corn, on the witness plot was prepared seedbed by disking at depth by 10-12 cm and sown winter wheat. This work gave way to appreciate the size of winter wheat harvest after introduction into the soil as organic fertilizer one and two harvest of vetch green mass on the experimental variations. Winter wheat harvest was rated on the plots with an area of 1 m^2 in 5 repetitions. Simultaneously, by separate collection of wheat, was rated differently the total harvest on the plot where was introduced as organic fertilizer the green mass of vetch (2 ha) and on the witness plot (2 ha) where wheat was sown after maize.

Modification of the main characteristics of the soil layers on the experimental variant which was introduced one harvest and experimental variant with two harvests of vetch green mass was assessed by comparing the initial data (up to incorporation the vetch into the soil) with results obtained on the experimental variant in 2016. During the vegetation period the wheat plants on experimental plots sown after incorporation the vetch green mass phenological differed from wheat on the witness plot by following: dark green leaves; greater thickness of stalks; ear size greater by 20-30% etc. Changes of the status quality of soil top 0-10 cm of former arable layer under the influence of vetch green mass incorporation is shown in Table 1.

Positive changes in quality state of structure is observed for the soil layer 0-10 (12) cm, formed by disking and mixing of artificial structural elements of this layer with debris of two vetch harvests.

Integral characteristic of physical quality state of soil arable layer is bulk density value. The data confirm a favorable bulk density value for plants growing of 0-10 cm layer, formed by disking and incorporating in this layer two harvests of vetch green mass.

The resistance to penetration values correlates with bulk density values of these layers and are small for loose layer and large for compacted underlying horizons.

The layer 0-10 (12) cm, as a result of the incorporation into the soil of two harvests of vetch, was characterized by the increasing of labile organic matter content of about 0.20% compared to the control variant. The content of organic matter in soil layers where was introduced the vetch green mass - increased by about 0.20%. It should be noted that this organic mass is not yet humus and represent a labile organic matter, which is slightly mineralized in result of soil microbiological processes.

A trend of positive change was found for other indicators of the quality status of chernozem cambic under the influence of vetch green mass incorporated into soil. However some agrochemical soil characteristics practically have not changed.

Strategic issue remains the necessity to restore the phosphorus content in arable soils, which reserves in arable layer have been exhausted. Using the vetch green mass as fertilizer solve the nitrogen problem in soil, but not for phosphorus. Research data confirms that the vetch green manure, solving the problem of nitrogen in the soil, leading to a massive increase in nitrate nitrogen content, which is ecologically positive.

Table 2 presents data on soil moisture on the control and experimental variants, where into the soil was introduced two vetch harvest as green manure. The results demonstrate that 2016 was very favorable in terms of the rainfall amount for crops first category. The winter wheat harvest was formed mostly due to water precipitation fallen during the wheat growing period.

Table 1. Modification of chernozem cambic average values of physical and chemical properties in result of incorporation into the soil by disking one and two harvests of vetch green mass, 01.07.2016

Horizon and depth, cm	Witness variant (initial data)		Variant with 1 harvest of vetch		Variant with 2 harvests of vetch	
	Value	Assessment	Value	Assessment	Value	Assessment
1	2	3	4	5	6	7
Bulk density, g/cm^3						
Ahp1 0-10	1.24	small	1.21	Small	1.16	very small
Ahp1 10-20	1.42	great	1.42	Great	1.34	Moderate
Ahp2 20-35	1.53	extreme	1.52	Extreme	1.51	Extreme
Ah 35-50	1.43	great	1.42	Great	1.43	Great
Total porosity, % v/v						
Ahp1 0-10	52.3	great	53.5	Great	55.4	Extreme
Ahp1 10-20	45.6	moderate	45.6	Moderate	48.7	Moderate
Ahp2 20-35	41.8	small	42.2	Small	42.6	Small
Ah 35-50	46.0	moderate	46.4	Moderate	46.0	Moderate
Resistance to penetration, kgf/cm^2						
Ahp1 0-10	13	small	11	Small	9	very small
Ahp1 10-20	21	great	20	Great	15	Small
Ahp2 20-35	26	extreme	26	Extreme	24	Great
Ah 35-50	20	great	21	Great	21	Great
Organic matter content, % g/g						
Ahp1 0-10	3.47±0,13	moderate	3.59	Moderate	3.67	Moderate
Ahp1 10-20	3.33±0,10	moderate	3.30	Moderate	3.37	Moderate
Ahp2 20-35	3.07±0,09	moderate	3.08	Moderate	3.05	Moderate
Ah 35-50	2.75±0,12	submoderate	2.71	Submoderate	2.76	Submoderate
Mobile phosphorus content, mg/100 g soil						
Ahp1 0-10	1.9	moderate	2.0	Moderate	2.1	Moderate
Ahp1 10-20	1.4	low	1.4	Low	1.3	Low
Ahp2 20-35	0.8	very low	1.1	Low	1.0	very low
Ah 35-50	0.8	very low	0.8	very low	0.8	very low
Exchangeable potassium content, mg/100 g soil						
Ahp 1 0-10	31±2	high	33	High	33	High
Ahp1 10-20	26±2	optimal	23	Optimal	21	Optimal
Ahp2 20-35	22±2	optimal	19	Moderate	18	Moderate
Ah 35-50	22±2	optimal	18	Moderate	18	Moderate
Nitrates content ($N-NO_3$), mg/100 g soil						
Ahp1 0-10	0.3	extremely small	0.6	very small	0.4	extremely small
Ahp1 10-20	0.2	extremely small	0.2	extremely small	0.1	extremely small
Ahp2 20-35	0.1	extremely small	0.1	extremely small	0.1	extremely small
Ah 35-50	0.1	extremely small	0.1	extremely small	0.1	extremely small
Nitrites content ($N-NH_4$), mg/100 g soil						
Ahp1 0-10	3.9	great	4.8	Great	4.3	Great
Ahp1 10-20	3.6	great	2.8	Moderate	3.9	Great
Ahp2 20-35	3.2	great	2.4	Moderate	3.0	Great
Ah 35-50	2.3	moderate	2.5	Moderate	2.2	Moderate

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Table 2. Soil moisture on the variants, %

Depth, cm	*Witness variant* - Mini-till technology, without vetch incorporation		*Experimental variant* - winter wheat, after incorporated of two vetch harvests	
	22.03. 2016	*01.07. 2016*	*22.03. 2016*	*01.07. 2016*
0-10	23.3	25.9	23.9	25.9
10-20	23.5	23.8	25.2	23.9
20-30	24.3	23.9	26.7	25.1
30-40	25.1	23.5	26.3	24.1
40-60	24.4	23.9	26.2	23.3
60-80	24.0	20.5	24.4	19.7
80-100	23.6	20.0	23.5	19.3
0-100	**24.0**	**22.4**	**25.0**	**22.4**
Water total reserves (mm) in soil layer 0-100 cm in different period of winter wheat vegetation				
-	**358**	**334**	**368**	**329**
Estimation	great	moderate	great	moderate

Data regarding winter wheat harvest on the variants is shown in Figure 1 and Table 3.

Figure 1. Status of winter wheat in early July on experimental plots

Table 3. Winter wheat harvest (grain moisture – 8%) on the experimental variants, 2016

Variant	Winter wheat harvest, t/ha	Harvest growth rate, t/ha / %
Control (without vetch incorporation)	**3.8**	-
After incorporation into the soil - one vetch harvest	**6.2**	2.4 63
After incorporation into the soil - two vetch harvests	**7.0**	3.2 84

The average harvest of winter wheat on the witness plot was 3.8 t/ha.

On the parcel where into the soil by disking was introduced one harvest of vetch green mass, the wheat harvest increased with 2.4 t/ha, on the plot where into the soil was introduced two harvest of vetch green mass – 3.2 t/ha.

The method used on preventive recovery the quality state of soil arable layer has led to restoration of physical, chemical and biological quality of this layer, to increase production capacity of the soil and created prerequisites for successful implementation of the conservation system Mini-till in the agriculture of Moldova (Cerbari, 2010b; Cerbari, 2011).

Soil is an organic-mineral system that can provide high capacity agricultural production if there is a constant flow of fresh organic matter in the soils (Florea et al., 1987).

Creating a equilibrated or positive balance of organic matter in the soil is the main condition for the preservation of soil fertility in the long term period and avoid the degradation of arable layer by dehumification, destructuration and secondary compaction.

This principle can be achieved through regular application organic fertilizers or green manure.

Research conducted on the chernozem cambic have demonstrated the possibility of restoring the soil quality state by phytotechnical methods in combination with agrotechnical, forming a positive balance of carbon, nitrogen and humus in soil, halting degradation processes in arable layer and regulate CO_2 emissions in the soils.

Phytoameliorative researches revealed the following recommendation: in a crop rotation with five fields, one field must be introduced as "occupied field" with a sidereal leguminous crop - winter and spring vetch.

This gives the opportunity to apply 2-3 vetch harvest per year into the soil as green manure on each field of rotation (once in 5 years).

Crop rotation structure may be: field occupied with vetch → corn → winter wheat → winter barley → sunflower.

This method, used in the tillage systems of agricultural land will lead to the formation of a equilibrated balance of organic matter in soil, remediation of soil quality state, and increasing the soil production capacity.

CONCLUSIONS

Researches was established that incorporation of two harvests of vetch green mass of 12.4 t/ha in the arable layer of chernozem cambic in the agricultural year 2015-2016 led at following:

- in the soil was accumulated about 310 kg of nitrogen, of which 180 kg was fixed from the atmosphere; was synthesized about 3 t/ha of humus or 1.7 t/ha of carbon; was sequestrated about 6.3 t/ha of CO_2;
- in the soil layer 0-10 (12) cm was increased labile organic matter with 0.20% compared to control variant; improved physical quality of this layer; formed a weak positive balance of organic matter and nitrogen content in the soil.
- on the variant with application by disking into the soil a harvest of vetch green mass, wheat harvest constituted 6.2 t/ha (rate increase 2.4 t/ha); on the variant with two harvest incorporation - 7.0 t/ha (rate increase 3.2 t/ha).
- the gluten content in wheat grains from fertilized soils consists 28%, from witness soil - consists 24%.

By systematic utilization of green fertilizers concomitantly with phosphorus and potassium fertilizers, the quality state of soil and agricultural productive capacity can be restored gradually. In this context it is necessary to organize a system for use of green manure and create the seed bases of annual and perennial grasses in the agricultural sector.

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REFERENCES

Canarache A., 1990. Fizica solurilor agricole. Bucureşti: Ceres. 268 p.

Cerbari V. (coordonator), 2010a. Monitoringul calităţii solurilor Republicii Moldova. Chişinău, Pontos, p.98-112.

Cerbari V., 2010b. No-Till - sistem de agricultură care protejează solul. *Agricultura Moldovei,* nr. 8-9, p.9-14.

Cerbari V., 2011. Programul de dezvoltare şi implementare a tehnologiilor conservative în agricultură. *Agricultura Moldovei*, nr.4-5, p.7-9.

Cerbari V., Leah C., 2016. Green manure - only possibility to save Moldova's arable soils from degradation. *Scientific Papers. Series Agronomy*, Vol. 59(2), p.155-158.

Florea N., Bălăceanu V., Canarache A., et al., 1987. Metodologia elaborării studiilor pedologice. Partea III-a. Bucureşti. 226 p.

Leah C., 2016. Proprietăţile morfologice comparative ale cernoziomului cambic înţelenit şi arabil. *Сборник научных статьей.* Академику Л.С.Бергу-140 лет: Бендеры: Eco-Tiras, Elan Poligraf, 604-608.

Leah T., 2016. Grasslands of Moldova: quality status, vulnerability to anthropogenic factors and adaptation measures. *Scientific Papers. Series A. Agronomy*, Bucuresti, Vol. LIX, p.100-105.

Leah T., Cerbari, V., 2015. Cover Crops - key to storing organic matter and remediation of degraded properties of soils in the Republic of Moldova. *Scientific Papers. Series A. Agronomy*, Vol. LVIII, p.73-76.

Wiesmeier M., Lungu M., Hübner R., and Cerbari V., 2015. Remediation of degraded arable steppe soils in Moldova using vetch as green manure. *Solid Earth*, nr.6, p.609–620.

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MONITORING OF DEGRADED SOILS IN THE REPUBLIC OF MOLDOVA: LANDSLIDES

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Abstract

Landslides in Moldova presents a characteristic component of the landscape, the age of majority of them reach in the tens of thousands years. The total landslide area is about 750 thousand hectares, of which predominate the old stabilized slides, but there are about 84 thousand hectares of active landslides and ravines, mostly on the agricultural land. The paper examined the factors that lead to the formation of landslides - geological-structural, hydrogeological, geomorphologic, seismic, climatic, and anthropogenic. Quantitative data are presented on the dynamics of land areas with slides in a period of 45 years. Although some of them were set aside and forested, the affected area continue to rise: 1970-1975 – average growth is 18500 ha, 1976-1980 - 8800 ha, 1981-1985 - 23600 ha, 1986-1990 - 6200 ha, 1990-2015 - 4400 ha. Landslides after their essence present a very complicated phenomenon. Therefore, at first are presented brief information on the genesis and diversity. Classification of landslides into five groups according to the complexity is needs to be finalization of the reasons that the number of these is significantly larger. Overall, landslide monitoring needs to develop a special method of execution because according to its nature, diversity, duration of process, the landslides as research objects are not included in common system of ecopedological monitoring.

Key words*: degradation factors, erosion processes, landslides, monitoring, stabilization measures.*

INTRODUCTION

The main feature of landslides is the separation of soil masses with different volumes and their fall to lower places, accompanied by damage the all or partly the soil cover, which leads to loss of agricultural land, destruction of settlements, roads and other social objects. During landslides the rocks moves along the slopes rather large distances (up to 4 km). On steep slopes, especially when the soil is saturated with water, rocks moving at high speed causing massive disasters. Slopes occur in all regions of the world. They can be steep or line, fallow or cultivated and gives landscape variety and provide evidence about the relief's formation (Cruden, 2007).

Mass displacements are movements under the influence of gravity. Movements occur when pressure in the inside of rocks and soil grow or when friction decreases. Water is a main factor causing mass displacement. More abrupt movements are caused by heavy or prolonged rainfall or snowmelt that infiltrates the soil slopes, weakening the link between minerals.

Avalanches are landslides with high speed. They can be caused by vibrations caused by earthquakes or even by gunshots.

Falling rocks and soil subsidence occurs when water infiltrates in the cracks of rocks and then freezes. Landslide designates any sudden movement that takes place on a slope.

Land subsidence involves travel of fine materials, such as clay or shale. Sometimes they become so saturated with rainwater, that the slightest vibration can lead to the collapse of the slope (Андриеш et al., 2005).

Factors influencing landslides triggering may be natural - gravity, lithological construction and mode of rocks stratification, groundwater, seismic processes, etc. and artificial - drubbing and deforestation, location of economic and hydro technical objects without design project, terracing of slopes (Smolianikov et al., 2007).

Landslide processes in Moldova are favored by the geological structure of the territory, relief particularities, high seismicity of the territory, human activity. Erosion processes, landslides and other geodynamic and anthropogenic degradation have intensified significantly since the 60s-70s of last century (Krupenikov, 2004). Thus is emerged the need to study natural phenomena that lead to soil erosion and landslides. Analysis of the results showed that these processes were influenced by intensive agricultural practices - deep ploughing on the slopes, immense irrigated areas, terracing of slopes, etc. (Dobrovolschi, 2004). Although the specialty literature sources on elucidating landslides are abundant, in them very little attention allotted to issues such as quantitative and qualitative assessment of their activities and monitoring of land affected by landslides as part of ecopedological monitoring.

MATERIALS AND METHODS

The methodological aspect was given preference on the quantitative indices (surfaces, ha), sliding scale processes during certain periods, related to action of concrete factors: destruction of slopes by old landslides, heavy rains in large quantities, seismic activities. The results are shown in dynamics for a period of 45 years under study. The information presented is necessary to assess the legalities of development processes which influence landslides, serves as a reference bases for further research and monitoring to protect land resources of Moldova.

RESULTS AND DISCUSSIONS

Landslide processes and their manifestation peculiarities in Moldova were studied over a period of 20 years (1970-1990), both as a phenomenon and as a process (after 1990 only surface, hectares). Landslide as a phenomenon is part of the geological environment of limited land area and the sliding surface on which basis without losing touch with its movement still is going to a new level, usually with a lower altitude. Landslide as a process shows a consecutive modification of composition, condition and characteristics of landslide, starting from its initiation and travelling to an another level, until the full termination, manifested by unrest of soils and rocks that compose it and producing new relief specific forms (Сергеева, 1986).

Investigation of landslide processes revealed that the slip is irreversible, initial restoration of the land to its initial stage is impossible.

Landslide classification. Study of landslides in Republic of Moldova has lead to several classifications development, taking into account certain specific features of their manifestation. Depending on the sliding base and the number of change position they differ: simple slides (single surface) and complex slides (with two or more sliding surfaces). Such landslides are distinguished by the surface of inclination, sliding surface depth and position (Table 1).

Table 1. Diversity of landslides

After the inclination of the sliding surface	
Landslides with small inclination	up to 5°
Landslides with moderate inclination	5°-10°
Landslides with high inclination	15°-45°
Landslides with very high inclination	over 45°
After the depth and position of the sliding surface	
Superficial landslides	up to la 1 m
Landslides with small deep	up to la 5 m
Landslides with moderate deep	up to 20 m
Landslides with high deep	over 20 m

Landslides that have formed in the past geological eras refer to ancient stabilized landslides, and those occurring due to actual anthropogenic erosion process - contemporary subsidence being activated and active landslides. Among contemporary slides was distinguished: moving landslides (active) temporarily or completely stabilized.

After morphology landslides differ: in the form of circus, frontal, glaciers, mudflows, and angular configurations.

After structure and movement mechanism in Moldova most often meet landslides: sliding, shearing, flow field with printing, and collapsed (Андриеш et al., 2005).

Despite the significant diversity of slopes affected by landslides, most of them are specific the some common features. Landslide processes occur more frequently in places where in the geological structure of the slope predominate relatively "weak", friable, stratified layers of the sandy-clayey Miocene and Pliocene rocks, which lead to the deformation of rocks, breaking and slipping them (Ткач, 1974 b).

The land of slide was divided into five groups (Smolianikov et. al., 2007), which differ according to the genesis and reclamation approaches concerning their practice value (Table 2).

Table 2. Grouping of sliding lands

Group	Landslide	Characteristics
I	Simple mono-genic	Slides with simple structure, with only one separation zone, the height of the rupture does not exceed 5 m.
II	Simple polygenic	Landslides, which passed several stages of development, the detach-ment are composed of overlapping fragments asymmetrical shape; some aquifers are related to inconsistent after thickness.
III	Moderate polygenic	Slides has several outbreaks slide interconnected events occurring at different times and covers the entire slope.
IV	Complex polygenic	Secondary slides on the stabilized slopes by insufficient measures to combat landslides.
V	Atrophic - industrial	Slides, which lands are fed with artificial industrial water due to technical defects.

The main factors that favor the formation of landslides in the Republic of Moldova are: highly fragmented relief, climate with frequent sudden change and intensive heavy precipitation, geological structure of the slopes, consisting of alternating sandy-loamy rock with physico - mechanical properties, that changes excessively, slow neotectonic (secular) and short term seismic vibration, human economic activity (Ткач, 1974 a).

Factors influencing the development of landslides are divided into: permanently active (geological structure and topography), that changing slowly (tectonic movements, specific regional climate) and those who are changing rapidly (weather and hydro-geological conditions).

Relief. Landslides are a geological process of forming the relief, which is manifested throughout the country and poses a constant danger. The highest quantity of landslides is attributed to relief items with absolute elevation 80-170 m (70.6-82.6%) - morphostructural relief of Drochia - Făleşti, Lower Prut, Comrat and Puhoi; 180-270 m (64.1-70.2%) – morpho-structural relief of Northern Moldova Plateau and Soroca; at the 130-220 m are located about 65.2% of landslides in the Codri morpho-structure (Smolianikov, et al., 1996).

Research has shown that location of the landslides on the slopes with diverse inclination and heights differs for geomorphologic areas. In the Northern Moldavian Plateau on the slopes with a height up to 30 m is triggered over 67% of landslides from the total quantity, with a height of 30-50 m - 31%, on slopes with a greater height - about 2% of landslides.

Geological rocks that form the slopes have a high variability of the mechanical (granulo-metric) composition of clay, dusty and sandy particle content in the vertical profile. On the many slides sectors was established location of moving landslides at the certain layers of sandy-clayey rocks that received the name - "main deformation horizon". The content of rock dust and sand particles regulate humidity of higher and lower plasticity diapason, infiltration coefficient and shear strength indicator. High rainfall infiltration in depth of slope suddenly increases the hydrostatic pressure and hydrodynamic of groundwater and reduce stability of slope rocks. Clayey rocks of landslides, even with homogeneous structure, frequently disturbed by macro- and micro-cracks caused by earthquakes and neotectonic moves. In such areas during heavy rainfall periods occurs selectively swelling clays, leading to deformities and strength loss index of rocks about 10 times (Ткач, 1974 b).

Atmospheric precipitations are one of the most important factors influencing the intensity of the slip process. Under their influence are increasing humidity and pressure of swelling rocks, reducing resistance and stress, redistribution in sliding slopes.

In Moldova the rainfall are distributed unevenly from 560 mm in the north to 370 mm to south part. In high regions the rainfall increased approximately 60 mm at each 100 m of height. The most favorable conditions for landslides producing are create at fall abundant rainfall in the months of October to March, exceeding the annual average of 1.3 times. On the territory of Moldova is characteristic the presence of cyclical precipitation falls, which is 29-30 years and 45 years (Сергеева, 1986).

Very strong activations of slides are related to abnormal fall of precipitation, which exceeding the annual average in the year and rainfall during the cold period of 1.2-2.4 times, which fell during 3-5 of consecutive years.

In periods of significant rain falling (2-3 consecutive years) they exert a great influence on the groundwater level and therefore on the landslides. The years with the highest level of groundwater (1969-1970 and 1979-1980) are noted as years with a strong landslide activity.

In these years the total area of farmland affected by landslides reaches 10 thousand hectares and more, and the surface of most landslides was increased 2-3 times.

Geological and hydrogeological conditions. Landslides in Moldova are developing in platform conditions of geological formations with subhorizontal settlement of sedimentary rocks, sometimes complicated by destructive rupture. In the deepness of current depth of the hydrological network, at the territory construction participate rocks of different ages and lithology. These deposits are sinking slowly (inclination from 2 to 6 m per 1 km) in the direction of south - southeast.

The slopes destroyed by landslides on the agricultural land spread in the north and centre of Moldova are influenced by sandy-loamy deposits of Middle Sarmatia, that forming the lower and middle parts of the slope, above which to the watershed are placed deposits of Upper Sarmatia and Miocene period (Ткач, 1974 b). In the south part of the Dniester basin, the downstream parts of the slopes are formed by Middle Sarmatia deposits and above them are situated the Upper Sarmatia deposits. On the slopes of Prut River vicinity in their place downstream openings the Upper Sarmatia and Miocene deposits and, on the surface are located the Lower Pontus deposits.

Across of the all these deposits are spread: the diluvial - proluvial Quaternary deposits - on the slopes, the alluvial deposits - in the watersheds areas of the rivers Dniester and Prut and on the their plains, the accumulations of landslide rocks - within the boundaries of contemporary and old landslides (Ткач, 1974 b).

Significant manifestations of landslides are related also to earthquakes with intensity of about 7 degrees and more, taking place in Moldova every 30-40 years. Anthropogenic factors favoring landslides include construction works on the terraces (cutting off), quarries, excavations, downloading deposits parts of old landslides etc.

Geological, hydrological, physico-mechanical characteristics of sliding land is required for its use in environmental monitoring (frequency, manifestation, category dynamics by slipping, forecasting, and development of control measures). Joint complex influence of objective assessment of all factors will allow developing and implementing concrete measures on prevention of landslides, restoration and enhancement of degraded land. Complex objective assessment of all common factors will allow developing and implementing concrete measures on prevention of landslides, restoration and enhancement of degraded land.

Dynamic of sliding surfaces. Until 1970 the documentary evidence of the sliding surface was not executed. It had only approximated data that relatively characterized the slopes affection after selective investigation results. Since 1971 in the land balance began to appear the number of ravines and land sliding surface, which were listed on annual household land plans, allowing tracing dynamics of sliding surfaces on agricultural land. According to mapping materials and landslides cadastre the Moldovan territory is characterized by 16 thousand of active slides covering an area of 83.5 thousand ha, old slides - 721200 ha (or 21.7%) of territory, including 2.4% of contemporary active landslides. This data can be considered as the initial (basic) information for ecopedological monitoring.

The highest degree (60-80%) of territory damage by old landslides is recorded for the upper river valleys Ikel - Bic. The extent of damage territory decreases towards the southwest and its value is equal to 10. Territory damage from contemporary landslides is significantly lower; the maximum value is 10-15 and the minimum - 0.05-0.1. Unlike the old landslides, the contemporary slides affect local slopes in the form of isolated outbreaks.

The unfavorable combination of natural and anthropogenic factors, the sliding activation processes took place in the late of 70s and 80s of XIX century, then in 1906, 1912-1915, 1923, 1932, 1937, 1940-1941, 1948, 1963, 1966-1967, 1969-1970, 1973-1974, 1977, 1978-1980, 1981 (Ткач, 1974 a).

On the bases of land cadastre materials, situation on the 01.11.1971 summary evaluation of active landslides surface was conducted in the households. These were classified into eight groups of land after graduation growing, in percentage of relative damage expressed by landslides area per 100 ha of agricultural land. According to research, it was found that landslides are triggered inconsistent across the country. Their biggest spread tends to plateaus and considerably fragmented lands with active neotectonic movements. At the 01.11.1971 the total area of active agricultural landslides constituted 19483 ha (without landslides of forestry fund), which constituted 0.62% (Cadastru funciar, 1971).

In the 1973 was estimated about 31.6 thousand ha of active landslides and ravines. Currently there are 16 thousand units of active slides covering an area of 84030 ha. The largest of them (over 70 thousand ha) are situated on the agricultural land. Ancient and old landslide area constitutes about 22% of Moldova territory. In activation periods the land areas affected by landslides reaches more 10 thousand ha annually, causing immense damage in the republic.

The dynamics of increasing landslides and gully areas in the republic was: 1970 - 21.2 thousand ha, 1980 - 48.6 thousand ha, 1990 - 79.3 thousand ha, 2015 - 84.0 thousand ha.

During period 1970-1990 the surface of landslides and ravens increased by 58.1 thousand ha or 2.9 thousand ha annually (Figure 1). The main factor of intensifying the land slipping process in this period was unreasonable terracing the slopes.

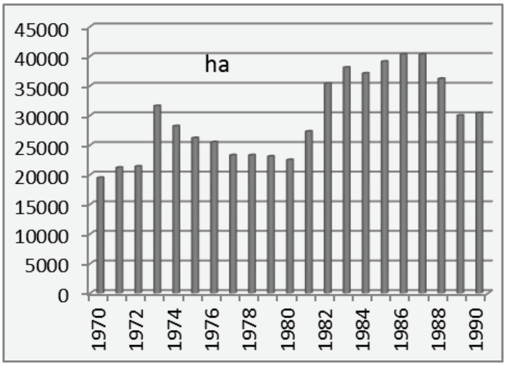

Figure 1. Dynamic of landslides areas in 1970-1990

During 45 years (1970-2015) as a result of human activity, landslides and gully area was increased by 62.8 thousand ha, increasing annually by 1.4 thousand hectares (Figure 2).

Currently a slip lies with every 200 ha of land and annual growth landslide areas are about 1000 ha. Considering that soil cover is completely damaged, only 20% of this area (200 ha) annual irreversible losses constitutes about 93 million Lei MD.

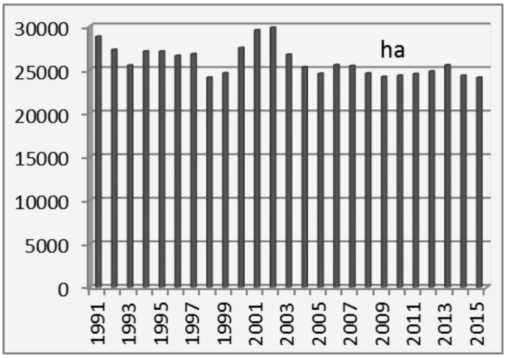

Figure 2. Dynamic of landslides areas in 1991-2015

In the land fund with agricultural destination of Moldova are highlighted 31.3 thousand ha of stabilized and semi-stabilized landslides with partially deformed soils and 39.6 thousand ha of active slides with completely destroyed soils. At the 01.01.2016 the total land area destroyed by landslides and ravines constituted 84.03 thousand ha, inclusive: ravines - 12031 ha, landslides - 24098 ha (Fișa cadastrală, 2016).

Landslides are a geological process of forming the relief, which is manifested throughout the country and poses a constant danger. From 15000 of landslides in recorded with a total area of 79 thousand ha, the 2300 of landslides occurs in localities and affecting over 12.5 thousand hectares of land occupied by various buildings.

Stabilization of landslides. The mechanism of landslides initiation is determined by following factors: the land resistance to deformation, the natural state of slope tension, the massive presence of water. Preventing landslides are possible if timely noticed and interpreted the specifics of these phenomena triggered by combating entry into the hazardous area of water, which through infiltration; increase groundwater reserves and favor the formation of sliding layer.

The main measures to prevent and combat landslides are:

- Construction channels that rapidly discharge rainwater;
- Land drainage through various methods;
- Capturing the coastal springs;
- Afforestation of affected or potentially damage land;
- Building fences, retaining walls, contrary banquets, etc;

- Consolidation of land by electro osmosis and heat treatment etc.
It is recommended for monitoring activities:
- Correctly identification the areas with high risk of erosion, for intervention with consolidation, stabilization, smoothing, shaping measures and other drainage works.
- Systematization the crops on arable land, choosing optimal land use category after land evaluation, use suitable agrosystem in order to prevent the negative effects of erosion.
- Monitoring of the erosion processes on the agricultural land using GIS technologies, expressed through the quality of accumulated biomass.
- To apply methodology for estimating the risk of erosion, given that each country uses a methodology for estimating the risk of erosion.
- Hydraulic works should be implemented at the incipient manifestation of the erosion process.

Capitalization of slippery surfaces is expensive, but more expensive is the abandonment of the affected areas. The easiest and most efficient way of capitalizing on slippery surfaces is afforestation with tree species rapidly increasing (willow, poplar, acacia), which will help them stabilization. At present require afforestation the 24.0 thousand ha of active landslides covering with damaged soils. Drainage work and other technical measures are needed where landslides threaten the destruction of communication lines, social and economic objects, settlements etc. and carried out under a special project.

CONCLUSIONS

For development of effective protective measures required knowledge of certain quantitative and qualitative characteristics of the factors forming slides over a long period. Preventing and combating landslide is possible only through research causal factors, minimize or remove their influence, conduct mapping and cadastre of affected land, monitoring establishment for predicting these processes. To forecast landslides is necessary implementation, function and updating the land with landslide risk, primarily in localities.

REFERENCES

Андриеш С.В. et al., 2005. Природные и антропогенные условия, способствующие проявлению и развитию процессов деградации почв. *Программа освоения деградированных земель и повышения плодородия почв.* Ч.1. Мелиорация деградированных земель. Chisinau, Pontos, c.7-28.

Cruden D., 2007. Landslides: Processes, Prediction, and Land Use. *Canadian Geotechnical Journal*, vol. 44, no. 6, p.737. *Academic One File*, Accessed 22 Jan. 2017.

Dobrovolschi. G., 2004. Procesele de alunecare. Valorificarea terenurilor degradate prin alunecări. *Eroziunea solului.* IPAPS N.Dimo. Chișinău, Pontos, p.288-317.

Krupenikov I., 2004. Esența procesului de eroziune. *Eroziunea solului.* IPAPS N.Dimo. Chișinău, Pontos, p.15-23.

Smolianikov P. et al., 1996. *Buletin de monitoring ecopedologic (terenuri degradate prin alunecări).* Ed. a IV-a. IPAPS N.Dimo, Secția editare ASDAP, Chișinău, 90 p.

Сергеева Н. С., 1986. Анализ изменения общей увлажненности и прогноз активации оползневого процесса в Молдавии. *Методы изучения и прогноза экзогенных геологических процессов*. Москва, 1986, Вып.153, c.66-71.

Ткач В.Н., 1974 a. О влиянии гидрогеологических условий и атмосферных осадков на развитие оползневых процессов. *Оползни и борьба с ними.* Кишинев, Штиинца. c.10-12.

Ткач В.Н., 1974 b. Оползневые процессы в плиоцен - четвертичных террасах Молдавии. *Геология четвертичных отложений в Молдавии.* Кишинев, Штиинца, c.121-134.

***Cadastru Funciar al Republicii Moldova la 01 noiembrie 1971. Chișinău, Cadastru, 1971.

***Fişa cadastrală centralizatoare a terenurilor din Republica Moldova la data de 1 ianuarie 2016. www.arfc.gov.md/transparenta/proiecte.

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SOIL MICROBIAL BIOMASS CONTENT INTO LEACHED CHERNOZEM STRUCTURAL AGGREGATES IN DIFFERENT LANDS MANAGEMENT SYSTEMS

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Abstract

The paper aimed to present the relationships between soil microbial biomass content and the sizes of soil structural aggregates in the leached chernozem from central part of Moldova in three different lands management systems as the long-term arable chernozem with crop rotation without fertilizers, long-term arable land covered for nine years with cover crops (grass mixture ryegrass and lucerne) which are used each year as a green manure and chernozem under 60 year-old fallow. It is based on the research carried out in the experimental sites of "Nicolae Dimo" Institute of Pedology, Agrochemistry and Soil Protection from village Ivancea, Orhei District. The data have been processed into the following indicators: soil structure, organic carbon content, microbial biomass carbon. Carried out research show that fallow chernozem under the forest stripe has a significantly better structure than arable and phyto improved soils. In all three experimental sites carbon content have a uniform distribution regardless of the aggregates size. Microbial biomass carbon is concentrated in the smallest aggregates of fallow cernozem in the surface layer and has a polynomial distribution in below layer. Arable cernozem is characterized by fairly uniform distribution in all size soil aggregates but with a slightly higher concentration in the 0.5-0.25 mm aggregates. Phyto improved cernozem differs from the arable by microbial biomass carbon higher content in medium sized (the highest in 3-2 mm) aggregates in the first layer from the surface. As a conclusion, despite a uniform organic carbon distribution in different sized soil aggregates, microbial biomass carbon has some preferences due to the used agricultural practice and can be an indicator of soil health.

Key words: *carbon, soil biomass, soil structure, cernozem, Moldova.*

INTRODUCTION

Soil framing in the agricultural use is immediately followed by negative changes in its quality. Soil structure is a morphological and agronomical soil index which makes it different from the parental rock and confers its fertility. Unfortunately, in the last decades this soil feature of particular importance has been significantly degraded on arable lands resulting in soil compaction, crop yields decreasing and erosion processes on ever wider surfaces extending, not only in Moldova, but also worldwide. Restoring soil fertility and its sustainable use is the primary aim of modern agriculture. A very sensitive indicator used to determine changes in soil is microbial biomass content. Although microbial biomass represents less than 5% of the total organic matter in soils, it plays an essential role in soil life contributing to substances transformation, pesticides degradation, and soil aggregation. Previous research has established that soils framing is resulting in its biota degradation - a phenomenon found in close correlation with soil dehumification and destructuration processes (Senicovscaia, 2012). Conventional tillage system leads to structural aggregates destruction, and therefore of microorganisms habitat (Senicovscaia et al., 2010). Microorganisms' interaction with organic matter and soil structure is complex and represents a heterogeneous phenomenon that contributes to soils quality and high productivity establishment. Soils used under perennial grasses, which form biogenic layer at the soil surface, compared with fallow and arable are ideal ecosystems for investigations of these interactions. In this context, the paper present an analysis of organic and microbial carbon distribution on different size of soil structural aggregates in three different lands management systems from central part of Moldova, in order to put into evidence the changes that occur with the soil microorganisms along with the soil transforming under ploughing, farming and phytotechnical improving.

MATERIALS AND METHODS

The research where carried out in the Republic of Moldova at Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo" experimental field located in the center of the country, in the Ivancha village, Orhei district. The soil is the leached chernozem with humus content around 3.0% and pH ≈ 6.6 in the 0-25 cm layer.

For research was chosen three experimental sites with different lands management systems as: leached chernozem under 60 year-old fallow in the forest strip from the field edge (forest strip), the long-term arable land with crop rotation without fertilizers (conventional agriculture) and nine years phyto improved arable land with grass mixture ryegrass+lucerne (grass strip) (Figures 1, 8).

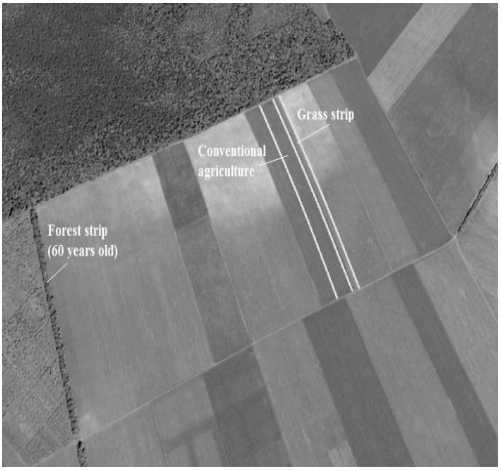

Figure 1. Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo" experimental field used for current research

Plots under mixtures of perennial grasses (ryegrass+lucerne) were founded in the autumn of 2007.

This study was performed in the period 2015-2016.

Soil samples were collected from the 0-10 and 10-25 cm layers in each experimental plot in five repetitions for statistical data processing.

In the middle of each experimental plot also was made a full profile to describe and analyse the soil in the deep.

In order to characterize the microbial biomass transformation under different lands management systems, the following indicators were used: soil structure, organic carbon content and microbial biomass carbon in soil structural aggregates with different size.

For soil structural composition or aggregate size distribution assessment was used the standard classical dry-sieving method (Savinov, 1936). Where is taken 500 g of air-dried, undisturbed soil which is sieved through a cluster of sieves having 10, 5, 3, 2, 1, 0.5, and 0.25 square mm from which results eight aggregate size classes (>10, 10-5, 5-3, 3-2, 2-1, 1-0.5, 0.5-0.25 and <0.25 mm).

Soil organic matter (%) or organic C was analyzed by the dichromate oxidation method (Arinushkina, 1970). The carbon content was calculated using the coefficient of 1.724.

The microbial biomass carbon was measured by the rehydratation method based on the difference between carbon extracted with 0.5 M K_2SO_4 from dried soil at 65-70^{0}C within 24 h and fresh soil samples with Kc coefficient of 0.25 (Blagodatsky et al., 1987). K_2SO_4 - extractable organic carbon concentrations in the dried and fresh soil samples were measured simultaneously by dichromate oxidation. K_2SO_4-extractable carbon was determined at 590 nm with СФ 103 spectrophotometer.

The obtained data have been statistically processed and interpreted. The microbial biomass index was evaluated statistically by the variance and correlation analysis.

RESULTS AND DISCUSSIONS

Leached chernozem under 60 year-old fallow from the forest strip is well structured in the entire profile. The main part of the soil is joined in agronomic precious aggregates (Figure 2). But after 60 years the effect of soil plowing can still be recognized in the layer 12-25 cm.

Arable chernozem is bad-structured (Figure 3). Less favourable for plant growth is exactly the layer of roots growth. First 0-10 cm from the surface is extremely dusty top layer. The underline layer 10 - 20 cm is so compacted, large aggregates greater than 10 cm predominate here as a result of soil compaction in this layer.

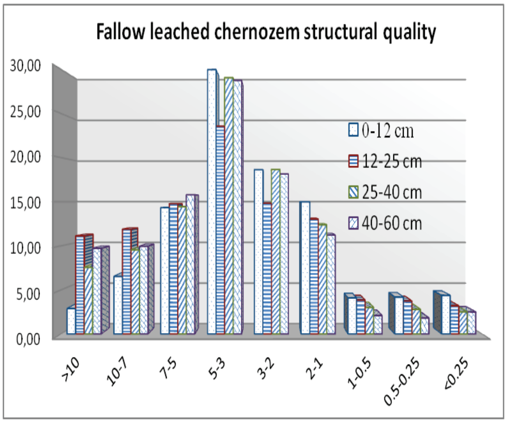

Figure 2. Fallow leached chernozem aggregate size distribution

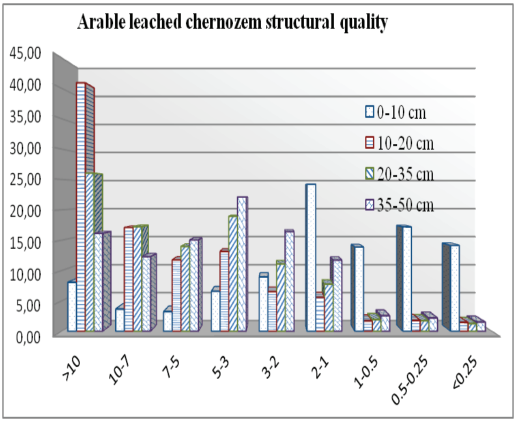

Figure 3. Arable leached chernozem aggregate size distribution

Cover crop into phyto improved leached chernozem experimental site help to destroy the big soil particles in the layer 10-20 cm (Figure 4).

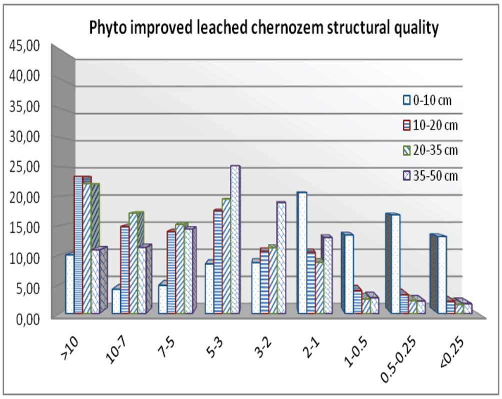

Figure 4. Phyto improved leached chernozem aggregate size distribution

This bad structural conditions affect to a large extent plants grow, but how it affect the organic carbon and soil microorganism distribution in various size aggregates?

The organic carbon values are higher in the fallow cernozem (3.0-3.5% in the top layer, 2.6- 2.9% in the 10-20 cm layer). Arable and phyto improved soils carbon content is in the range of 1.7-2.1%.

In all three experimental sites organic carbon content have an almost uniform distribution in all soil aggregates regardless of the aggregates size.

But a size of soil particles plays an important role in the distribution of microorganisms in the aggregate fractions of leached chernozem under 60 years-old fallow (Figure 5). The largest concentrations of microbial biomass carbon were found in the layer of 0-12 cm.

The highest amounts of the microbial biomass in the layer of 0-12 cm are localized in fractions of 0.5-0.25 mm (16.9%) and < 0.25 mm (13.5%). The lowest amounts of the microbial biomass have been recorded in the fraction of > 10 mm (6.4%).

All remaining biomass was distributed approximately equally among soil particles with the size of 10-7, 7-5, 5-3, 3-2, 2-1 and 1-0.5 mm, which is 63.2% of the total amount. The link between microorganisms and soil fractions is strongly positive.

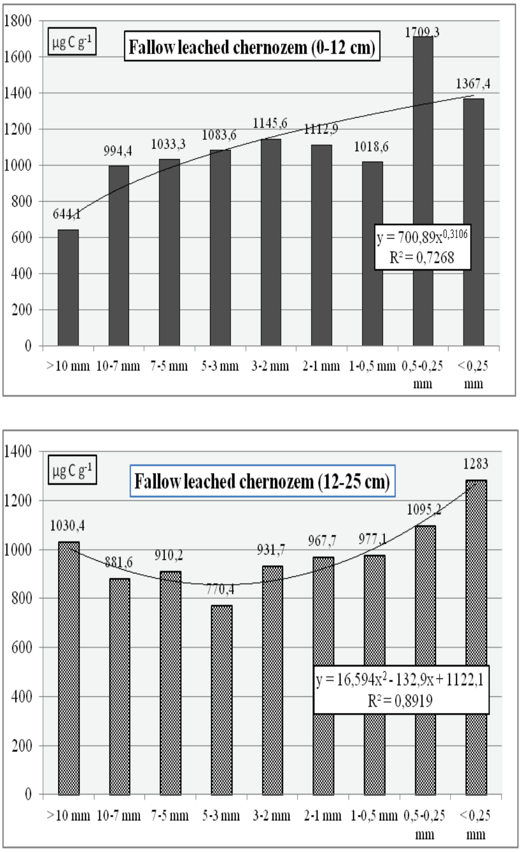

Figure 5. Distribution of microorganisms in soil aggregates of the fallow leached chernozem

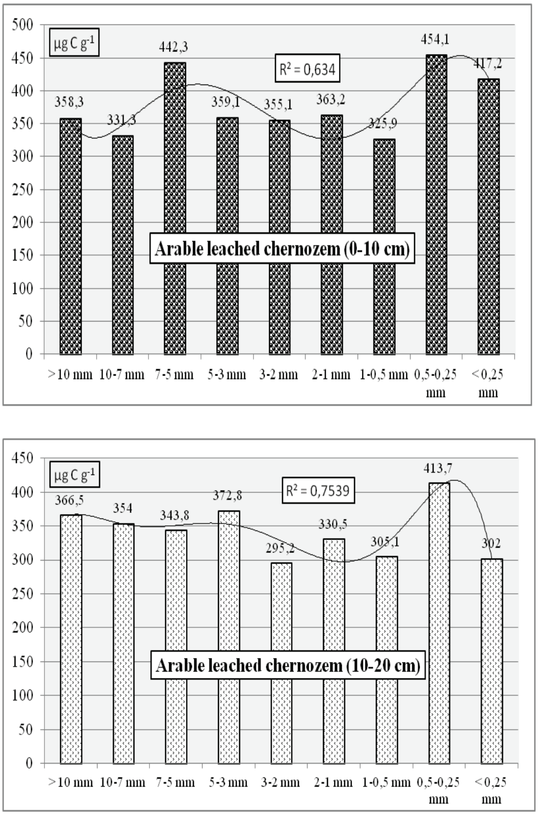

Figure 6. Distribution of microorganisms in soil aggregates of the arable leached chernozem

Trend of the microbial biomass content in soil aggregates in the layer of 0-12 cm is described by the power function. Correlation coefficient constitutes $R^2 = 0.73$.

The highest amounts of the microbial biomass in the fallow chernozem (layer of 12-25 cm) are localized in the fractions of < 0.25 mm (14.5 %), 0.5-0.25 mm (12.4 %) and > 10 mm (11.7 %). The lowest amounts of the microbial biomass have been recorded in the fraction of 5-3 mm (8.7 %). Fractions with the particles size of 10-7, 7-5, 3-2, 2-1 and 1-0.5 mm contained approximately the same number of microorganisms (881.6-977.1 μg C g^{-1} soil). Trends are described by the polynomial function with the high correlation coefficient ($R^2 = 0.89$).

Soil matrix under arable chernozem contains significantly lower amounts of microorganisms in comparison with fallow chernozem in 0-12 cm layer and as well as in the layer of 12-25 cm (Figure 6). Enrichment of soil fractions with microbes was reduced by several times. It should be noted the decrease in the microorganisms abundance in the 10-20 cm layer.

The trend of the microbial biomass and particles size in the arable chernozem is described by polynomial function of 6 degrees and reveals moderate and strong links (R^2 = 0.63 and 0.75).

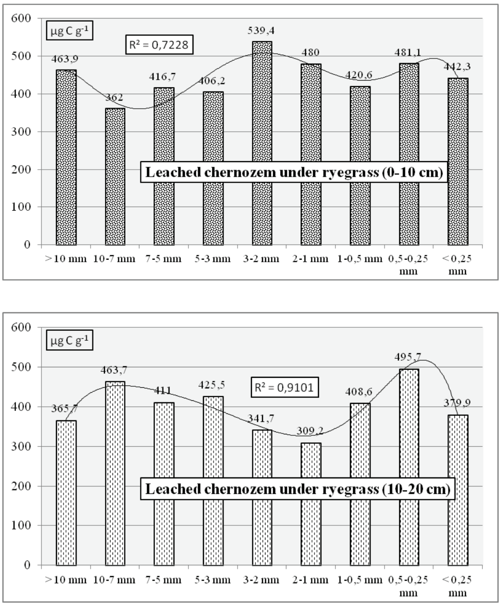

Figure 7. Distribution of microorganisms in soil aggregates of the leached chernozem under ryegrass

The highest numbers of the microbes in the arable chernozem (0-10 cm layer) are localized in fractions of 7-5, 0.5-0.25 and < 0.25 mm (38.5%).

The maximal amount of microorganisms in the 10-20 cm layer of arable chernozem were recorded in the fraction of 0.5-0.25 mm, their number reached 413.7 µg C g^{-1} soil.

Statistically, all other factions of the chernozem under arable were not different from each other.

Microbial biomass in the leached chernozem under ryegrass in the 0-10 cm layer is localized mainly in fractions of 3-2, 2-1, 0.5-0.25 mm and > 10 mm fraction, in the 10-20 cm - in 10-7 mm and 0.5-0.25 mm fractions (Figure 7). The number of microbes in 10-20 cm layer is less by 10.2% in comparison with the 0-10 cm layer.

The link between the microorganisms and the size of fractions in the leached chernozem under ryegrass is positive and shows the strong correlation (R^2 = 0.72 and 0.91). The trend is described by polynomial function of 6 degrees.

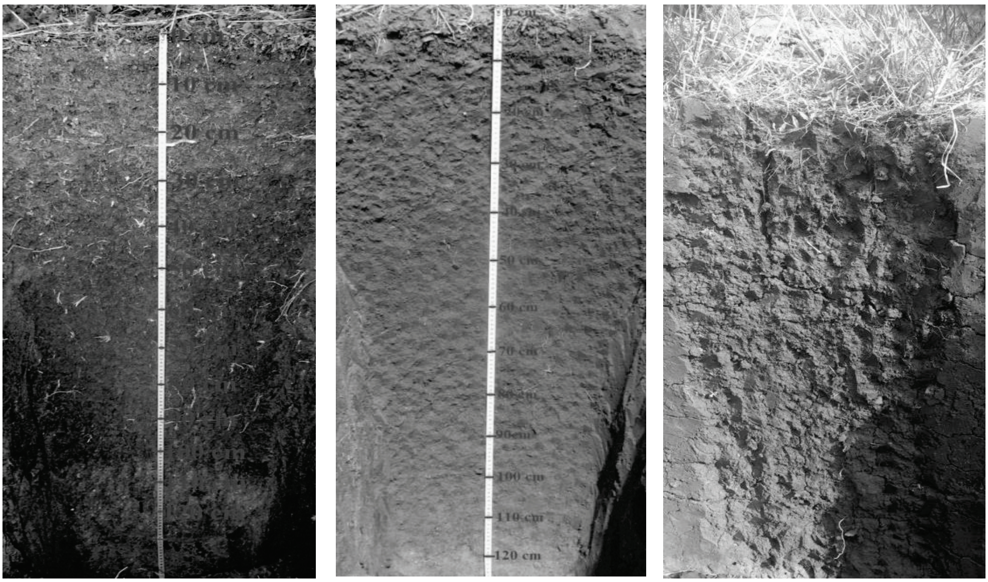

Figure 8. Studied soil profiles from Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo" experimental field. Fallow leached chernozem - in the right, arable leached chernozem - in the middle and phyto improved leached chernozem - in the left

CONCLUSIONS

Conventional agricultural management practices lead to leached cernozem agronomically valuable aggregates destroying (soil dusting) in 0-10 cm toplayer and their hardening in big sized soil particles (soil compaction) in underlying 10-20 cm layer. It almost doesn't affect organic carbon content which is distributed evenly throughout all soil aggregates. But it affects microbes and soil organisms' habitat, so their content in soil and in its different size particles. The interaction between microbial components and the soil structure in the leached chernozem under different land management is very close and can be described by the complex equations of power and polynomial functions with high correlation coefficients. The microbial biomass content in soil aggregates decrease in the sequence: 60 years-old fallow land → arable land under ryegrass → arable land. The number of microbes in the aggregates in the topsoil is always higher than in the lower.

The largest amount of microorganisms in the soil under fallow are concentrated in soil particles with a smaller size – 0.5-0.25 mm and < 0.25 mm. As a result, resistance of natural soil matrix to natural and anthropogenic negative impacts is higher than in the soils from agricultural ecosystems.

The microbial biomass in arable chernozem is lower by 2.9-3.0 times than in the fallow chernozem. The microorganisms' distribution in the arable chernozem has more or less uniform character. The soil structure destruction and the significant deterioration of microorganisms in arable chernozems aggregates lead to their natural stability decrease and to the degradation processes development.

The use of ryegrass for the long-term arable chernozem quality restoration contributed to the microbes content increase then in the soil aggregates with 14.4-15.1%. These values do not achieve the level of the soil under natural vegetation.

ACKNOWLEDGEMENTS

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REFERENCES

Arinushkina E.V., 1970. Guide for chemical analysis of soils. MGU, Moscow.

Blagodatsky S.A., Blagodatskaya E.V., Gorbenko A.J., Panikov N.S., 1987. Rehydration method for the determining of the microbial biomass in the soil. Pochvovedenie, Moscow, 4: p. 64-71.

Bossuyt H., Denef K., Six J., Frey S.D., Merckx R., Paustian K., 2001, Influence of microbial populations and residue quality on aggregate stability. In: Applied Soil Ecology, Vol. 16. p. 195-208.

Degens B., Sparling G., 1996. Changes in aggregation do not correspond with changes in labile organic C fractions in soil amended with 14C-glucose. In: Soil Biology and Biochemistry (28), p. 453-462.

Kennedy A.C., Papendick R.I., 1995. Microbial characteristics of soil quality. J. Soil and Water Conservation, 50, No. 3, p. 243-248.

Oades J.M. and Waters A.G., 1991. Aggregate hierarchy in soils. In: Australian Journal of Soil Research (29), - p. 815-828.

Oades J.M., 1993. The role of biology in the formation, stabilization and degradation of soil structure. In: Geoderma (56), p. 377-400.

Pankhurst C., Doube B., Gupta, V.V.S.R., 1997. Biological indicators of soil health. CABI Publishing, 451 p.

Senicovscaia I., Marinescu C., Balan T., 2010. Agricultural land use impact on typical chernozems biota. Republic of Moldova soil quality monitoring (database, conclusions, forecasts, recommendations). Chisinau: Pontos, p. 164-171.

Senicovscaia I., 2012. Biota of degraded soils and methods for its restoration. In: AgroLife Scientific Journal, V. 1, p. 78-83.

Senicovscaia I., 2012. Sustainable management and conservation of biota in agricultural soils of the republic of Moldova. In: Proceedings of the International Symposium on Agrarian Economy, p. 283-288.

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INFLUENCE OF LONG TERM FERTILIZATION WITH NITROGEN AND PHOSPHORUS ON WHEAT PRODUCTION AND ON SEVERAL CHEMICAL CHARACTERISTICS OF THE SOIL

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Abstract

This paper presents the evolution of soil fertility as a result of long-term fertilization (35 years) with NP. The doses of nitrogen and phosphorus were: 0, 50, 100, 150, 200 kg/ha. The experimental field is located on chernozem soil. Soil samples were collected on 0-20 cm depth. Fertilization with $P_{100}N_{100}$, $P_{100}N_{150}$, $P_{100}N_{200}$ led to very significant increases of production (42%, 53% and 52%) after 35 years of fertilization of wheat crop; the variants fertilized with $P_{100}N_{150}$ have ensured the highest production (7522 kg/ha) followed by those fertilized with $P_{100}N_{200}$. Doses of 150 and 200 kg/ha nitrogen have significantly increased soil humus level from 3.06% for the control variant to 3.27%, respectively 3.25%. The application for 35 years of doses of 50-200 kg/ha phosphorus with the same doses of nitrogen did not led to statistically significant changes of the humus level, total nitrogen and mobile potassium. The content of phosphorus in the soil increased significantly once a dose of phosphorus was applied.

Key words: *long-term experience, wheat, nitrogen, phosphorus.*

INTRODUCTION

This experience is part of the 18 long-term experiences placed by Academician Cristian Hera in 1966 in a network with different climate and soil conditions specific to Romania. The organization of the experiences was made after a single concept. In the period after 1990 scientific research in agriculture was undercapitalized on all "fronts", without bringing in new sources for the revitalization of new structures that could continue the reconstruction of Romanian agriculture. Thus, 12 of these experiences are now left (Hera, 2013), one of which is at Valu lui Traian.

At the time the experimental scheme for these experiences was established it was expected that in Romania the use of mineral and organic fertilizers will increase. It was estimated that no matter how good the organic fertilizers are, even if the number of animals will increase, the amount of organic fertilizer will remain insufficient to provide the necessary for agriculture. Mineral fertilizer consumption increased until 1986 when there were applied, 129.9 kg/ha of NPK fertilizers on arable land, or 86.4 kg NPK/ha on agricultural land. In the year 2012 in Romania were used 290 000 t of nitrogen, 113 000 t of phosphorus and 35 000 t of potassium, which implies a total of 438 thousand tons NPK fertilizers, respectively 30.85 kg/ha arable N, 12 kg/ha P and 3.7 kg/ha K (Anuarul Statistic al României, 2015).

Long-term experiences with nitrogen and phosphorus started from the following premises:

1) The soils in our country ensure an important nitrogen amount for plant nutrition through humus mineralization, yet this usually insufficient to achieve high productions (Vintilă et al., 1984);

2) The use of fertilizers with phosphorus is based on the experimental results regarding the response of crops fertilized with phosphorus under different conditions and due to the need of increase of the accessible phosphorus content from the soil to optimal levels, in order to comply with the nutritional requirements of plants and with the increase of agricultural production (Davidescu et al., 1974; Hera and

Borlan, 1980; Borlan and Hera, 1984). It was considered that in most soils with medium and soft texture from the temperate zone, the potassium from soil presents a satisfactory level (Borlan and Hera, 1973, 1977; Băjescu and Chiriac, 1984).
Given all of the above in this experience was followed the effect of different doses of mineral fertilizers with phosphorus and nitrogen on corn production and on some chemical characteristics of the soil.

MATERIALS AND METHODS

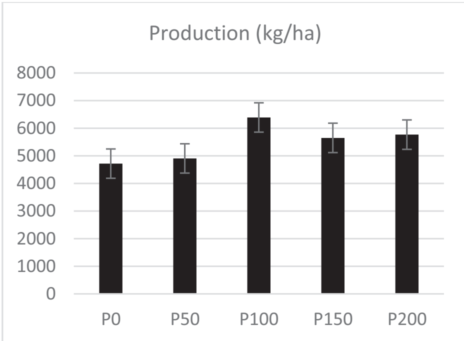
The experience organized on chernozem followed the influence of the interaction of phosphorus doses (P_0, P_{50}, P_{100}, P_{150}, P_{200} kg/ha) with nitrogen doses (N_0, N_{50}, N_{100}, N_{150}, N_{200} kg/ha).
The experiment consisted of 25 placed in a randomized block design using 18 variants in 3 replications. To investigate the chemical characteristics, the soil samples that were collected at the depth of 0-20 cm, and the following analyzes were performed: pH, humus, total nitrogen, accessible phosphorus, accessible potassium, soluble salts, carbonates and total forms of heavy metals (copper, zinc, cadmium and lead).
The methods used for the chemical characteristics are presented as follows:

- STAS 7184/21-82. - Organic matter (humus): volumetric method - Walkley Black, Gogoașă.
- SR7184/13-2001 - pH: determined by potentiometric method with combined with glass and calomel electrode in aqueous suspension soil/water - 1/2.5.
- SR ISO 11261: 2000 - total nitrogen (N%): Kjeldahl method, H_2SO_4 digestion at 350 °C, using potassium sulfate and copper sulfate as catalyst;
- Accessible (mobile) phosphorus: Egner-Riehm-Domingo method and spectrophotometric determination with molybdenum blue in accordance with Murphy-Riley method (reduction with ascorbic acid);
- Accessible (mobile) potassium: extraction according to Egner-Riehm-Domingo method and determination by flame photometry.

RESULTS AND DISCUSSIONS

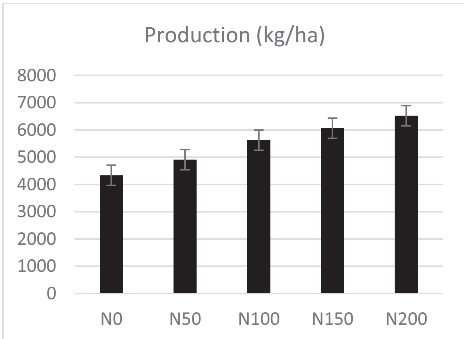
1. The influence with different nitrogen and phosphorus doses on wheat production

The influence of different phosphorous and nitrogen doses on the production of wheat grown on chernozem at Valu Traian are shown in Figures 1-3.



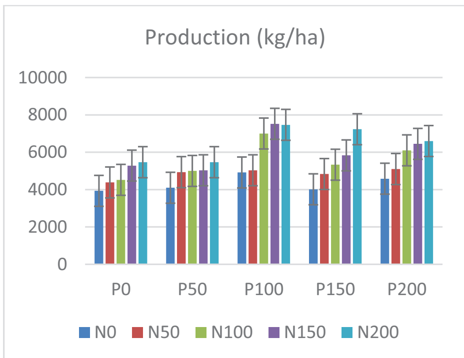
DL5% 531; DL1% 772; DL0.1% 1158

Figure 1. Phosphorus influence on the wheat yield



DL5% 371; DL1% 496; DL0.1% 652

Figure 2. Nitrogen influence on the wheat yield



DL5% 829; DL1% 1108; DL0.1% 1457

Figure 3. Influence of interaction phosphorus and nitrogen on wheat yield

The dose of phosphorus of 100 kg/ha, without nitrogen, led to the largest production increase (35%) compared to the unfertilized variant. The application of nitrogen on a background unfertilized with phosphorus shows that the production increased very significantly at doses > than 100 kg/ha nitrogen. The production yield, on a soil well supplied with organic matter and under irrigation conditions increased with the dose of nitrogen and was statistically ensured only at doses of 150 (distinctly significant) and 200 kg/ha nitrogen (very significant).

Variants fertilized with doses of P_{100} and N_{100}, N_{150} and N_{200} led to very significant increases of production (42%, 53% and 52%); the largest production (7522 kg/ha) was assured at variants $P_{100}N_{150}$ followed by those fertilized with $P_{100}N_{200}$.

At the application of $P_{150}N_{200}$ was obtained the highest production (7233 kg/ha), where the production yield compared to the nonfertilized variant with nitrogen was 80% (3220 kg/ha). A very significant increase of production of 1820 kg/ha was obtained also after the fertilization with $P_{150}N_{150}$.

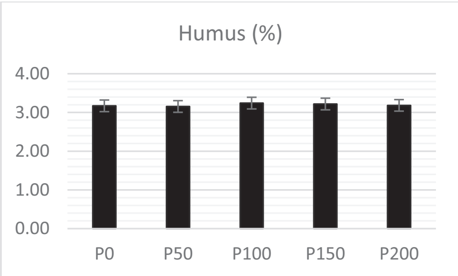
On a background of fertilization with P_{200}, the doses of 100, 150 and 200 kg/ha nitrogen led to very significant increases of production, the production increased with the increase of nitrogen dose; the combination of P_{200} and N_{200} provided a high production (6600 kg/ha), but much smaller than in the case of application of 150 and 200 kg/ha nitrogen on a background of 100 kg/ha phosphorus. The soils with high cation exchange capacity and saturation degree in bases larger than 75-80% are conditions for a better use of phosphorus fertilizers under soluble form (Berca, 2008).

Under irrigation conditions, the best corn productions of were obtained by fertilization with 100 kg/ha phosphorus and 150-200 kg/ha nitrogen; when the corn is well stocked with water, the nitrogen is efficiently exploited even if in high doses, and the phosphorus is seen as an amplifier of nitrogen effect (Zamfirescu, 1977). Similar results are were reported by Hera (2015); in many cases it was noted that the associated application of nitrogen and phosphorus fertilizers led to higher productions compared to the separate application of these fertilizers; therefore there is an interaction between these elements (Hera et al., 1984).

On background of P_{100} fertilization the average increase of production per kg of nitrogen in the case of fertilization with N_{100} and N_{150} was 10.4 kg, and in the case of fertilization with N_{200}, 8.5 kg.

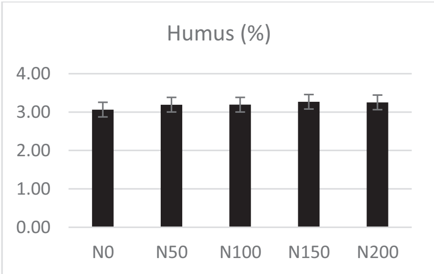
2. The influence of different doses of nitrogen and phosphorus on humus in soil

The effect of phosphorus and nitrogen doses applied for 35 years on humus content in the soil is presented in Figures 4, 5, 6. It was found that the doses of 150 and 200 kg/ha nitrogen have significantly increased the humus level in the soil.



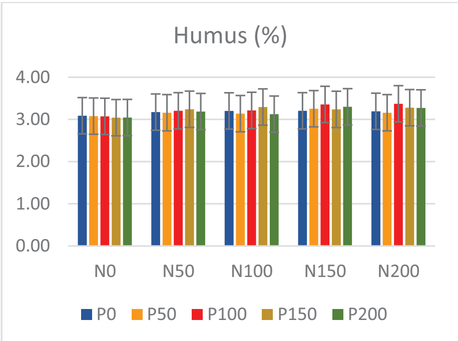
DL5% 0.15; DL1% 0.21; DL0.1% 0.32

Figure 4. Phosphorus influence on the humus evolution



DL5% 0.19; DL1% 0.26; DL0.1% 0.34

Figure 5. Nitrogen influence on the humus evolution



DL5% 0.43; DL1% 0.57; DL0.1% 0.75

Figure 6. Nitrogen and phosphorus influence on the humus evolution

Long term researches conducted by Andrieș (2007) in Moldova showed that the systematic application of mineral fertilizers leads to the stabilization of organic matter in the soil; in the long-term experiences from Halle (Germany) it has been found that after mineral fertilization, soil organic substance was maintained for 80 years at the same level (Eliade et al., 1983); the content of organic carbon from the soil presents significant decreases in NP combinations (without organic resources) and the high mineral doses (over 120-150 kg/ha and 80 kg/ha P_2O_5) balances after 30-40 years these changes and bringing them at least at the initial levels on account of the amount of organic material in the soil, depending on the nitrogen dose (Hera, 2013). Rusu et al. (2005) shows that mineral fertilization decreases soil humus and the organic fertilization increases the organic nitrogen and humus content and ensures favorable development of soil fertility. Otherwise, the long-term humus-reducing measures affect the fertility and the buffering capacity of soils, making them more vulnerable to degradation and pollution factors.

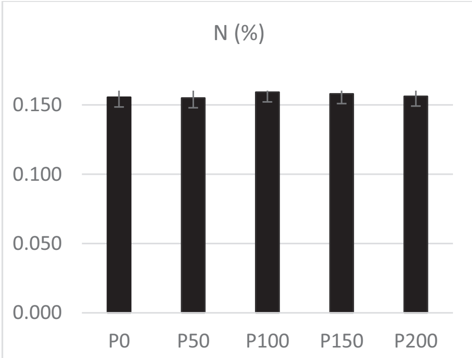
3. The influence of different doses of nitrogen and phosphorus on nitrogen in soil

Nitrogen cycle in the soil-plant system is very dynamic and complex. The transformations of nitrogen in soil, its uptake in plants and the immobilisation are determined by climate variability, soil type and plants (Fageria, 2009; Mocanu et al., 2005).

Part of the nitrogen applied from chemical fertilizers and the one resulted from the humus mineralization and unused for plant nutrition is lost during the nitrification process. The nitrate ions resulted are leaching on the soil profile at the same time with rainfall or irrigation water (Lăcătuşu et al., 2005; Ghiglieri et al., 2009; DEFRA, 2010). Researches carried out by Borlan et al. (1994) have shown that on middle texture soils with good water permeability, from the nitrogen applied in optimum economical doses after chemical fertilization, the denitrification losses are 20-25% and 5-10% from the organic nitrogen resulted from humus mineralization.

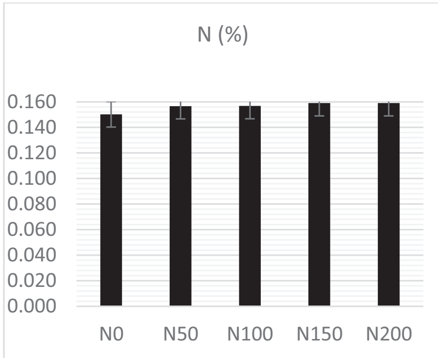
In Figures 7-9, is presented the effect of various doses of nitrogen and phosphorus on the total nitrogen content on chernozem.

Fertilization with phosphorus in doses of 50-200 kg/ha and nitrogen in doses of 50-200 kg/ha for 35 years did not led to significant changes in the total nitrogen in soil. The nitrogen cycle is closely linked to the carbon cycle (Andrieș, 2011), and the lack of changes in humus content justified the absence of changes in total nitrogen content in the soil.



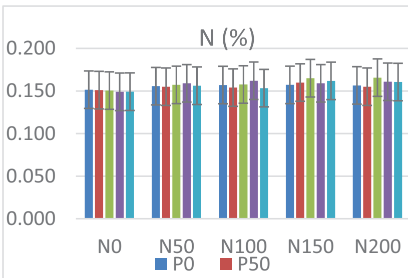
DL5% 0.007; DL1% 0.011; DL0.1% 0.016

Figure 7. Phosphorus influence on the evolution of soil nitrogen



DL5% 0.010; DL1% 0.013; DL0.1% 0.017

Figure 8. Nitrogen influence on the evolution of soil nitrogen

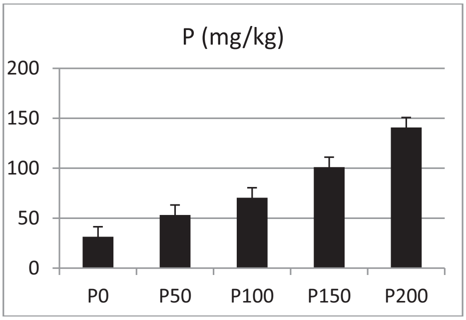


DL5% 0.022; DL1% 0.029; DL0.1% 0.038

Figure 9. The influence of fertilization with nitrogen and phosphorus on soil nitrogen evolution

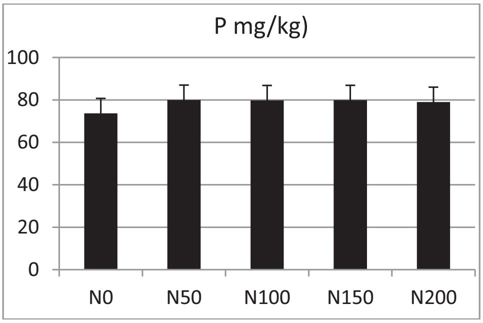
4. The influence of different doses of nitrogen and phosphorus on the mobile phosphorus in soil

In Figures 10-12 is presented the influence of phosphorus and nitrogen fertilization for 35 years on mobile phosphorus content.



DL5% 10; DL1% 14; DL0.1% 21

Figure 10. Phosphorus influence on the evolution of phosphorus in soil



DL5% 7; DL1% 9; DL0.1% 12

Figure 11. Nitrogen influence on the evolution of phosphorus in soil

The phosphorus content in soil increases significantly with the increase of phosphorus dose; at the dose of 50 kg/ha phosphorus the increase is distinctly significant and at dosages ≥100 kg/ha phosphorus the increase is very significant.

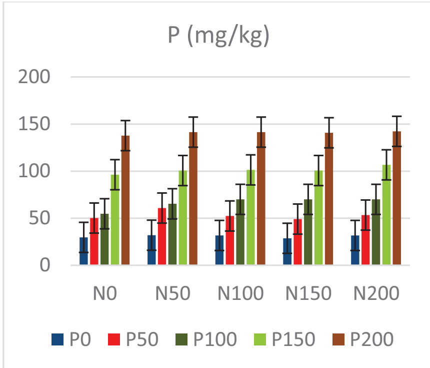
Mobile phosphorus content in soil was not afected by the application of different doses of nitrogen.

Under the influence of fertilization with doses of phosphorus higher than the productive consumption, the content of mobile phosphorus significantly increases during the first 20 years of the experiment (Hera, 2013).

Borlan et al. (1990) show that mineral fertilization with nitrogen negatively influences the of mobile phosphorus content from the arable layer of the soil.

This was not the case in our study since the soil is well supplied with phosphorus and saturated with bases.

Avarvarei et al. (1997) showed that organic matter protects phosphorus ions precipitation by forming chelates organomineral compounds, that retain phosphorus ions. Also certain organic ions can release phosphate ions fixed on soil particles and the CO_2 released after organic matter mineralization, can play an important role in the solubilization of phosphates.



DL5% 16; DL1% 21; DL0.1% 28

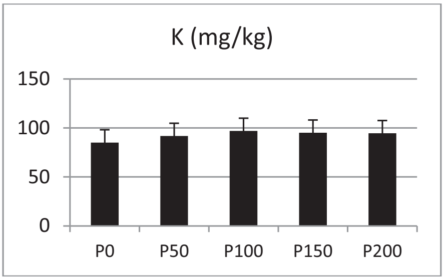
Figure 12. The graphical representation of the influence of nitrogen and phosphorus fertilization on the evolution of the mobile phosphorus in the soil

McBride et al. (1987) (cited by Vrânceanu et al., 2010) showed using various adsorption environments that the presence of high concentrations of phosphate ions in solution leads to the decrease of zinc and copper adsorption.

The phosphate ion does not form stable complexes with zinc and copper, but it is absorbed on soil surface, blocking the access of the copper and zinc ions to the specific adsorption sites.

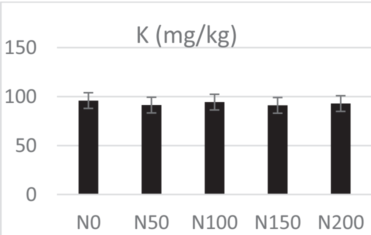
5. The influence of different doses of nitrogen and phosphorus on the mobile potassium in soil

The influence of long-term treatments (35 years) with nitrogen and phosphorus on the mobile potassium content in the soil are shown in Figures 13-15 and highlight that the long term fertilization with dose of 50-200 kg/ha nitrogen and similar phosphorus doses did not led to significant changes in the mobile potassium content of the soil.



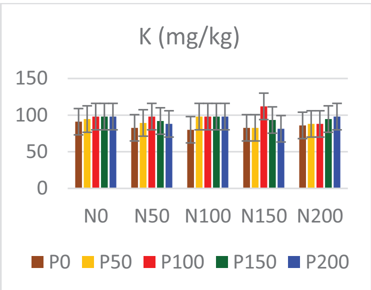
DL5% 13; DL1% 19; DL0.1% 29

Figure 13. Phosphorus influence on the evolution of mobile potasium in soil



DL5% 8; DL1% 11; DL0.1% 14

Figure 14. Nitrogen influence on the evolution of mobile potasium in soil



DL5% 18; DL1% 24; DL0.1% 31

Figure 15. Graphical representation of the influence of fertilization with nitrogen and phosphorus on the evolution of the mobile potassium in the soil

Borlan (1998) estimated that only nitrogen and phosphorus fertilization decreases the value of mobile potassium. Such that on soils poor on mobile forms of potassium ($K_{AL} \leq 100$ mg/kg) the efficiency of NP fertilization decreases.
The rate of decrease of the mobile potassium content seems to intensify with the decrease of the saturation with bases and bases content in soils (Borlan et al., 1982). The mobile potassium level from our experimental variants did not decreased because the soil was saturated with bases.

The long-term fertilization with different doses of phosphorus and nitrogen did not lead to any statistically significant changes of pH. We mention that the soil is 100% saturated with bases and its calcium carbonate content that ranges between 0.08 and 0.70%. Values were between 7.9-8.0 pH units.

CONCLUSIONS

The production presented a significant increase in the variants fertilized with 50 kg/ha nitrogen and very significant in those with doses above 100 kg/ha nitrogen; the production yields under irrigation conditions, on a soil well supplied with organic matter, increased with the increase of nitrogen dose.
On a background unfertilized with phosphorus, the corn production increased with the dose of nitrogen, being statistically ensured only at the doses 150 (significantly distinct) and 200 kg/ha nitrogen (very significant).
On a background of P_{50} fertilization, nitrogen doses of 50, 100 and 150 kg/ha provided a significant production yield, and the doses of 200 kg/ha nitrogen led to a distinctly significant production yield.
On a background of P_{100} fertilization, N_{50} fertilization with did not result in statistically ensured increases of production; the N_{100}, N_{150} and N_{200} doses led to significant production increases (42%, 53% and 52%); the variants with fertilized $P_{100}N_{150}$ have ensured the highest production (7522 kg/ha) followed by those fertilized with $P_{100}N_{200}$.
On a background of P_{150} fertilization, the highest production (7233 kg/ha) was obtained in variants fertilized with N_{200}, the production yield compared to the variant non-fertilized with nitrogen was 80% (3220 kg/ha); fertilization with $P_{150}N_{100}$ ensured a distinctly significant production yield and $P_{150}N_{150}$ fertilization ensured a very significant production yield.
On a background of P_{200} fertilization, the dose of 50 kg/ha nitrogen did not ensured a significantly statistic production yield, while the doses of 100, 150 and 200 kg/ha nitrogen led to very significant increases of the production, the production increased with the increase of nitrogen dose; the combination of P_{200} and N_{200} provided a high production (6600 kg/ha), but much smaller than in the case of

150 and 200 kg/ha nitrogen application on a background of 100 kg/ha phosphorus.

Under irrigated conditions the best wheat productions were obtained after fertilization with 100 kg/ha phosphorus and 150-200 kg/ha nitrogen.

On a background of P_{100} fertilization, the average production yield per kg of nitrogen in the case of N_{100} and N_{150} fertilization was 10.4 kg, respectively 8.5 kg in the case of using N_{200} fertilization.

Application for 35 years of doses of 50-200 kg/ha phosphorus with the same doses of nitrogen did not result in statistically significant changes of the level of total nitrogen and mobile potassium from the chernozem.

The mobile phosphorus content increases significantly with the increase of phosphorus dose; at the dose of 50 kg/ha phosphorus the increase is distinctly significant and at the doses ≥100 kg/ha phosphorus the increase is very significant.

The long-term fertilization with different doses of phosphorus and nitrogen did not led to statistically significant changes of pH.

REFERENCES

Andrieș S., 2007. Optimizarea regimurilor nutritive ale solurilor și productivitatea plantelor de cultură. Ed. Pontos, Chișinău.

Andrieș S., 2011. Agrochimia elementelor nutritive. Fertilitatea și ecologia solurilor. Ed. Pontos, Chișinău.

Avarvarei I., Davidescu D., Mocanu M., Goian M., Caramete C., Rusu M., 1997. Agrochimie. Ed. Sitech, Craiova.

Băjescu I., Chiriac A., 1984. Distribuția microelementelor în solurile din Romania. Implicații in agricultură. Ed. Ceres, Bucuresti, pp. 219.

Berca M., 2008. Managementul integrat al nutriției plantelor. Ed. Ceres, București.

Borlan Z., Hera Cr., 1973. Metode de apreciere a stării de fertilitate a solului în vederea folosirii raționale a îngrășămintelor. Ed. Ceres, București.

Borlan Z. și Hera Cr., 1977. Îndrumător pentru stabilirea necesarului de îngrășăminte și amendamente la plantele de câmp. Ed. Ceres, București.

Borlan Z., Hera Cr., Ghidia A., Pasc I., Condei Gh., Stoian L., Jidav E., 1982. Tabele și monograme agrochimice. Ed. Ceres, București.

Borlan Z. și Hera Cr., 1984. Optimizarea agrochimică a sistemului sol-plantă. Ed. Academiei R.S.R., București.

Borlan Z., Hera Cr., Dornescu D., Kurtinecz P., Rusu M., Buzdugan I., Tănasee Gh., 1994. Fertilitatea și fertilizarea solurilor. Ed. Ceres, București.

Borlan Z., 1998. Prognoza evoluţiei însuşirilor agrochimice şi corelarea acestora cu cerinţele de amendare şi fetilizare a solurilor agricole. In monitoringul stării de calitate a solurilor din România, Bucureşti, Vol. II, pp. 363-400.

Davidescu D., Borlan Z., Davidescu V., Hera C., 1974. Fosforul în agricultură. Ed. Academiei R.S.R., Bucureşti.

Eliade Gh., Ghinea L., Ştefanic Gh., 1983. Bazele biologice ale fertilităţii solului. Ed. Ceres, Bucureşti.

Fageria N.K., 2009. The use of nutrients in crop. CRC Press Taylor & Francis Group.

Ghiglieri G., Barbieri G., Vernier A., Carletti A., Demurtas N., Pinna R., Pittalis D., 2009. Potential risks of nitrate pollution in aquifers from agricultural practices in the Nurra region, northwestern Sardinia, Italy. Journal of Hydrology, Vol. 379, Issues 3-4, pp. 339-350.

Hera Cr., Borlan Z., 1980. Ghid pentru alcătuirea planurilor de fertilizare. Ed. Ceres, București, pp. 15, 18, 23, 36, 45-52.

Hera Cr., Borlan Z., 1984. Optimizarea agrochimică a sistemului sol-planta. Ed. Academiei, București, pp. 66, 71, 102, 119, 128-145.

Hera Cr., 2013. Cuvânt de recepție. Chișinău.

Hera Cr., 2015. Al VIII-lea Congres Mondial de știința solului - eveniment de referință în știința românească. În Al VIII-lea Congres Mondial de știința solului. Pledoarie pentru sol. Hera C., editor, Ed. Academiei Române.

Lăcătușu R., Lungu M., Kovacsovics B., 2005. Poluarea nitrică - o temă veche de marea actualitate. CIEC-Diversitatea sortimentului de îngrășăminte și îmbunătățirea calității acestora în raport cu cerințele agriculturii durabile, Ed. Agris.

McBride M.B., 1987. Processes of heavy metal and oxyanion sorption by soil constituients. Lucrările Congresului al XIII-lea al Societății Internationale de Știința Solului, 13-20 august 1986, Hamburg.

Mocanu R., Mocanu A.M., Susinski M., 2005. Efectul unor tipuri de îngrășăminte cu azot la unele culturi pe diferite tipuri de sol din Oltenia. CIEC-Diversitatea sortimentului de îngrășăminte și îmbunătățirea calității acestora în raport cu cernțele agriculturii durabile, Ed. Agris.

Rusu M., Marghitaş M., Oroian I., Mihăiescu T., Dumitraş A., 2005. Tratat de agrochimie. Ed. Ceres, Bucureşti.

Vintilă I., Borlan Z., Răuță C., Daniliuc D., Țigănaș L., 1984. Situația agrochimică a solurilor din România. Prezent și viitor. Ed. Ceres, București.

Vrînceanu N.O., Dumitru M., Motelică D.M., Gamenț E., 2010. Comportarea unor metale în sistemul sol-plantă. Ed. Solness, Timișoara.

Zamfirescu N., 1977. Bazele biologice ale producției vegetale. Ed. Ceres, București.

***Anuarul statistic al Romaniei, 2015.

***DEFRA Department for Environment Food and Rural Affairs, Fertiliser Manual (RB 209), 8th Edition UK, 2010.

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PEDOLOGICAL AND AGROCHEMICAL STUDY AT SC AGRILEMI SRL, TO DEVELOP FERTILIZATION PLAN ON CULTURE

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Abstract

Mavrodin town, is located in the center of Teleorman County on DJ 703, between the towns Buzescu and Calinesti. Research has been conducted on an area of approximately 400 hectares on land plane, belonging to SC Agrilemi SRL, the soil cover is represented by reddish preluvosoil molic subtype. In order to characterize morphologic and physicochemical soil type representative, it opened soil profile from which samples were taken and modified natural soil settlement and several polls.
For the preparation of fertilizer on crops, it was made an agrochemical mapping, which consisted of a collection of 40 soil samples environments, which are conditional and analyzed in laboratories ICPA. Also it determined the productive potential of the soil cover based on the study of evaluation and mitigation measures recommended enunciation.

Key words: *soil fertility, potential, agrochemical, fertilizer.*

INTRODUCTION

This study, scientific research under contract no. 1187/09.11.2016 between SC Agrilemi SRL, as beneficiary, and the University of the Agronomic Sciences and Veterinary Medicine of Bucharest, as a performer.
The object is to control the execution of a research entitled "Development of soil and agrochemical study to elaborate the plan of fertilization on crop area of 400 ha".
For this study were carried out works on morphological characterization, physical and chemical, determining the production potential of the soil cover, stating the measures to improve soil and crop fertilization plan development, with recommendations on the types of fertilizers.

MATERIALS AND METHODS

Soil sampling agrochemical middle of plowed horizon (0-20 cm) were composed of 15-20 individual samples from the surface sampling plots of ground. The parceling of land, was considered pedological complexity, uniformity of land utilization, crop structure so that each sample representing a plot as uniform. The results were analyzed and interpreted based on the standards contained in the catalog A.S.R.O. that are consistent with international standards.
Methods of analysis used to determine the chemical characteristics.
Organic matter (humus): determined by volumetric wet oxidation method after Walkley-Black, the change Doughnut - STAS 7184 / 21-82.
Carbonates - gasometric method using calcimetrul Scheibler after SR ISO 10693: 1998 (%).
Nitrogen content was determined indirectly (by calculation) based on the humus content and degree of saturation with bases.
IN = humus x V / 100
Accessible phosphorus (P mobile): after Egner-Riehm-Domingo and dosed with molybdenum blue colorimetric after Murphy-Riley method (reduction with ascorbic acid).
Available potassium (K mobile): extraction after Egner-Riehm-Domingo and determination by flame photometry.
pH: determined potentiometrically with a combined glass and calomel electrode in an aqueous suspension to the Soil / Water 1/2.5 - SR 7184 / 13-2001
The acidity of the hydrolytic - extraction with sodium acetate to pH 8.2.

Amount bases - Kappen method Schoffield Chirita by extraction with 0.05 normal hydrochloric acid

Methods of analysis used to determine the physical properties:

The apparent density (AD): the method of the metal cylinder of known volume (100 cm^3) to the temporary humidity of the soil (g/cm^3)

The total porosity (PT) by calculating (% by volume -% v / v)

The coefficient of hygroscopic (CH) drying at 105 ° C of a sample of soil moistened in advance in equilibrium with an atmosphere saturated with water vapor (in the presence of a solution of H2SO4, 10%) -% by weight (% w/w).

Wiping coefficient (CO): calculated by multiplying by 1.5 the hygroscopicity factor determined by the modified Mitscherlich method (no vacuum, witness evidence) – weight %.

RESULTS AND DISCUSSIONS

The soil specific area mapped is represented by red preluvosol molic subtype, with the following formula: Am-Bt_1–Bt_2-Ck, whose morphologic and physico-chemical characterization will be presented below (Figure 1).

Figure 1. Reddish preluvosoil, molic subtype (EL - rs.mo)

Morphological characteristics

Am (0-36 cm), 7.5YR color wet and dry material with well developed grainy structure in the upper horizon and medium developed at its base polyhedral aggregates shatters hard. The texture is clayey loam horizon is poorly compacted, hard wet, rough dry, moderately plastic and sticky, very compact and strongly cemented.

Bt_1 (36-135 cm), uniform color in shades of 7.5YR 3/2 material 3/3 7.5YR wet and dry material, columnoid-prismatic structure is medium and high. The texture is clay.

The material is very strong in wet and dry very hard, very plastic and sticky, very compact and strongly cemented;

Bt_2 (135-180 cm), uniform color in shades of 7,5YR 3/3 material 3/4 7,5YR wet and dry material. The texture is clay. The structure is prismatic medium and high frequencies fine cracks. The material is very hard wet and very tough when uacată very plastic and sticky, very compact, there is waste in the form of films neoformaţii clay faces structural aggregates;

Ck (> 180 cm), uniform color in shades of 7.5YR 4/4 material 5/4 7.5YR wet and dry material. The texture is clay loam. The material is unstructured, friable wet, moderately dry cohesive, presents rare grains of sand, rare spots of $CaCO_3$, strong effervescence.

Physico-chemical characterization

The physico-chemical characteristics of this type of soil, are consistent with the formation of physical and geographical conditions thereof.

Analytical data for preluvosoil reddish-molic are shown in Table 1.

Analyzing data from the table, it appears that the texture is fine, differentiated profile, the amount of clay is greater in B horizons (36-180 cm) compared to the value recorded the horizon surface (Figure 2).

Table 1. Physico-chemical analysis at soil EL rs-mo, of studied territory

Horizon	Am	Bt_1	Bt_2	Ck
Dept (cm)	0-36	36-135	135-180	> 180
Sand gr. (2-0,2 mm)	19.4	16.1	11	26.5
Sand fin (0,2-0,02 mm)	16.6	10.9	9.5	19.5
Dust (0,02-0,002 mm)	30	25	27.5	18
Clay (< 0,002 mm)	34	48	52	36
Texture	TM	AL	AL	TT
pH	5.7	6.2	6.5	7.2
Humus (%)	3.2	1.7	1.3	0.8
Bulk density (g/cm^3)	1.38	1.46	1.47	1.39
Total porosity (%)	47.5	45.7	45.7	47.7
Degree of compaction GT (%)	weak	moderate	moderate	weak
Carbonates (%)	0	0	0	9.7
Phosphorus (ppm)	52	18	10	-
Potassium (ppm)	254	112	67	-
Coefficient of hygroscopic (%)	7.9	12.3	12.2	4.7
Wilting coefficient %	1.9	16.9	18.3	12.7
Field capacity %	21.2	24.2	24.5	23.5
Usable water capacity%	9.3	7.3	6.2	10.8
Total capacity (%)	34.4	33.1	33.9	33.6
Humus reserve (t/ha)	156	109	81.2	21.6

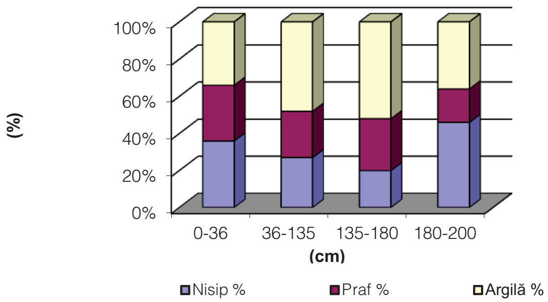

Figure 2. Granulometric composition

The total porosity of the soil is between 45% and 47%.

The degree of compaction of the soil is poor in the ranges of 0-36 cm deep and 180-200 cm becomes moderate between 36-180 cm depth profile in the Bt horizons and may be a factor limiting fertility to be corrected (Figure 3).

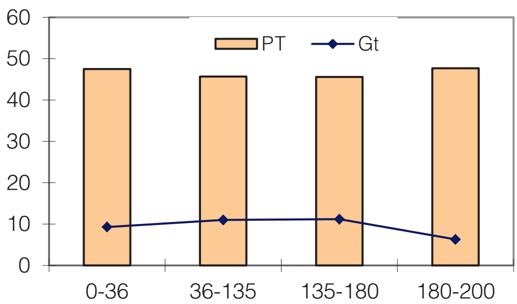

Figure 3. Variation porosity and degree of compaction the soil profile

The reaction is slightly acidic soil and soil fertility is a limitation. Also humus reserve in the upper horizon is medium and small drops to the underlying horizons. There is a tendency of decrease in humus content and increase the profile of the reaction studied (Figure 4).

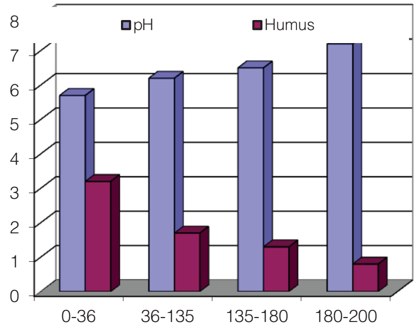

Figure 4. Variation reaction soil and humus content the soil profile

The results of analysis based on agrochemical four samples taken from the sole, as well as agrochemical recommendations on fertilizer application rates in crops, they are shown in Table 2 (a and b).

Table 2 (a) Dosing recommendations of chemical fertilizers and amendments based on agrochemicals analyzes

PAO	Plot	Area (ha)	Crop	Previous crop	Production obtained (t/ha)	pH	Humus, %	P ppm	K ppm	IN %	Ah	SB	Vah %
1	S 90	90	Wheat	Sunflower	2500	5.43	3.08	29.6	250	2.26	6.13	23.2	79
2	S60	60	Wheat	Peas	3000	5.72	4.30	85.3	300	3.35	5.46	25.8	82
3	S25	25	Rapeseed	Wheat	5500	5.48	4.44	92.0	345	3.39	5.84	25.0	77
4	S60	60	Wheat	Rapeseed	3000	5.55	4.15	58.0	270	3.13	5.84	23.9	80
5	S160	160	Rapeseed	Sunflower	2500	5.66	4.57	42.0	280	3.55	5.98	26.9	81

Table 2 (b)

PAO	Plot	Area (ha)	Crop	Previous	Production obtained (t/ha)	N (kg a.s./ha)	P_2O_5 (kg a.s./ha)	K_2O (kg a.s./ha)
1	Mag.	90	Wheat	Sunflower	2500	85	60	-
2	Grp. F	60	Wheat	Peas	3000	40	100	80
3	S25	25	Rapeseed	Wheat	5500	125	40	-
4	Grp. S	60	Wheat	Rapeseed	3000	100	50	25
5	Agrom.	160	Rapeseed	Sunflower	2500	70	45	-

CONCLUSIONS

The soil is in concordance with the physical and geographical conditions of the area being identified only one soil type with regional character is reddish preluvosoil – molic subtype.

The reaction is moderately acidic soil with pH values between 5.23 and 5.86 reason for Correction of reaction by applying calcium-based amendments or fertilizers with physiologically alkaline reaction.

Nitrogen supply, represented by nitrogen index (IN) is average, with values between 2.01 and 3.95%.

The supply of phosphorus is medium-high for the whole area studied, by between 21-80.

Supply mobile potassium is like for phosphorus, medium-high, with values between 144 and 363.

Total surface presents moderately acidic pH, so it must be fertilized with ammonium nitrate. It is banned applying fertilizer ammonium nitrate, ammonium sulfate or urea on the sole.

Make fertilization with NP/NPK (20:20)/(15:15:15) and ammonium nitrate (CAN azomures = 27% N + 7%CaO + 5%MgO sau NAC Linzer = 27% N + 12.5% CaO).

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REFERENCES

Canarache A., 1990. Agricultural soil physics. Editura Ceres, Bucharest.
Coteţ P., 1973. Geomorphology Romania. Editura Technical Bucharest.
Lixandru Gh. şi colab, 1997. Agro-chemistry, EDP. Bucharest.
Madjar R., Davidescu V., 2009. Agro-chemistry. Editura Didactica si Pedagogica Bucharest.
Musat M., Burcea M., Radu A., 2013. Pedoagrotechnica. Editura Ceres, Bucharest.
Posea Gr., 2003. Physical geography of Romania. Editura Foundation of Maine Romania, Bucharest.
xxx Methodology drafting soil studies, ICPA, 1987.
xxx Romanian soil map, sheet 43 (Neajlov).

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AIR BUBBLED OR WATER FILLED BUBBLED SOLARIZATION SHEET WAS FURTHER EFFECTIVE ON NUMBER OF SOIL MICROORGANISMS, CO_2 PRODUCTION AS WELL AS MICROBIAL BIOMASS CARBON

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Abstract

Solarization has been commonly used method for last decades to eliminate weed and pathogen microorganisms which it is economic and environmental friendly. Despite of rising temperatures during soil solarization, some thermophilic or thermo-tolerant microorganisms may survive in the soil; therefore, natural soil flora re-establishes their activity soon after this practice. To evaluate the effects of different polyethylene cover materials as well as bio-fumigation applications, two years field experiments in 2011 and 2012 were carried out. In 2011, results revealed that heat-sensitive microorganisms in the surface soil have been eliminated rapidly. Sub soil layer was not as heated as the surface, thus, the higher CO_2 formation was determined in 15-30 cm soil depth. In the second year of experiment, heat-tolerant microorganisms become more dominant; therefore, the higher CO_2 production observed in surface than the sub soil. According to the enumeration carried out in 2011, the highest number of fungi at 0-15 cm soil depth was determined on the plots covered by water filled bubbled sheet. In 2012, the highest value was determined in a soil samples taken from 15-30 cm deep of conventional solarization application. Bacteria number was reduced up to soil depth; however, the highest bacteria number observed in air bubbled cover sheet treatment. There were great fluctuation on actinomycetes numbers, thus it is hard to evaluate the best cover material considering the data gathered. It was determined that the effect of temperature increase by solarization application on soil microorganism activity varies significantly between the years.

***Key words**: actinomycetes, bacteria, fungi, microbial activity, solarization.*

INTRODUCTION

Soil solarization emerges as an environmentally friendly method of struggling to heat sensitive soil-borne pathogens by covering with soil polyethylene (PE) covering material for one or two months during the hottest months of the year. Herbicides are more preferred recently in conventional production systems because of the features such easy application and quick results. However, misuse of this xenobiotic chemicals lead to threatening of human and animal health, gaining resistance of the weed species to herbicides over time, damaging of non-targeted organisms etc. Solarization is the most important alternatives to chemical applications (Kitiş, 2011). Despite rising temperatures during soil solarization, some thermophilic or thermotolerant microorganisms in the soil can survive. These microorganisms colonize in the zone that occurs as a result of the death of pathogenic microorganisms. As a result of solarization the balance of pathogenic and beneficial organisms shift to a favor of beneficial organisms; therefore, long term effect occurs. Most of the microorganisms promoted after the solarization encourage biological control and plant development (Öztürk, 2008). Bio-fumigation not only stimulates the biological activity of the soil but also increases the soil organic matter content which helps to development of microorganisms. An effect of this practice is more apparent in the soils which have lower organic matter. As a result, bio-fumigation promote the plant development (Bello et al., 2008). Stapleton (1990) reported different temperatures for destroying plant pathogenic fungi, bacteria, weed seeds and nematodes; however, the elimination effect of the temperature of 45 °C or even higher, could not been evaluated. Furthermore, solarization is effective on preventing colonization of competitive organisms in the soil. Although the heat generated in soil by solar radiation and the resultant death of plant pathogens and pests encompass the mayor principles of soil solarization, the increase in available plant nutrients and relative increase in populations of rhizosphere competent bacteria (Stapleton and DeVay, 1984). In this study, the effects of different PE cover material and bio-fumigation on soil microbial activity was studied.

MATERIALS AND METHODS

The research was carried out in 90 m^2 greenhouse at Suleyman Demirel University, Agricultural Research and Implementation Center for two years as 2011 and 2012. The texture class of the greenhouse soils was clay whereas organic matter contents and pH was 1.85% and 7.96, respectively. The water content of the soil at field capacity was 23.31% whereas the bulk density was 1.53 g cm^{-3}. Two different PE cover materials were used in the study. One was the 0.04 mm thick transparent PE covering sheet which used for solarization and bio-fumigation applications. This material commonly used by the farmers for regular solarization practices. Second was air bubbled PE sheet, which is available in the market as a packaging material. The diameter and the height of air bubbles were 30 mm and 12.5 mm. In this experiment this material was used either as is or bubbles were filled by water to gain condensing lens effect.

The experiment was consists of four experimental plots as well as control application. In the first application (Sol) a 0.04 mm thick colorless transparent PE covering sheet was used. Same sheet was used in second application (BioSol); however, before covering the soil 1.5 kg m^{-2} of fresh poultry manure was applied to the plot according to Barbour et al. (2002). In the third application (BSol), air bubbled packaging material was used as a solarization cover material in accordance with recommendation of Bainbridge (2010). The fourth application (BWSol) was the main tested idea in this experiment. The air bubbles of above mentioned material were filled with water in this application. The expected benefit from filling the bubbles with water is to focus the sun's rays and achieve a higher temperature in soil depth. The last application was the control (NonSol) which the soils were sampled between the test plots.

At the end of the solarization applications, 0-15 and 15-30 cm depth soils were sampled and their microbial biomass carbon (MBC), CO_2 formation as well as bacteria, fungi and actinomycetes numbers were determined according to Öhlinger (1993), Isermayer (1952) and Gürgün and Halkman (1988), respectively.

Results statistically analyzed using MSTAT-C software (Crop and Soil Sciences Department, Michigan State University, Version 1.2) according to randomized complete block design.

RESULTS AND DISCUSSIONS

Microbial Biomass Carbon (MBC)

The amount of microbial biomass carbon, which is indicator of the total microbial abundance of soils, was determined by fumigation-extraction method and the obtained results are given in Table 1.

Table 1. Microbial biomass carbon values (µg C g dry $soil^{-1}$)

Years[1]	Depth	Sol	BSol	BWSol	BioSol	NonSol
2011	0-15 cm	25.35a	14.65abc	10.09c	17.82abc	17.06abc
	15-30 cm	8.23c	24.58ab	11.66bc	13.68abc	17.49abc
2012	0-15 cm	6.35d	47.88a	7.12d	23.57bc	17.93c
	15-30 cm	12.66cd	33.54b	22.22bc	20.65bcd	8.37d

[1]Different small letters indicate significant differences for P<0.05 in the column for each year

In the first year of the experiment, the highest MBC values were determined in the Sol application, whereas in the second year the highest value was obtained from the application of BSol. Considering these findings, both applications may be defined as the least effective practices in suppressing total microorganisms. On the other hand, the lowest values were determined at 0-15 cm depth of BWSol and 15-30 cm depth of Sol applications in the first year. In the second year, the lowest values were determined on the surface soils of Sol and BWSol applications whereas the highest were in BSol and BioSol. It can be said that the traditional solarization application is more effective in applications where low values are determined in terms of MBC values. Scopa et al. (2008) determined the microbial biomass carbon in their solarization studies and reported MBC as 34.69 µg C g dry soil^{-1}. The mean values obtained in the first year were lower than the values reported by Scopa et al. (2008) whereas the second year values were higher. This indicates that the heat sensitive organisms were disappeared in the first year and number of heat tolerant species is increased in the second year.

CO_2 formation of the soil

Although the numbers of microorganisms as well as MBC in the soil have been determined in the study, this may not represent the actual activity of soil microorganisms. Therefore, it was necessity to reveal the real activities of microorganisms (Çengel, 2004). Determining CO_2 as a respiratory product of the microorganism provides clear clue about the activity of the soil microorganism. Considering this fact, carbon dioxide production of experimental soil was determined and the obtained results are presented in Table 2.

Table 2. CO_2 production (µg CO_2 g dry soil^{-1} 24h^{-1})

Years[1]	Depth	Sol	BSol	BWSol	BioSol	NonSol
2011	0-15 cm	44.93a	45.43a	45.10a	47.47a	38.50b
	15-30 cm	50.13a	49.50a	48.27a	50.73a	43.40a
2012	0-15 cm	54.77a	59.27a	66.10a	63.77a	46.90b
	15-30 cm	55.10a	58.77a	55.37a	60.47a	47.50b

[1]Different small letters indicate significant differences for P<0.05 in the column for each year

Statistical differences ($p<0.05$) were determined between the values obtained for both years. Although it was not statistically significant, the higher values were obtained in the second year in correspondence with the MBC values (Table 1). The amounts of carbon dioxide formation measured in the deeper soil (15-30 cm depth) were higher than the surface soil (0-15 cm). Most probably this was because of the higher temperatures achieved at the surface as a result of solarization. However, in the second year the values in the surface soil were higher except Sol which kept its state. In the first year of solarization, heat sensitive microorganisms existing in the surface soil have been eliminated. As a result, higher CO_2 production was observed in the lower layers where temperature in this layer was not influenced as much as surface soil. In the second year of experiment, heat-tolerant microorganisms that were not as effected from first year application, become more dominant, thus, remaining ones promotes CO_2 production.

Tülün (2011) carried out a solarization experiment and reported the highest and lowest CO_2 production as 20.75-11.32 mg CO_2 100 g_dry_soil^{-1} 24h^{-1}. In both years of the study where the results are given here, obtained values were considerably higher than these values.

However, the study of Tülün (2011) was carried out in the greenhouse where intense agricultural practices followed. Unlikely this study conducted on the greenhouse where no agricultural activities have been carried out for 3-4 years. Therefore, possible harmful inputs for soil microbiota such as fertilizers and agrochemicals were not widely used in this area. The higher values are seems to be associated with this situation.

Number of fungi, bacteria and actinomycetes

Solarization application increase soil temperature which threaten both harmful and beneficial microorganisms; however, at the end of solarization the beneficial organisms have become predominant in a short time (Elmore et al., 1997). Classification progress was not followed in this research, yet, total fungal, bacterial and actinomycet numbers presented below in related subheadings without considering if they are beneficial or not.

Fungi enumeration

The number of fungi determined in the soil at the end of the solarization is given in Table 3. According to the enumeration in agar plate belonging to soils in 2011, the highest number of fungi was determined in 0-15 cm soil depth of BWSol application and in 2012 the highest value was determined 15-30 cm depth of Sol application. All values determined in the first year were lower than NonSol application whereas this phenomenon was not observed in the second year. Determination of fewer fungi in the second year can be explained by the residual effect of the first year solarization.

On the other hand, only Sol application provided higher fungi number in subsoil layer than surface. In the second year, the higher fungi numbers were determined in subsoil of Sol and BioSol applications. Based on the average results, it is thought that Sol application did not constitute sufficient effect in fungal elimination. In this application, it is estimated that the temperature increase in the first year does not spread enough to the depths, and fungi spores are transported to the upper layers at the second year. The increase on microorganism abundance in BioSol application can be explained by fresh poultry fertilizer application which is rich in microorganism.

Table 3. Fungi cfu numbers ($*10^4$ cfu g dry soil^{-1})

Years[1]	Depth	Sol	BSol	BWSol	BioSol	NonSol
2011	0-15 cm	3.95de	8.16bc	15.08a	2.96de	8.30b
	15-30 cm	6.19cd	4.08de	11.31b	2.32e	9.15b
2012	0-15 cm	8.82b	4.03c	3.08c	3.18c	2.85c
	15-30 cm	12.72a	3.48c	2.44c	3.79c	4.13c

[1]Different small letters indicate significant differences for P<0.05 in the column for each year

Bacteria enumeration

Determined bacteria numbers at the end of the experiment were presented in Table 4. In the first year of the experiment, the highest bacteria number was in 0-15 cm soil depth of BSol application. Although bacteria number is decreasing by the depth, the higher value among the values belong to 15-30 cm depth was in BSol once more. In general, considerable lower bacteria numbers were determined in the second year, comparing to first year.

Table 4. Bacteria cfu numbers ($*10^5$ cfu g dry soil^{-1})

Years[1]	Depth	Sol	BSol	BWSol	BioSol	NonSol
2011	0-15 cm	5.58d	27.95a	17.71b	18.81b	4.94d
	15-30 cm	1.78d	21.77b	12.83c	2.23d	8.80c
2012	0-15 cm	0.50b	0.99ab	1.01ab	1.61a	1.60a
	15-30 cm	0.51b	0.47b	0.84b	0.98ab	1.78a

[1]Different small letters indicate significant differences for P<0.05 in the column for each year

Although there is no significant difference between the years of NonSol application, all of the surface areas of other applications are significantly reduced. These effect also observed in 15-30 depth of all applications except BioSol.

Actinomycetes enumeration

Actinomycet numbers determined in the soil are given in Table 5. It is hard to conclude a trend of the effects of applications considering the number of actiomycetes. Because in some applications actinomycet numbers increased, while in some applications they decreased. In the first year of the study, the highest actinomycet number was determined at 0-15 cm depth in BSol application. According to second year measurements, the highest value was determined in BioSol application at a depth of 15-30 cm. The only significant increase was in the depth of 15-30 cm of BioSol application which was associated with the organic fertilizer application in this treatment.

Table 5. Actinomycetes cfu numbers (*10^5 cfu g dry soil^{-1})

Years[1]	Depth	Sol	BSol	BWSol	BioSol	NonSol
2011	0-15 cm	2.79b	4.83a	3.36ab	2.21b	2.12b
	15-30 cm	3.20ab	3.35ab	2.78b	3.14ab	1.92c
2012	0-15 cm	2.63c	6.52b	3.05c	2.46c	1.84d
	15-30 cm	3.75c	2.62c	2.47c	13.11a	1.29d

[1]Different small letters indicate significant differences for P<0.05 in the column for each year

CONCLUSIONS

It has been determined that the effect of temperature elevation due to solarization on soil microorganism activity shows a significant difference between the years. Based on the overall results, different cover materials have different effects on soil microorganism related parameters indicating that the new approaches should be applied to improve benefit of solarization. Moreover, when the solarization is over, it is considered that the possible differences in the activity of the microorganism may disappear. Therefore, in order to determine the reliable activity values belonging to soil microorganism, sample should be collected before solarization application is over.

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REFERENCES

Bainbridge D.A., 2010. Soil solarization for restorationists. Restoration and Management Notes, 8:(2), 96-97.

Barbour E.K., Husseini S.A., Farran M.T., Itani D.A., Houalla R.H., Hamadeh S.K., 2002. Soil solarization: a sustainable agriculture approach to reduce microorganisms in chicken manure-treated soil. Journal of Sustainable Agriculture, 19:(4), 95-104.

Bello A., Porter I., Diez-Rojo M.A., Rodriguez-Kabanas R., 2008. Soil biodisinfection for the management of soil-borne pathogens and weeds. III. International Biofumigation Symposium, 21-25 July, Australia, 35-43.

Çengel M., 2004. Toprak Mikrobiyolojisi, Ege Üniversitesi Ziraat Fakültesi Yayınları, No:558, 166s. İzmir (in Turkish).

Elmore C.L., Stapleton J.J., Bell C.E., Devay J.E., 1997. Soil solarization-a nonpesticidal method for controlling diseases, nematodes, and weeds. University Of California, Division of Agriculture and Naturel Resources Puplication, 21377, 1-16.

Gürgün V., Halkman A.K., 1988. Mikrobiyolojide sayım yöntemleri, San Matbaası, 6-14, Ankara (in Turkish).

Isermayer H., 1952. Eine einfache Methode zur Bestimmung der Bodenatmung und der Karbonate im Böden. Z. Pflanzenaehr. Bodenkd 5, 56-60.

Kitiş Y.E., 2011. Mulch and solarization applications ın weed control. GAP VI Conf of Agriculture, Şanlıurfa. May 9-12. p. 463-468 (in Turkish).

Öhlinger R., 1993. Bestimmung des Biomasse-Kohlenstoffs mittels Fumigation-Exstraktion. In:Schinner, F., Öhlinger, R., Kandler, E., Margesin, R. (eds.). Bodenbiologische Arbeitsmethoden. 2. Auflage. Springer Verlag. Berlin, Heidelberg.

Öztürk H.H., 2008. Güneş Enerjisi ve Uygulamaları, Birsen Yayınevi, 277s. İstanbul (in Turkish).

Scopa A., Candido V., Dumontet S., Miccolis V., 2008. Greenhouse solarization: effects on soil microbiological parameters and agronomic aspects. Scientia Horticulturae, 116, 98-103.

Stapleton J.J., DeVay J.E., 1984. Thermal components of soil solarization as related to changes in soil and root microflora and increased plant growth response. Phytopathol, 74, 255-259.

Stapleton J.J., 1990. Thermal inactivation of crop pests and pathogens and other soil changes caused by solarization. Proceedings of the First International Conference on Soil Solarization, Feb 19-25, Amman, (Jordan), 108-117.

Tülün Y., 2011. Investigation of the effectiveness of soil solarization applications in greenhouses and mathematical modeling of temperature distribution of soil profile. Doctoral thesis. University of Çukurova, Adana, Turkey (in Turkish).

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STUDY OF SOIL COVER CENTRAL PACLE VALEY, AREA MUD VOLCANOES, BUZAU COUNTY

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Abstract

Pacle Valley basin is located in the west of Buzau Slănic, it is bordered by sinuous its turn to the north basin in the area of origin. It continues with the corresponding elementary surface haze hill where the mud volcanoes.
These formations are created by natural gas from more than 3,000 meters deep, passing through a clay layer in combination with the groundwater. Gas pushing toward the surface water mixed with clay.
The sludge formed by them resurfaces in those places, dry in contact with air, forming structures similar to conical volcanoes. This area was declared a natural monument since 1924, the only place in Europe where mud volcanoes can be seen, similar phenomena recorded only in Siberia and Australia.

Key words*: hydrographic basin, erosion, improvement, mud volcanoes.*

INTRODUCTION

In terms of geomorphology, Pacle Valley is part of the natural unit Berka-Pacle basin being located upstream of Berca. It charactetization through a mixed relief in the form of marbles, with narrow valleys separated by just scales and sharp. Slope processes and degradation of land, which are removed from the day-clay marl deposits, printing area a typical aspect of Badland. All surface basin is occupied by pastures and meadows, which are interspersed between small chaotic area used as arable land for maize.
Based on morphological and structural features, Pacle Valley can be divided into three zones, each with corresponding sub-basins: the upper third (area of origin); comprising the middle third of mud volcanoes; where closes the valley bottom third.
In all these perimeters soil mappings were conducted in order to obtain data on the natural resources of soil, useful economic outlook and tourist area. In this paper are presented results of studies undertaken in the middle third of the basin.

MATERIALS AND METHODS

Primeter Central Valley haze consists of two sub-basin: Strawberry Peak. Within this perimeter there are two relief units represented by the steep slopes of the two sub-basins and down stream area where the predominant slope below 10% (Figure1), the total area of 201.1 ha.
The data in Table 1 that the largest share (43.3%) held by areas with slopes between 20-25%.
Note also that an area 62.3 ha, or 31% of the total area studied, it has an inclination of 5-10%.

Figure 1. Central perimeter at Pacle Valey

Table 1. Distribution surfaces at perimeter Pacle Valley, on slope categories

Slope categories (%)	Surface	
	ha	%
5-10	62.3	31
10-15	23.8	11.8
15-20	14.6	7.3
20-25	87.6	43.6
>35	12.8	6.3
TOTAL	201.1	100

Lithological substrate consists mainly of clay and marl sometimes salif, loose sand or cement. The climate study area falls within the continental climate, characterized by average annual rainfall of 512 mm and an average annual temperature of 10.5°C. The most important feature of rainfall during the growing season is their high degree of torrential, causing erosion and landslides and flooding in lowland areas.

The vegetation in the central perimeter of the valley haze is woody and herbaceous. Vegetation timber from plantations or natural regeneration, occupy small areas in Eastern Valley Peak. Herbaceous vegetation is made up of associations *Botriochloa ischaemum* and *Festuca valesiaca*.

Meadow Valley in the crag where processes occur salinization, develops halophile micocenoze.

Farmland in the study area are exploited as pastures and hayfields less like. Overgrazing, without taking into account the precarious state of soil degradation have led to alarming southern slopes of the two sub-basins studied. Predominates in sub perimeters strong erosion, landslides weak paths thick and very dense areas without vegetation, basins and ravines.

Pedological study overall assessment of soil resources, presenting an overview of the potential of the earth, in the current degradation. Pedological mapping was carried out in two sub-basins, and the coating was carried out cartogram the ground (Figure 2).

Figure 2. Cartography of the soils in the central pond of the Pacle Valley

They opened six profiles of which were sampled for physical and chemical determinations. The results obtained led to the identification of soil types confom current classification system (SRTS, 2012). Their spatial demarcation was carried out based on secondary profiles and surveys. The number of profiles and analytical methods have been established confom "Methodology drafting soil studies" - ICPA Bucharest, 1987.

RESULTS AND DISCUSSIONS

The soils in sub-basins studied were classified into two classes of soils, according SRTS 2012 namely: cernisoils and protisoils.
Pedogenetical processes are specific to the bioacumulation, argillic alteration, gleyzation and salinization.

Soil characterization of Pisca Valley
In this sub-opened three main sections of the ground. Soil types identified are: mold subtypes cambic, salinated and alkalized: regosol with typical subtype.

1. Cambic-chernozem (UT6)
The profile has been positioned in the middle third of the Pisca Valley, the slope uniform, moderately inclined faces north and has a profile Am-Bv1-Bv2-Bv3-Ck. Groundwater is 10 m deep, herbaceous vegetation, use of pasture, clay soil formation rock.
Soil is eroded weak because I have thick horizon of 22 cm, is deeply powerful, weak leachate, high-volume edafic used as pasture. The texture is smooth, uniform profile.
The proportion of clay in the range between 40.8% and 45.2% on the basis of the I profile, in Ck (Figure 3).

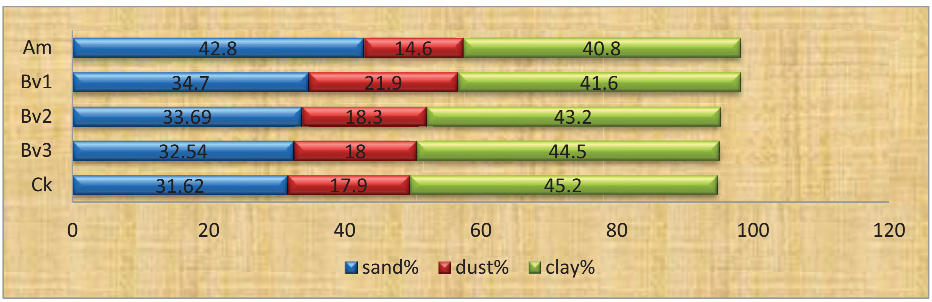

Figure 3. Granulometry of cambic-chernozem at Pisca Valley

Soil reaction is neutral in the first 60 cm of the profile, where the pH is 7 to 7.2 and slightly alkaline values in underlying horizons, where the pH value is 7.7-7.9.

Humus content is medium, with the highest values in bioaccumulation horizon with pronounced decrease since Bv2 horizon. (Figure 4).

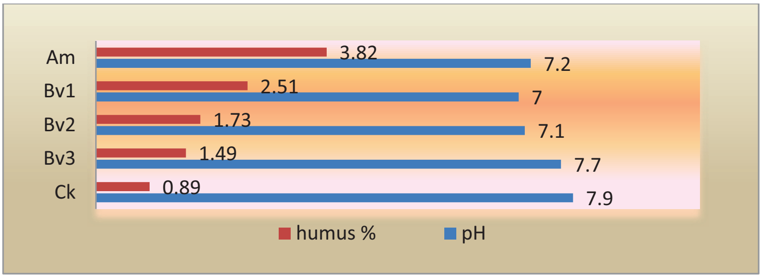

Figure 4. pH and humus contentat cambic-chernozem at Pisca Valey

2. Cambic-chernozem, salinated-gleize

The profile has been placed at the base of the slope, in the sub-basin floodplain with low inclination. The sequence of profile horizons: I-Bv1-Bv2sc-Bv3sc-CGO.

The argillic alteration is accompanied by a weak salinization, based gleyzation there is a moderate profile.

These two processes were triggered by soil mineralized aquifer, located at middle depth. The soil is very powerful deep edafic extremely high volume.

The texture is fine, loamy clay medium, uniform profile (Figure 5). The percentage of clay is between 40% and 50% in I underlying horizons.

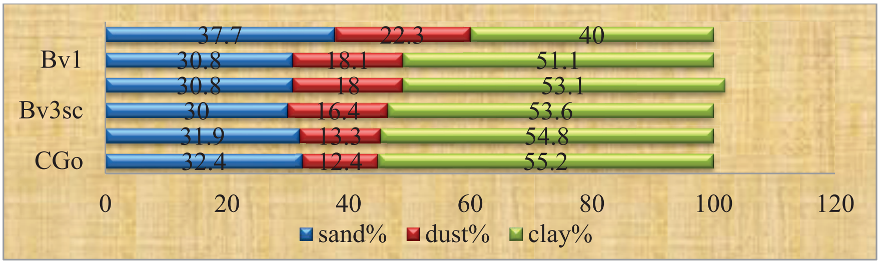

Figure 5. Granulometry cambic-chernozem, salinatat-gleize at Pisca Valley

In the first part of the profile horizons nesalinization, humus content is medium, and the reaction is slightly alkaline (Figure 6). In the second part of the profile, from 60 cm to the bottom profile in salinity and even gleyzation horizons, humus content is very low and moderately alkaline reaction.

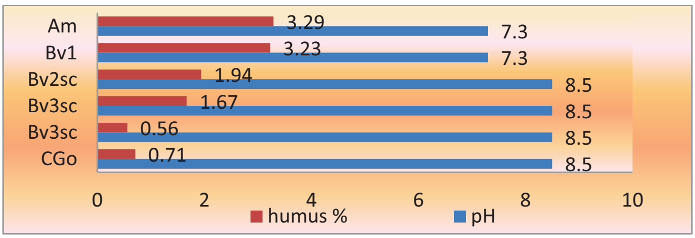

Figure 6. Humus content and pH at cambic-chernozem, salinat-gleize Pisca Valley

3. Tipic regosoil

Profile has been positioned in the upper third of Pisca Valley, on versed uneven, heavily tilted moderately shallow, small edaphic volume. The soil profile is short: Ao-C.

The texture is fine clay medium, uniform profile.

The percentage of clay was more than 42 %, the C is just 47 % (Figure 7).

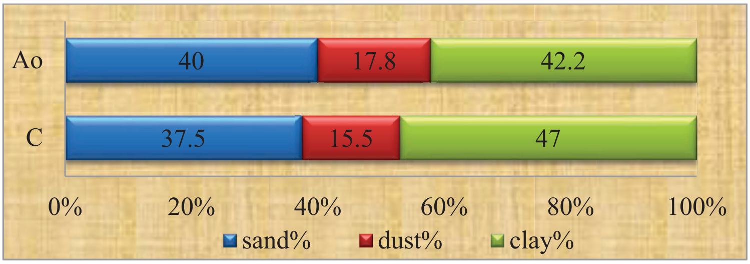

Figure 7. Granulometry of tipic regosoil at Pisca Valley

In the first horizon profile, reaction is neutral, there is an average humus, indicated that the horizon is only 10 cm thick.

Horizon C with weak alkaline reaction and low humus content (Figure 8).

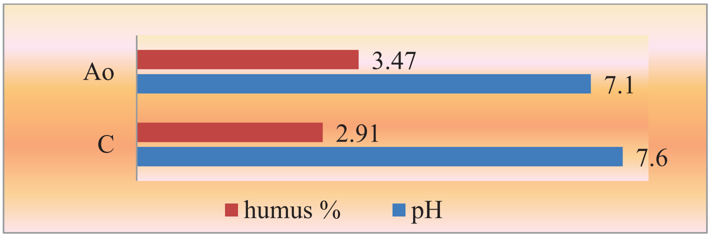

Figure 8. Humus content and pH at tipic regosoil at Pisca Valley

Characterization of soils at Capsuna Valley

In this hidrographic basin, two main profiles to the ground. Soil types identified are: colluvic aluviosoil and regosoil with typical subtype that continues from previous sub analyzed

1.Colluvic aluviosoil (UT9)

The profile has been sub-placed in the bottom third on upland slopes affected by landslides stabilized with weak tilting.

Soil profile is: Ao-C1-C2 (Bv). The texture is fine, loamy clay medium, uniform profile (Figure 9).

Clay has the highest value in the first part of the profile, because the original soil was covered with mineral slipped on the slope, came from a fine texture Bv horizon.

Humus content is small, decreases from 2.24% in Ao to 1.1% in C2 (Bv). The reaction is slightly alkaline (Figure 10).

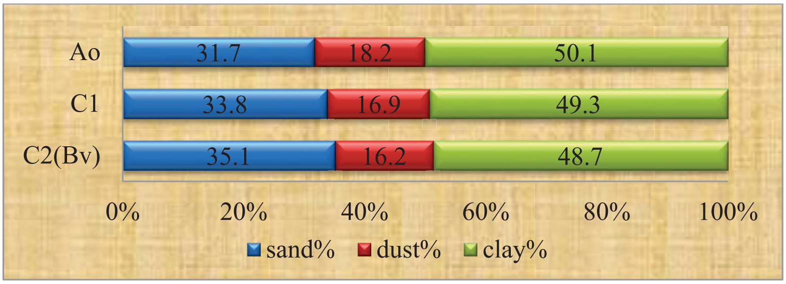

Figure 9. Granulometry at coluvic aluviosoil Capsuna Valley

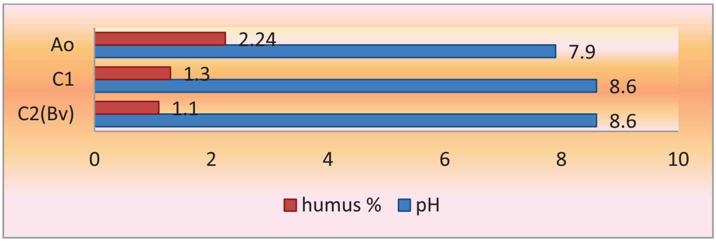

Figure 10. Humus content and pH at coluvic aluviosoil Capsuna Valley

2. Tipic regosoil (UT10)

The profile has been positioned in the upper third of sub Capsuna Valley, on the slope evenly heavily tilted moderately eroded with deep phreatic water sea. Soil profile is: Ao-C, with the upper horizon 10 cm thick.

The texture is fine, loamy clay medium, uniform profile. The percentage of clay is between 47.3% and 40.7% in Ao horizon in C (Figure 11).

The reaction is slightly alkaline, humus content is low with decreasing trend (Figure 12).

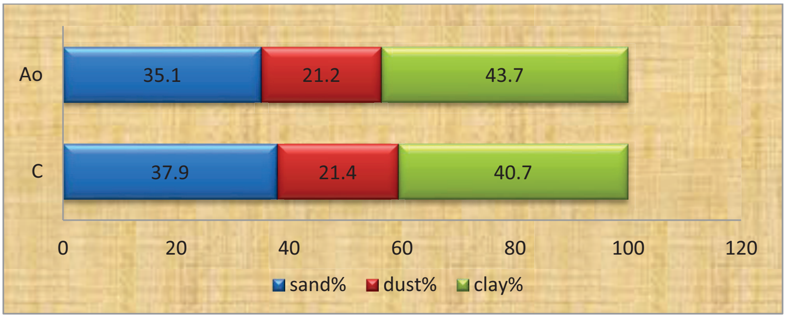

Figure 11. Granulometry at tipic regosoil Capsuna Valley

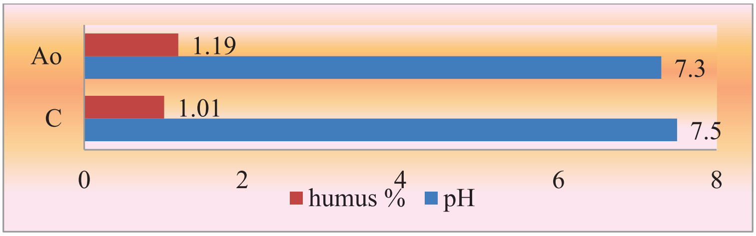

Figure 12. Humus content and pH at tipic regosoil Capsuna Valley

Characterization of soils at Pacle Valley

The right side of the Pacle Valey close perimeted studied.

In the watershed of the slope are mud volcanoes known as Small Pacle.

Salinic regosoil (UT14)

Uniform slope is moderately slope volume edafic small format Salif marl. Soil profile is short: Ao-C1sa-C2sa.

The texture is fine, loamy clay medium, uniform profile.

Clay content is between 39.6% and 45.3% (Figure 13).

Humus content is middle in the upper portion and the reaction is slightly alkaline, with pH values of 8.1 based on profile (Figure 14).

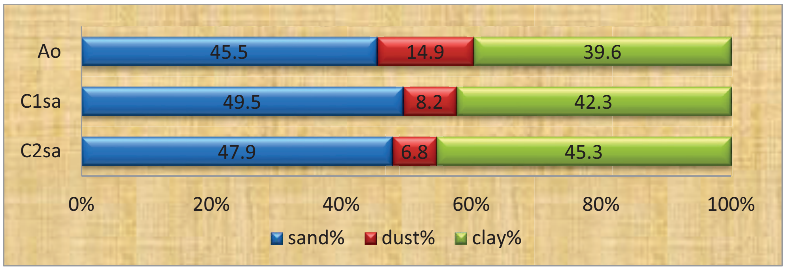

Figure 13. Granulometry salinic regosoil Pacle Valley

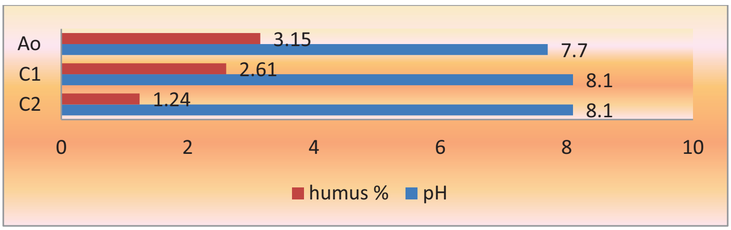

Figure 14. Humus content and pH at salinic regosoil Pacle Valley

CONCLUSIONS

Soils in the area studied fall into two classes: cernisoils and protisoils, soil type influent is regosoil. Pedogenetical main processes are bioacumulation and argillic alteration, which was added to salinization and gleyzation.

Parental materials are clay, marl and marl salif that all soils therefore have a fine texture, uniform profile and weak alkaline reaction.

Most of the area studied is operated under pasture.

Hydrographic basin studied slopes steeply and are affected by erosion and landslides.

Soil degradation processes are intensified by overgrazing and large animals load per unit area.

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REFERENCES

Oanea N., 2005. General soil science. Editura Alutus, Miercurea Ciuc.

Florea N., 2003. Degradation, protection and improvement of soil and land. Editura Publisching House Bucharest.

Miclaus V., 1991. Soil sciences and environmental improvement methods. Editura Publishing House Dacia, Cluj.

xxx Methodology of drafting soil studies, 1987. ICPA Bucharest.

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EVOLUTION OF THERMAL AND HYDRIC REGIME OF SOILS FROM THE TRANSILVANIAN PLAIN DURING 2008-2014

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Abstract

Tranyilvanian Plain is considered as an area with a low capacity to adapt to climate changes, monitoring the climate and implementing the adaption measures being essential for the development of certain durable agricultural technologies. The monitoring and variability of climate elements were achieved during 2008 (March) - 2014, through a network of 10 HOBO stations which store soil temperature data electronically (at 10, 30, 50 cm deep) and air (at 1 m hight), soil moisture (at 10 cm depth) and are equipped with rain gauges. The purpose of the paper is to establish the tendency in the evolution of the soil thermal and hydric regime, to predict and identify the climate tendencies from the Transylvanian Plain. The thermal regime of soils in this area is mesic, the differences between the annual averages of summer temperatures and the average of winter temperatures 50 cm deep in the soil are ranging between 12.81-20.01°C. The evolution of temperatures at the soil level during 2008-2014 indicate the clear tendencies of rising temperatures at the soil surface (0 cm). The coefficients of linear correlation among the data lines analyzed indicate a rising synchronous evolution of the annual average temperature, with values of the correlation indices of 0.52-0.81. The same linear tendency in evolution of rising of the annual average temperature is recorded also in the case of temperatures from 10 cm and 30 cm deep in the soil. The evolution of temperatures in the air during 2008-2014 shows slightly rising evolutionary tendencies. The evolution of rainfall during 2008-2014 shows a falling linear tendency of them, the highest values of the annual average is recorded in 2010 (631 mm), and the lowest quantities of rainfall were recorded in 2012 (263.9 mm). The value of the correlation coefficient associated to the falling evolution tendency of rainfall is r = -0.51. The multiannual average of rainfall from the Transylvanian Plain is 466.52 mm. From the analysis of the statistical relation between rainfall and soil moisture, the calculated correlation coefficient has a value of r = 0.92 which indicates a direct and positive causal relation between the two parameters.

Key words*: thermal regime, hydric regime, climate changes, Transylvanian Plain.*

INTRODUCTION

Climate is the dynamics of all meteorological phenomena from the atmosphere, including the soil thermal and hydric regime, from a certain place or region in the world, during a very long period of time (Dumitrescu et al., 2015). The climate change supposes the systematic deviation from the average state which defines a climate, which lasts for a longer period of time, usually tens of years or even more, to a new average state, a new climate (Coste, 2015; Purton et al., 2015). Climate changes can be caused by the simultaneous action of certain internal as well as external natural factors and/or certain external anthropogenic factors which result in the change of the atmosphere composition by the increase of concentration of greenhouse gases (Perry, 2015; Marin et al., 2016).

In the fourth evaluation report, AR4 (IPCC, 2007) of *Intergovernmental Panel on Climate Change* it is mentioned that during 1956-2005 a rise of temperature by 0.13°C/decade took place, a value approximately double compared to the value of 0.74°C from the last 100 years (during 1906-2005). This rise of temperature during the last 50 years is much and with a high probability caused by greenhouse emissions coming from human activities (Heinrich and

Gobiet, 2012; Lereboullet et al., 2013; Niacsu et al., 2015; Luo et al., 2016).

According to the fifth evaluation report, AR5 of IPCC (IPCC, 2014) the climate projections during 2016-2035 compared to 1985-2005 show a rise of the air temperature worldwide by 0.3ºC up to 0.7ºC, this warming being caused by the emissions resulted from the anthropogenic activity, but also by the natural climate variabilitaty. The global temperature average, calculated during 1880-2012 shows a rising tendency by 0.85ºC (0.65ºC-1.6ºC) for several series of independent data, with a varied interannual and decade variability; during 1998-2012, the warming rate was 0.05°C per decade, with variations up to 0.15ºC per decade (AR5, IPCC, 2014).

Changes in the rainfall regime, at a European level, show a higher time and space variability compared to temperatures, these rising in the north and north-west of Europe, but falling in the south of Europe. Most of the projections of the climate models show a continuity of rising rainfall in the north of Europe and their decrease in the south of Europe (EEA, 2012).

For Romania, in "*The Guidance on adaptation to climate change*" prepared by the Ministry of Environment and Forests in 2008, approved by the Order of Ministry no. 1170/2008 are mentioned rising of extreme temperatures during 2070-2099 compared to 1961-1990 by 4.0°C-6.0°C inside the Carpathian region and lower in the rest of the country in the case of minimum winter temperatures and 0.8°C-0.9°C in the north-west and north-east of the country. As for the average of the summer maximum value, there is a rising recorded of 4.0°C-5.0°C in the north of the country, a higher rising is recorded in the south of the country. These temperature changes were obtained by projecting the simulations made with HadAM3H global climate model under the conditions of A2 IPCC scenario (Coste, 2015).

When it comes to the soil moisture there aren't any clear clues in the tendencies to retain water in the soil due to the lack of systhematic and harmonized data. Projections suggest a reduction of the soil moisture in the greatest part of Europe, significant reductions in the mediterranean region and its rising in north-eastern Europe (EEA, 2012). At a European level, from the point of view of the need of water for irrigations during 1975-2010, in Italy and in the Iberian Peninsula we have noticed an increase of the water volume needed for irrigations while in other parts of south-eastern Europe it decreased. According to the EEA report (2012) under the influence of future climate changes in the south of Europe, an increase of the need for irrigations in agriculture is forecast (Trif and Oprea, 2015).

The Transylvanian Plain (TP) which has a surface of approximately 395,616 ha is favoured for cereal crops on relatively large surfaces (wheat and maize), but also for soy, sunflower and sugar beet, these are the main agricultural crops present in this geographical unit, which covers surfaces from Cluj, Bistrita-Năsăud and Mures counties. The surface of arable lands, which occupies approximately 60% of the territory of the Transylvanian Plain tends to reduce due to the transformation of certain large surfaces of productive lands into degraded lands, and even unproductive, process resulting from: applying certain irrational agricultural technologies, deforestation, setting up communal pasturs on fast slopes, pseudogleization, alkalinization and salinization of soils (Sopterean, 2012; Haggard, 2012).

The Transylvanian Plain is considered as an area with a low capacity to adapt to climate changes thus, under these conditions, monitoring the climate and implementing measures to adapt to these conditions are essential for the development of certain durable agricultural technologies. The climate changes from the last years modified significantly the climate indicators of the Transylvanian Plain, as our previous research shows (Rusu et al., 2017).

Monitoring the soil thermal and hydric regime, the air temperature and the rainfall from the Transylvanian Plain aims to set up the tendency in the evolution of these parameters. The paper responds to the need of making a long term monitoring of climate variability, a forecast and an identification of climate tendencies which had a negative impact on agriculture in order to evaluate the risk of agricultural surfaces and of the species cultivated as well as to take the best measures to adapt to the effects of climate changes.

MATERIALS AND METHODS

Monitoring and variability of climatic elements was achieved during 2008 (March) - 2014, through a network of 10 HOBO-MAN-H21-002 (On-set Computer Corp., Bourne, MA, USA) stations which store soil temperature data electronically (at 10, 30, 50 cm deep) and air (at 1 m hight), soil moisture (at 10 cm depth) and rain gauges. HOBO Smart Temp (S-TMB-M002) temperature sensors and Decagon EC-5 (S-SMC-M005) moisture sensors were connected to HOBO Micro Stations. Additionally, tipping bucket rain gauges (RG3-M) were deployed to measure rainfall. Data was downloaded from the Micro Stations every four months via laptop computer using HOBOware Pro Software Version 3.7.2. Soil types, land slope and exposition, altitude and geographic coordinates of the locations in which stations were set are shown in Table 1 (Haggard et al., 2010). The majority of soils have a loam-clay texture, pH between 6 to 8.69 and humus content of 2.5 and 4.15 in the first 20 cm (Rusu et al., 2014).

The determination of modifiations of the soil thermal and hydric regime from the Transylvanian Plain is based on the calculation of primary data recorded by HOBO stations, during the research years 2008-2014. Upon the opening of the electronically stored data files, a diagram is generated with the series of data recorded by each sensor for the period starting with launching the program and up to the download of data.

After the data was visualized, its export was made into Excel calculation sheets ordering the data series into a continuous form for each year according to the station and to the climate parameter analyzed.

The analysis instruments of the program allow the customization of graphs and the differentiated analysis of data series (calculation of monthly, annual and multiannual averages of soil, air temperatures and soil moisture for each station).

For the calculation of rainfall, HOBOware program allowed to record events (daily monitoring of the number of dumpcart of the arm to collect rainfall) which in their turn have been exported into Excel calculation sheets where the monthly and annual quantity of rainfall was calculated by multiplying the number of events by 0.2 (mm), value which corresponds to each swing of the dumpcart mechanism the rain gauge is equipped with.

Table 1. Analytical data on location of measuring stations

No	*Station (County)*	*Soil Type and Subtype**	*Latitude*	*Longitude*	*Elevation, m*	*Slope, %*	*Exposition*
1	Caianu (CJ)	Chernozem calcaro-calcic	46º79’	23º52’	469	17	SE
2	Mociu (CJ)	Chernozem luvic	46º47’	24º04’	435	5	V
3	Taga (CJ)	Preluvosol typic	46º97’	24º01’	469	17	N
4	Branistea (BN)	Eutricambosoil typic	47º17’	23º47’	266	1	V
5	Dipsa (BN)	Phaeozem typic	46º96’	24º26’	356	3	E
6	Zoreni (BN)	Preluvosol typic	46º89’	24º16’	445	17	NV
7	Silivasu de Campie (BN)	Eutricambosoil mollic	46º78’	24º18’	463	7	NV
8	Filpisu Mare (MS)	Districambosoil typic	46º74’	24º35’	375	19	S
9	Band (MS)	Phaeozem luvic	46º58’	24º22’	318	1	SE
10	Triteni (CJ)	Phaeozem vertic	46º59’	24º00’	342	10	N

SE =southeast; V = west; N = north; E = east; NV = northwest; S = south; *RSST, 2012

CJ = Cluj county; BN = Bistrita-Nasaud county; MS = Mures county

RESULTS AND DISCUSSIONS

Soil thermic regime from the Transylvanian Plain. The soil thermal regime depends on a complex of factors, first on the intensity of solar radiation and its periodic variations in time, to which we add the soil physical properties, composition, structure, texture, the soil moisture or dryness degree, the specific heat and thermal conductivity, the orientation and tilt slopes, as well as the nature and degree of covering the soil surface with vegetation. The soil surface receives a certain quantity of energy which is converted into thermal energy which subsequently is propagated and/or taken over, then, by the soil layers by conduction.

The soil thermal regime influences in its turn the plant growth, the biological activity and water movement inside the soil. In the evaluation of the soil thermal regime, the multiannual average of temperature represents the value mostly used.

The analysis of the soil thermal regime from the Transylvanian Plain during 2008-2014 by indirect determination according to RSST, 2012 (adding 2°C to the annual average temperature of the soil 50 cm deep from the surface) is not confirmed as, in the case of the majority of stations from the Transylvanian Plain, the values of the annual average temperature, 50 cm deep in the soil are higher than the air ones. Figure 1 presents the multiannual averages of soil temperatures during 2009-2014 in the Transylvanian Plain, where one can notice that the highest values are registered at Filpisu Mare, and the lowest at Triteni, Caianu and Silivasu de Campie stations.

The resulted values of the thermal regime of the soils, directly, by calculating the difference between the average of summer temperatures and the average of winter temperatures of soils, 50 cm deep, were used to establish the thermal regime of the soils from the Transylvanian Plain. It results that the thermal regime of the soils from the Transylvanian Plain is ***mesic***, with values of the annual average temperature of the soil 50 cm deep ranging from 8°C to -15°C, and the differences between the averages of summer temperatures and the averages of winter temperatures are higher than 6°C at 50 cm deep in the soil.

The annual averages of the soil temperature have values ranging between 10.58°C and 13.72°C and one can notice, during 2012-2014, increases of values of the annual averages by 0.55°C up to 0.86°C compared to the previous period 2008-2011. Even if the value limits of the annual average temperatures grew during 2012-2014, the soil set up in the *mesic type* thermal regime established previously (Rusu et al., 2014) hasn't changed.

Evolution of soil temperatures during 2008-2014. The temperature from ***the soil surface (0 cm)*** was recorded at Taga, Filpisu Mare, Band, Triteni and Zoreni stations, the annual averages ranging between 10.12°C (Triteni, 2013) and 13.00°C (Filpisu Mare, 2014). The annual average temperatures of the soil recorded ***10 cm*** deep ranged between 10.32°C, in 2013, at Triteni and 13.89°C, in 2014, at Filpisu Mare station. At ***30 cm*** deep in the soil, the annual average temperatures ranged between 10.91°C at Caianu station in 2012 and 12.22°C at Dipsa and Branistea stations in 2014. At ***50 cm*** deep in the soil, a percentage of 53.33%, is represented by the annual average temperatures ranging between 11.01°C and 12.00°C, recorded at the majority of stations from the Transylvanian Plain. In a percentage of 26.66% are found the annual average temperatures ranging between 10.01°C and 11°C at Band, Triteni, Zoreni and Silivasu de Campie stations.

In order to analyze, statistically, the general direction in time of the soil temperature, the *linear tendency* of the annual average temperatures at the soil surface was used, 10 cm, 30 cm and 50 cm deep during 2008-2014, achieved based on the size of the determination index R^2 and of the correlation coefficients. Temperature data indicate clear growing tendencies of temperature at the ***soil surface (0 cm)*** for Band, Taga (Figure 2), Triteni, Filpisu Mare and Zoreni stations. The linear correlation coefficients of the data lines analyzed indicate a growing synchronous evolution of the annual average temperature, with more clear tendencies at Zoreni, Filpisu Mare and Band stations, where the value of the correlation indices is 0.81 at Zoreni station, 0.61 at Filpisu Mare station and respectively 0.52 at Band station (Figure 3).

At ***10 cm*** deep in the soil the linear tendencies of evolution of the annual average temperature are rising at the majority of stations except for Triteni station, where the linear tendency shows a slight evolution down of the annual average temperature. The same linear tendency in growing evolution of the annual average temperature is recorded also in the case of temperatures ***30 cm*** deep in the soil, except for Silivasu de Campie station where the tendency indicates a clear decrease of the annual average temperatures (Figure 4).

The linear correlation coefficients indicate a rising evolution of the annual average temperature, with clear tendencies for Branistea, Dipsa and Zoreni stations, followed by Filpisu Mare, the value of correlation coefficients of which is 0.82, 0.73 and 0.72, respectively 0.63 for Filpisu Mare station. In the case of Triteni station, the value of correlation coefficient associated to linear tendency (-0.04) indicates a drop of the anual average temperature insignificant almost inexisting, and for Silivasu de Campie station is -0.46, indicating a higher decrease of the annual average temperature 30 cm deep (Figure 5).

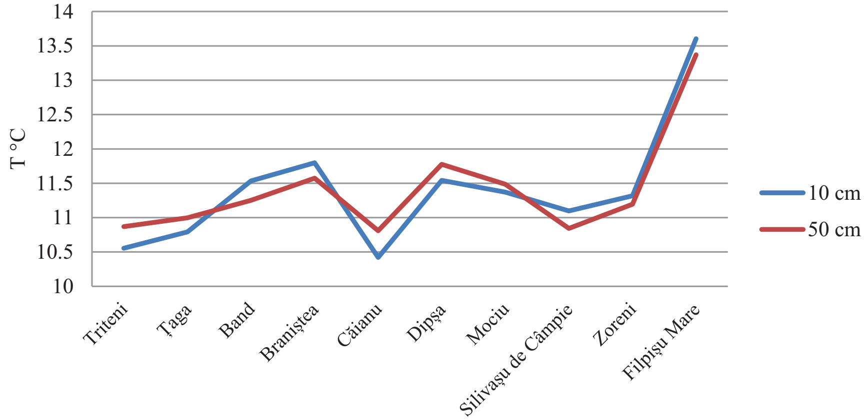

Figure 1. Multiannual average of soil temperature in Transylvanian Plain (2009-2014)

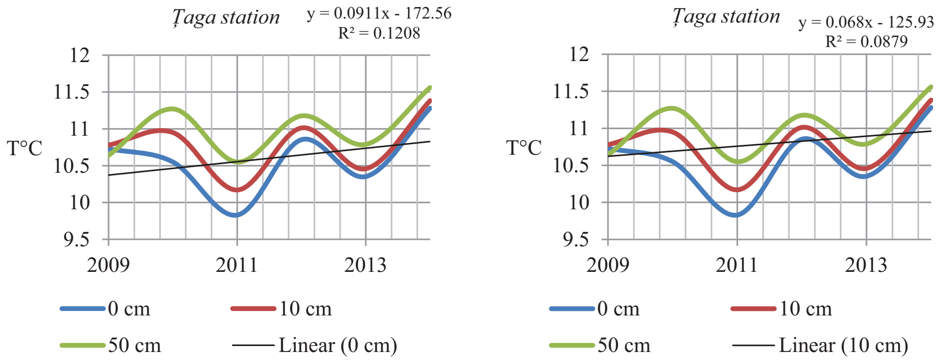

Figure 2. Linear trend of annual averages temperature evolution (0 cm, 10 cm) at Taga Station

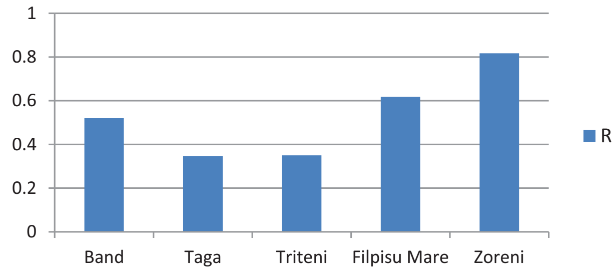

Figure 3. Values of correlation coefficient associated with trend evolution of annual average temperature at soil surface (0 cm)

The tendencies of temperature evolution 30 cm deep in the soil indicate growing, moderate to significant tendencies, for Dipsa (r = 0.57) and Branistea (r = 0.8) stations compared to Silivasu de Campie (r = -0.4) station where there is a moderate falling tendency.

Evolution of soil moisture during 2008-2014. The soil moisture is one of the meteorological elements derived from atmosphere with a determining role, next to other factors, for the ongoing under optimal conditions of the plant vegetation cycle.

The evolution analysis of the annual average values of soil moisture, recorded 10 cm deep, during 2008-2014 the Transylvanian Plain indicates a general falling tendency at the majority of stations except for Dipsa station where the linear tendency indicated a rising evolution of soil moisture.

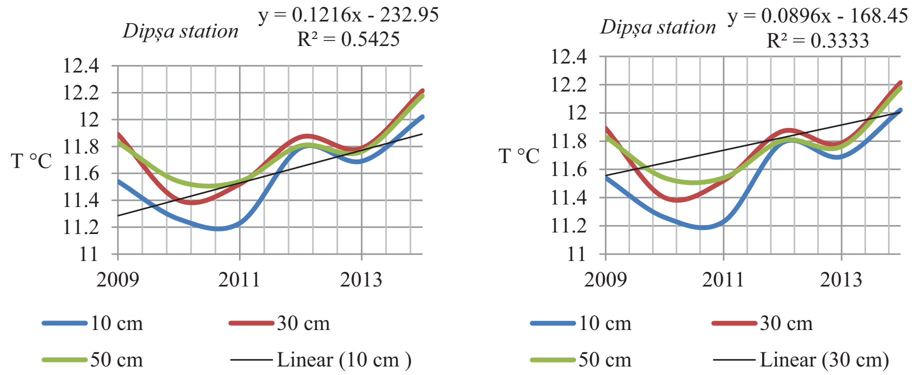

Figure 4. Linear trend of annual averages temperature evolution (10 cm, 30 cm) at Dipsa station

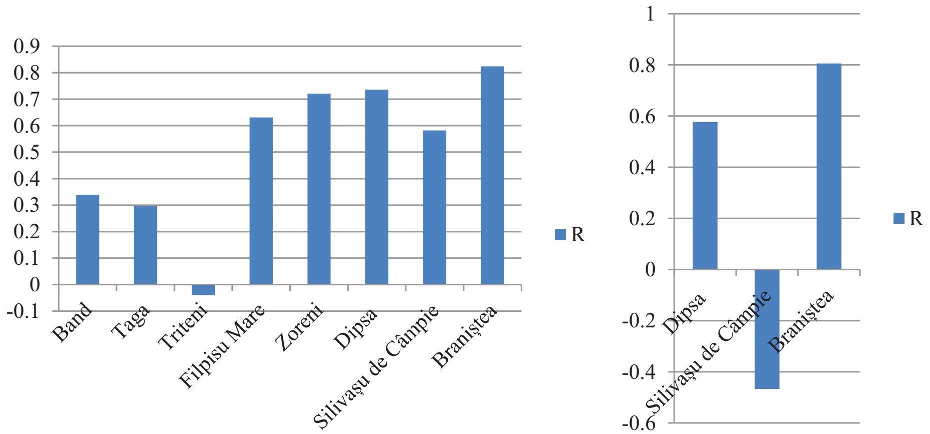

Figure 5. Values of correlation coefficient associated with trend evolution of annual average temperature at 10 cm (left) and 30 cm (right)

The correlation coefficients associated to the falling linear tendencies of soil moisture, presented in Figure 6 have values ranging between - 0.95 at Branistea and -0.04 at Caianu station.

The negative values and the values close to zero of the correlation coefficients from Caianu and Taga stations (-0.13) indicate us slightly falling tendencies, almost insignificant to nul of the soil moisture.

The positive value, close to zero, of the correlation coefficient in the case of Dipsa station (0.13) indicates a growth almost insignificant of the soil moisture.

The most clear tendencies of falling evolution of soil moisture were recorded at Branistea, Silivasu de Campie and Filpisu Mare stations, followed by Zoreni and Triteni stations.

For a synthetic image of the space and time variability of the soil moisture variation we used the *standard deviation*, frequently used in climatology, index which has the same measuring unit like the one of the values from the data lines used. From the analysis of the values of the standard deviation calculated for each station, it results that the soil moisture varies by 0.021 m^3/m^3 up to 0.027 m^3/m^3 compared to the multiannual average of each station analyzed (Figure 7).

Evolution of air temperature during 2008-2014. Air temperature was recorded at the station equipped with rain gauge, 1 m high from the soil surface. The annual averages of air temperature are ranging from 10.53°C at Band (2012) to 12.18°C at Mociu (2014).

The variation of air temperatures (daily, monthly and annual) is determined by a complex of factors which comprises aspects related to orientation and tilt slope, altitude variation, circulation of air masses, content of water vapors or powders in suspension, vegetal cover etc.
After the analysis of evolution tendencies of the annual average temperatures, based on the data recorded during 2008-2014 one can notice that at Dipsa, Silivasu de Campie (Figure 8) and Branistea stations they are rising, and at Caianu station the evolution tendency of the annual average temperature is falling. The values of the correlation coefficients (Figure 9) associated to the evolution tendencies of the air annual average temperature at Branistea and Dipsa stations indicate insignificant growths of air temperature, and at Caianu station the value of the correlation coefficient of -0.55 indicates a moderate tendency of falling evolution of the air annual average temperature. At Silivasu de Campie station, the value of the correlation coefficient associated to the evolution tendency of the air annual average temperature indicates a very slight rising tendency.

Evolution of rainfall during 2008-2014. From the data recorde at the stations equipped with rain gauges, the highest quantities of rainfall from the Transylvanian Plain were recorded at Branistea station in 2014 (580.65 mm/year), and the lowest at Mociu station (267.06 mm/year).
From the analysis of data regarding the quantity of rainfall recorded in the Transylvanian Plain during 2008-2014 one can notice its falling linear tendency, the highest values of the annual average are recorded in 2010, with an average value of 631 mm, it is considered a year with rainfall close to the normal in the area. The lowest quantities of rainfall were recorded in 2012 (358.62 mm), a drought year from the point of view of the quantities of rainfall (Figure 10). The multiannual average (2009-2014) of rainfall in the Transylvanian Plain is 466.52 mm, under the inferior limit of the area (500-700 mm/year).
The value of the correlation coefficient associated to the falling evolution tendency of rainfall is -0.51 which indicates a reverse, moderate to good index of the relation between the two variables analyzed.
In 2009, the average of rainfall recorded at the stations from the Transylvanian Plain was 533.1 mm, value close to the inferior limit in the area, and in 2011 rainfall was recorded in average value of 372.75 mm, 2011 being considered a year with deficit in rainfall. In 2012 the rainfall deficit emphasized, a drop of their average by 14.13 mm compared to the previous year was recorded. In 2013 and 2014 the annual average values of rainfall were under the inferior limit of the normal value in the area, they were 466.72 mm, respectively 436.93 mm.
In order to visualize the statistical relation between rainfall and soil moisture we used the correlation graph betwen the two variables. The correlation coefficient calculated for the analysis of the relation between rainfall and soil moisture 10 cm deep has a value of r = 0.92 which indicates a very close, direct, positive and significant relation between the two parameters (Figure 11). The value of the relation coefficient indicates a very good association between the two parameters, and the value of the determination coefficient R^2 indicates the fact that 84% of moisture variation can be explained by the linear relation with rainfall.

CONCLUSIONS

The Transylvanian Plain is the unit with the highest water deficit from the Transylvanian Depression. The soil thermal regime in this area shows a *mesic type* regime, the differences between the annual averages of summer temperatures and the averages of winter temperatures 50 cm deep in the soil are ranging between 12.81-20.01°C. The multiannual averages of the differences between the averages of the summer months and the averages of the winter months are ranging between 13.77-15.89°C.
The evolution of temperatures at soil level during 2009-2014, indicate the clear growing tendencies of temperature at the *soil surface (0 cm)*.
The coefficients of linear correlation among the data lines analyzed indicate a rising synchronous evolution of the annual average temperature, with values of the correlation indices of 0.81 at Zoreni station, 0.61 at Filpisu

Mare and respectively 0.52 at Band station. The same linear tendency with a rising evolution of the annual average temperature is recorded also in the case of temperatures *10 and 30 cm deep* in the soil.

The evolution of air temperatures during 2008-2014 shows slightly rising evolution tendencies, except for Căianu station where the evolution tendency of the annual average temperature is slightly falling.

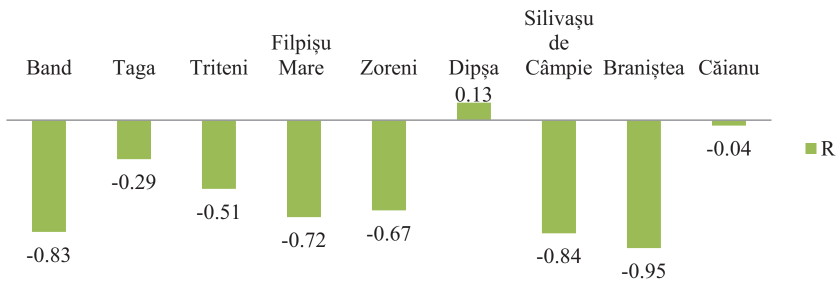

Figure 6. Values of correlation coefficient associated with trend evolution of annual average soil moisture in Transylvanian Plain

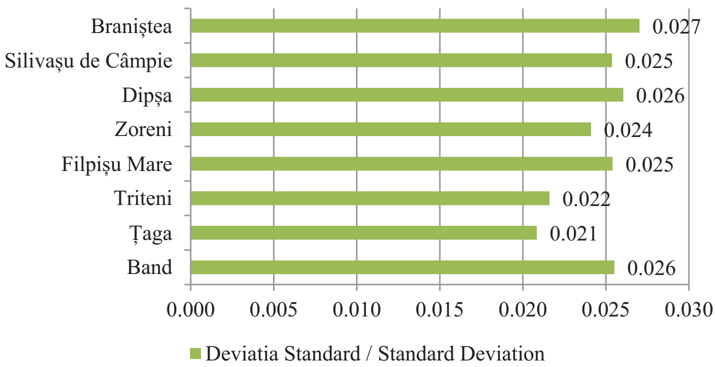

Figure 7. Standard deviation of annual value of soil moisture (m^3/m^3)

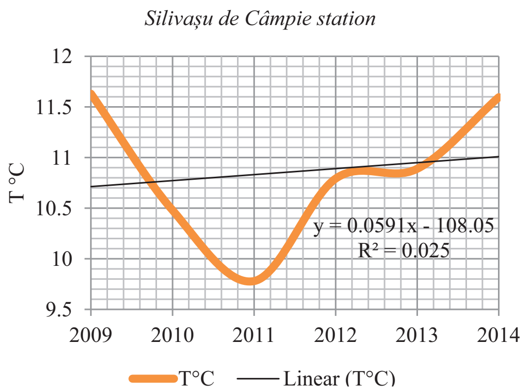

Figure 8. Linear trend of annual averages air temperature evolution at Silivasu de Campie station

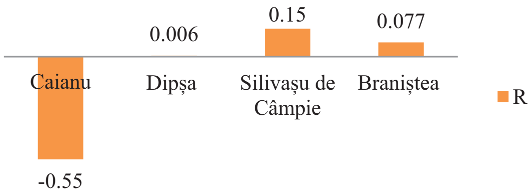

Figure 9. Values of correlation coefficient associated with trend evolution of annual average air temperature

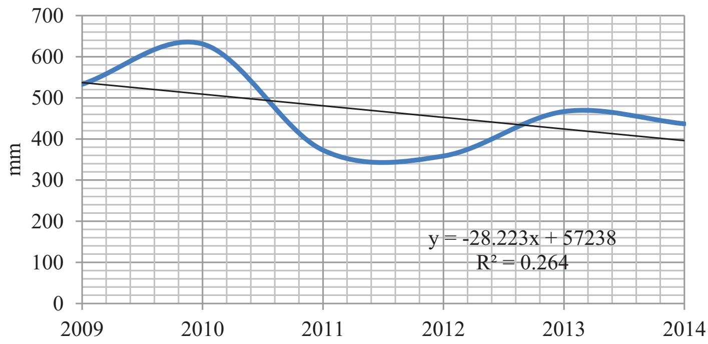

Figure 10. Linear trend of rainfall evolution in Transylvanian Plain during 2009-2014

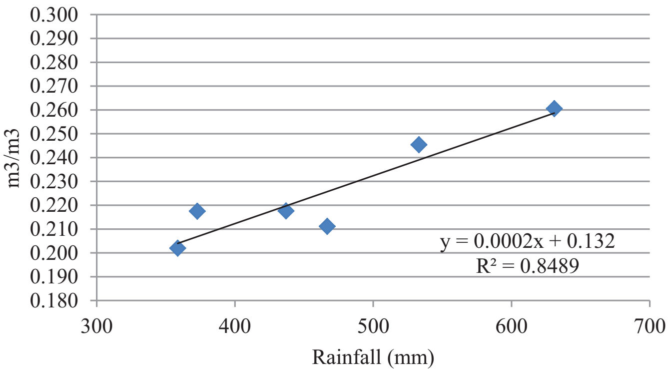

Figure 11. Correlation between annual value of soil moisture and rainfall during 2009-2014

The evolution of rainfall during 2008-2014 shows its falling linear tendency, the highest values of the annual average is recorded in 2010, with an average value of 631 mm, 2010 is considered a year with rainfall close to the normal of the area, and the lowest quantities of rainfall were recorded in 2012 (263.9 mm) a drought year from the point of view of rainfall quantities. The value of the correlation coefficient associated to the falling evolution tendency of rainfall is r = -0.51 which indicates a negative, moderate to good correlation of the relation between the two variables analyzed.

The multiannual average (2008-2014) of rainfall from the Transylvanian Plain is 466.52 mm, under the inferior limit of the area (500-700 mm/year). At the level of the Transylvanian Plain, the standard deviation of the annual values compared to the multiannual average of the area is 93.8 from which it results that, on an average, the annual values deviate by ±93.8 mm compared to the multiannual value of the area.

The evolution of soil moisture during 2008-2014 recorded 10 cm deep indicates its general falling tendency at the majority of stations except for Dipsa station where the linear tendency indicated a slightly rising evolution, almost negligeable of soil moisture. The values of the correlation coefficients associated to linear tendencies of soil moisture are ranging between -0.95 at Branistea and -0.04 at Caianu station. The most clear falling evolution tendencies of soil moisture were recorded at Branistea, Silivasu de Campie and Filpisu Mare stations, followed by Zoreni and Triteni stations.

From the analysis of values of the standard deviation calculated for each station it results that soil moisture varies by 0.021 m^3/m^3 up to 0.027 m^3/m^3 compared to the multiannual average of each station analyzed. From the analysis of the statistical relation between rainfall and soil moisture, the calculated correlation coefficient has a value of r = 0.92 which indicates a direct and positive causal relation between the two parameters, a very good association between them, and the moisture variation can be explained by the linear relation with rainfall (84%).

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REFERENCES

Coste C. L, 2015. The evolution of agroclimatic indicators and potential impact of climate change on Agricultural Land of Transylvanian Plain. Ph.D. Thesis, UASMV Cluj-Napoca.

Dumitrescu A., Bojariu R., Birsan M.V., Marin L., Manea A., 2015. Recent climatic changes in Romania from observational data (1961-2013). Theoretical and Applied Climatology, 122(1-2): 111-119. doi: 10.1007/s00704-014-1290-0.

Haggard B., Rusu T., Weindorf D., Cacovean H., Moraru P., Sopterean M., 2010. Spatial soil temperature and moisture monitoring across the Transylvanian Plain in Romania. Bulletin UASVM Agriculture, 67(1): 130-137.

Haggard B., 2012. Soil climate and pedology of the Transylvanian Plain, Romania. Ph.D. Thesis, Louisiana State University, USA.

Heinrich G., Gobiet A., 2012. The future of dry and wet spells in Europe: a comprehensive study based on the ENSEMBLES regional climate models. International Journal of Climatology, 32: 1951-1970.

Lereboullet A. L., Beltrando G., Bardsley D. K., 2013. Socio-ecological adaptation to climate change: A comparative case study from the Mediterranean wine industry in France and Australia. Agriculture, Ecosystems & Environment, 164: 273-285.

Luo Z., Wang E., Rossel R. A. V., 2016. Can the sequestered carbon in agricultural soil be maintained with changes in management, temperature and rainfall? A sensitivity assessment. Geoderma, 268: 22-28. doi:10.1016/j.geoderma.2016.01.015.

Marin D.I., Bolohan C., Oprea C.A., Ilie L., 2016. Influence of sowing period and fertilization on the naked oat crop grown in the Ilfov county. Agrolife Scientific Journal, 5(1): 127-130.

Niacsu L., Ionita I., Curea D., 2015. Optimum agricultural land use in the hilly area of eastern Romania, case study: Pereschiv catchment. Carpathian Journal of Earth and Environmental Sciences, 10(1): 183-192.

Perry J., 2015. Climate change adaptation in the world's best places: A wicked problem in need of immediate attention. Landscape and Urban Planning, 133: 1-11.

Purton K., Pennock D., Leinweber P., Walley F., 2015. Will changes in climate and land use affect soil organic matter composition? Evidence from an ecotonal climosequence. Geoderma, 253-254: 48-60. doi:10.1016/j.geoderma.2015.04.007.

Rusu T., Moraru P. I., Coste C. L., Cacovean H., Chetan F., Chetan C., 2014. Impact of climate change on climatic indicators in Transylvanian Plain, Romania. Journal of Food, Agriculture & Environment, 12(1): 469-473.

Rusu T., Coste C. L., Moraru P. I., Szajdak L. W., Pop A. I., Duda B. M., 2017. Impact of climate change on agro-climatic indicators and agricultural lands in the Transylvanian Plain between 2008-2014. Carpathian Journal of Earth and Environmental Sciences, 12(1): 23-34.

Sopterean M. L., 2012. Monitorization of the thermic and hydric regime of the Transylvanian Plain and technological characterization of lands for the main crops. Ph.D. Thesis, UASMV Cluj-Napoca.

Trif A., Oprea A. O., 2015. The impact of climate changes on winter wheat crops and corn from Oltenia, between 2001-2014, compared with the reference period of 1981-2010. Conference Agriculture for Life, Life for Agriculture, Edited by: Cimpeanu S. M., Fintineru G., Beciu S., Book Series: Agriculture and Agricultural Science Procedia, 6: 525-532. doi:10.1016/j.aaspro.2015.08.079.

EEA, 2012. Climate change, impacts and vulnerability in Europe, An indicator – based report, Summary, European Environment Agency, doi:10.2800/66071.

IPCC, 2007. Climate Change 2007: Synthesis Report, Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva. <http://www.ipcc.ch/ipccreports/ar4-syr.htm>.

IPCC, 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, pp. 151.

On-set Computer Corp., Bourne, MA, USA. http://www.onsetcomp.com/products/data-loggers/h21-002.

RSST, 2012. Romanian System of Soil Taxonomy. Authors: Florea, N. & Munteanu, I. Ed. Estfalia, Bucharest, pp. 182.

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ORGANO-MINERAL FERTILIZER APPLICATIONS FOR SUSTAINABLE AGRICULTURE

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Abstract

Intensive farm applications which were the major solution were proposed to nutrient to growing human population, damage to soil fertility, ecosystem elements and human healthy seriously. This damages come up long terms. Intensive farm applications cause to decrement of soil fertility and yield quality. While the soil reduces because of intensive farm applications human population increases every year. So intensive farm applications is not a good solution and idea for nutrient to increasing human populations.

This study aimed to present solutions alternative of intensive farm applications. We propose to alternative farm applications against to intensive farm applications are organic farm (OF), organo-mineral farm (OMF). In this paper it was given some organic and chemical farm applications results to compare. Some of the results of organic and mineral applications given in this paper were studied by our research group. Some of results of this paper showed that, some of organic farm applications were increased to yield more than chemical applications. However organic applications cost is higher than other chemical or intensive farm applications. Because of the high cost and low yield of organic farming it is not prefer commonly. So that we suggested that organic and mineral (organo-mineral) applications together with suitable rate for sustainable agriculture and soil quality.

Key words: *organic farm, soil ecology, intensive agriculture, organo-mineral farm.*

INTRODUCTION

Organic agriculture; including preparation of soil before planting in agriculture, in agricultural production from planting to harvest, chemical fertilizer, drug, etc. can be named as the form of agricultural production in which inputs are not present and each stage is controlled in a certificated manner. Organic agriculture has also become popular in developing countries other than developed countries. The organic agriculture in Turkey, which is among the developing countries, started production in the middle of the 1980s with the aim of meeting the demands of the developed countries first. Production started with contracted production with a few kinds of products such as raisins, dried figs, dried apricots and hazelnuts and the production quantity and fields continued to increase with the increasing demand in years. While the area of organic production in Turkey was 89,827 hectares in 2002, it increased by 5.7 times in 2015 with 515,268 hectares. The organic production area in Turkey was seen in Eastern Anatolia with a share of about 30% and at least about 0.7% in Marmara. In the same year, the amount of organic production in Turkey was 310,125 tons in 2002 while it increased by 3.75 times in 2015 to 1,164,202 tons (Kızıltuğ and Fidan, 2016).

The lack of chemical fertilizers in organic agriculture contributes to the reduction of input cost in production and contributes to soil fertility and sustainability and it may be considered that our current fertile soil will be transferred to future generations and directly affect the future nutritional problem. Otherwise, the increase in the use of chemical fertilizers and medicines is not difficult to predict, firstly, that our existing agricultural land will become inefficient in time and deteriorate the quality of the products. Excessive chemical use destroys the viability of the soil and can cause poisoning after a certain place. Turkey has increased its use of chemical fertilizers by 4.8% in the last 6-7 years. But our arable land has decreased by about 1.5% in the same years (TUIK, 2015). As understood from this, the use of chemical fertilizers has reduced our existing arable land. In this research, the effects of organic, intensive and conventional agriculture on the land of the country will be examined, the differences between the productivity and the economy in the products produced.

MATERIALS AND METHODS

Many researches and reports on the current status of organic agriculture, development over years, foreign trade and marketing have been made with the beginning of organic agriculture in Turkey. In this study, the reports of the thesis, articles and institutions used from the existing data were utilized. The production amount, production area, number of farmers, changes in the diversity of crops, fertilizer and drug use data, and the statistical data of TÜİK and the Ministry of Agriculture and Livestock. The obtained data were interpreted by calculating the percentages by using the appropriate program and the changes according to the years.

RESULTS AND DISCUSSIONS

1. Advantages and disadvantages of organic, intensive and conventional agriculture in Turkey and World

Soils, one of the indispensable elements of production, are decreasing and exploited every year. In the same time human population is growing rapidly. Because of this case people have to do intensive agriculture. However, this is a paradox for sustainable agriculture. Because, intensive tillage applications damage to soil productivity and quality. While people population is increasing rapidly on the other hand soils are decreasing because of intensive tillage applications. The most important cause of intensive farming is human population growth. So firstly we have to keep the human population under control and save to fertile soil.

Organic agriculture is done to get better and healthier products and to protect soil health and productivity. Organic materials have regulatory effect for soil. Soil organic matter is an important source of nutrients for plant growth that needs to be maintained for agricultural sustainability. Conventional and intensive farming involves repeated heavy tillage and large use of fertilizers and pesticides and can result in organic matter losses and yield degradation in cultivated soils (Lampkin, 1998; Herencia et al., 2006).

Lots of studies have shown good and beneficial effects of organic material application for crop production. In this regard, Aggelides and Londra (2000) assessed the effects of compost produced from municipal solid waste (MSW) and sewage sludge on soil physical properties. According to several research resuts, addition of organic matter improved soil properties such as aggregation, water-holding capacity, hydraulic conductivity, bulk density, the degree of compaction, fertility and resistance to water and wind erosion (Franzluebbers, 2002; Çelik et al., 2004). Not only organic materials but also some microorganisms as mycorrhiza effect soil physical properties. Addition of organic materials of various origins to soil has been one of the most common rehabilitation practices to improve soil physical properties. Mycorrhiza has been known to play a significant role in forming stable soil aggregates (Çelik et al., 2004). According to Ortas (2002) plant roots, root hair, mycorrhizae and fungal hyphae play a significant role by binding agents within and between aggregates. Since soil management systems influence soil physical fertility, it is important to determine the effect of long-term organic and inorganic fertilizer amendments on soil physical properties such as aggregation, porosity and water-holding capacity (Çelik et al., 2004).

Conventional horticultural cropping, due to continuous soil removal and intensive use of pesticides and fertilizers, is a main activity leading to deterioration of soil physical, chemical and biological properties (Albiach et al., 2000; Ferreras et al., 2006). Mineral fertilization provides readily available nutrients for plant growth; however, it does not contribute to improve soil physical condition on the other hand mineral applications damage to soil nutrient balance. Organic matter inputs through organic amendment, in addition to supply in nutrients, improve soil aggregation, and stimulate microbial diversity and activity (Shiralipour et al., 1992). Improvement of soil aggregation through its effects on soil water content, temperature, aeration and mechanical impedance influences root development and seedling emergence (Ferreras et al., 2006).

Organic and conventional agriculture can be incalculated in many areas. It is necessary to answer the questions such as the positive and negative effects of organic and conventional agriculture. Organic farming is including ecological agriculture tillage systems and stimulate to soil productivity. There isn't any chemical material in organic agriculture. According to a study by Merdan (2014) organic agriculture is regarded not only as an agricultural technique but also as a health and life prescription. Depending on societies' level of consciousness related to environment and health, the interest in organic agriculture is rising and organic agriculture market in the world is increasingly expanding. Since the developed countries can't cover the home demand in organic agriculture they consume the products exported by the developing countries. Since developed and wealthy countries are exploitation to organic products more than developing countries, it is not advantage. If all people could use organic products it was a advantage. But unfortunately most of people think about this that a utopia. Some of researchers like us think that if organic farm's products use just for vital need as food, clothes and drugs can be enough for healthy life and agricultural sustainable. But like this life style isn't acceptable for most of people. However, a lot of people in the world have to live like this condition because of most of countries which never accept like this life style and live in wealthy. So cost of organic farm inputs is decreased by government and organic farm's incentives by government are increased.
Organic agriculture is a production system in which animal and herbal production is considered as a whole, land productivity and animal welfare are based on, the use of inputs acquired in the business firm is aimed, the latest information and technology are used, the supervision and certification based on certain rules from seed to soil are required (Merdan, 2014).
The pricing of organic products in the outer and inner market is higher than in conventional agriculture. A new employment field has been created for many people in our country with the presence of the new international market. No chemical substance (nitrate, nitrite etc.) accumulates in the products since no chemical application is made in organic products (Anonymous, 2017). Major disadvantages of organic farming are increasing population, demand of outside market and inadequate organic farm's product, small ecological farming areas, and antagonistic effect of neighbour conventional and intensive farm areas and applications.
Conventional agriculture. Agricultural technique which is widely used today. The use of plant and animal breeds as a single species, in general modified by genetics or exposed to excessive chemistry. It is an agricultural technique which has the destruction of the soil by frequent and dense soil treatment and the damages which can lead to irregular and excessive irrigation, salinization and even sodification which is a later stage.
It can be said that the advantage of conventional agriculture is that the products come to the early harvest with the applied chemicals. Disadvantages are the disruption of the aggregate structure of the soil with irregular and heavy tillage machines, the loss of the living areas of the living organisms living in the soil, the increase in cost due to the use of too many chemical substances, the lack of application of cropping seasons, the rapid loss of organic matter from the soil, Nitrate accumulation, and many other disadvantages.

2. Changes in organic agriculture in Turkey over the years

The development of organic production in our country by organic production and foreign trade and the support of many state institutions (universities, research institutes etc.) have accelerated the development of organic production by farmers (Demiryürek, 2011).
These developments led to an increase in the number of producers, the amount of production and the variety of products.
Table 1 shows the number of farmers, their production, their area, and the variation in product variety between 2002 and 2015 for organic production. While the number of products was 150 in 2002, an increase of 31.33% in 2015. The number of products has been increasing and decreasing over the course of 14 years and the year with the highest product variety is 2008. The number of farmers increased by about 5.6 times from 2002 to

2015. Compared to the previous year, there was an increase of 138.3% in farmers, 200% in product area and 85% in product quantity in 2009. The reason for this was implemented between 2000-2008 years of Direct Income Support. This support has been made more comprehensive by changing the way of ending with organic farming, good farming practices and supporting many crops (Tan et al., 2014). It is thought that organic products in 2009 were caused by the change in the supporting policy due to the increase in the area, quantity and number of producers. Despite a 5.7-fold increase in organic production by the end of 2002, there was a 38.8% decrease in 2015 compared to the previous year. The amount of organic production was 310,125 tons in 2002 and increased about 6 times in 2015 to 1,829 million tons.

Table 1. Organic production area, production, number of farmers and number of crops (2002-2015)

Years	Number of crops (Number)	Number of holdings (Number)	(%)	Area (Hectares)	(%)	Production (Tonnes)	(%)
2002	150	12 428	-	89 827	-	310 125	-
2003	179	14 798	19.1	113 621	26.5	323 981	4.5
2004	174	12 751	-13.8	209 573	84.4	377 616	16.6
2005	205	14 401	12.9	203 811	-2.7	421 934	11.7
2006	203	14 256	-1.0	192 789	-5.4	458 095	8.6
2007	201	16 276	14.2	174 283	-9.6	568 128	24.0
2008	247	14 926	-8.3	166 883	-4.2	530 224	-6.7
2009	212	35 565	138.3	501 641	200.6	983 715	85.5
2010	216	42 097	18.4	510 033	1.7	1 343 737	36.6
2011	225	42 460	0.9	614 618	20.5	1 659 543	23.5
2012	204	54 635	28.7	702 909	14.4	1 750 127	5.5
2013	213	60 797	11.3	769 014	9.4	1 620 466	-7.4
2014	208	71 472	17.6	842 216	9.5	1 642 235	1.3
2015	197	69 967	-2.1	515 268	-38.8	1 829 291	11.4

Source: www.tarim.gov.tr , 2017

Table 2: Organic Products in Conventional Products in Turkey (2014)

Products	Organic Products Amount of Production (Ton)	Conventional Products Amount of Production (Ton)	Total	Range (%)
Wheat	217,843.08	15,482,156.92	15,700,000	1.41
Olive	62,664.25	1,705,335.75	1,768,000	3.67
Fig	52,130.35	248,151.65	300,282	21.01
Apple	48,449.45	2,431,994.55	2,480,444	1.99
Grape	27,319.09	4,148,036.91	4,175,356	0.66
Cotton	27,058.22	2,322,941.78	2,350,000	1.16
Nut	10,192.75	439,807.25	450,000	2.32
Lentil	9,314.48	335,685.52	345,000	2.77
Apricot	4,102.34	265,897.66	270,000	1.54

Source: GTHB and TÜİK (Kızıltuğ and Fidan, 2016)

Table 3: Chemical fertilizer use, 2009-2015 (tons)

	2009	2010	2011	2012	2013	2014	2015
Fertilizerused	10 278 731	9 592 752	9 074 308	10 148 982	11 415 756	10 694 543	10 777 779
Nitrogen (21% N)	6 730 852	6 397 089	5 995 500	6 817 217	7 542 247	7 107 106	7 077 214
Phosphorous (17% P_2O_5)	3 416 978	3 028 666	2 882 296	3 129 299	3 662 099	3 353 104	3 437 368
Potash (50% K_2O)	130 901	166 997	196 512	202 466	211 410	234 333	263 197

Source: GTHB, 2017

Table 2 shows organic production and conventional production quantities of some products in 2014. According to the chart, it is observed that organic production quantities are produced in 1-4% of total production quantities except vetch (Karaman et al., 2013). In his study, 449.29 kg of product was purchased from conventional cherry production whereas 351.43 kg of organic cherry production was received. In this case it is observed that there is a loss of approximately 22% with a loss of 97.86 kg. Despite the product losses on the obtained yield basis, as well as higher yields in conventional agriculture, soil, environmental and economical losses are experienced. The amounts of chemical fertilizers used in this direction between 2009 and 2015 are presented in Table 3. No significant change has been observed in the amount of fertilizer used during the current years. However, the differences between organic and chemical fertilizer applications have been investigated (Demir et al., 2003). As a result of different organic fertilizer applications in tomato plant ecological production, it has been argued that the mineral content of tomatoes is not much different from traditional agriculture. However, in terms of nutrients it is said that it is the same as the traditional method, even richer. In a similar study, the results of the application of chemical and organic fertilizers on yield and quality of tomato plant were investigated. In the results obtained, only the chemical fertilizer application was found to be better than the organic fertilizer application in terms of efficiency. However, it has been observed that the best yield is obtained from chemical + organic fertilizer application (Demirtas et al., 2012). As can be understood from both studies, the use of chemical fertilizers alone with the use of organic fertilizer tillage is both effective in quality and yield, and also minimizes the damage to soil and environment. Consideration should be given to environmental and soil damage as well as loss of quality and efficiency in the use of chemical fertilizers alone.

The fertilizers used have direct and indirect damages. Excessive fertilizer use is harmful to the environment as a result of soil salinization, heavy metal accumulation, nutrient element imbalance, degradation of soil vitalities, nitrate and nitrite accumulation in groundwater, atmospheric spreading of gases and ozone layer effect, and greenhouse effect. To overcome these problems, serious economic investments and long-term implementations are required (Sönmez et al., 2008).

CONCLUSIONS

Organic or ecological agriculture is useful for soil fertility and healthy. However it is not enough to nutrition for increasing human population. Nowadays it is proposed as a major solution against to nutrition of growing human population is conventional and intensive farm. This farm applications and their products damage to soil quality and human healthy. In addition as a result of this applications fertility soils are decreased seriously. İntensive and conventional tillage agriculture to nourish growing people population, caused a new soil and human health problems. So we proposed to organic and mineral (organo-mineral) applications with suitable rate.

REFERENCES

Aggelides S.M. and Londra P.A., 2000. Effects of compostproduced from town wastes and sewage sludge on thephysical properties of a loamy and a clay soil. Biores. Techno. 71: 253 259.

Albiach R., Canet R., Pomares F., Ingelmo F., 2000. Microbialbiomass content and enzymatic activities after the application oforganic amendments to a horticultural soil. Biores. Technol. 75,43–48.

Anonymous, 2017. http://www.reitix.com/ Makaleler/ Geleneksel-Tarim-ile-Organik-Tarim-Arasindaki-Fark Date of Access: 27.01.2017

Celik I., Ortas I., Kilic S., 2004. Effects of compost, mycorrhiza, manure and fertilizer on some physical properties of a Chromoxerert soil. Soil & Tillage Research 78 (2004) 59–67.

Demir H., Topuz A., Gölükçü M., and Polat, E., 2003. EkolojikÜretimdeFarklı Organic Gübre Uygulamalarının Domatesin Minarel Maddeİçeriği ÜzerineEtkisi, Akdeniz Üniversitesi Ziraat Fakültesi Dergisi, 16 (1): 19-25.

Demirbaş E. I., Özkan C. F., Öktüren Asri, F. and Arı, N., 2012. Bazı Organik Ve Kimyasal Gübre Uygulamalarının Domateste Verimve Kalite Üzerine Etkileri, Alatarım Cilt 11, Sayı 2: 9-16.

Demiryürek K., 2011. Organik Tarım KavramıveOrganikTarımınDünyaveTürkiye'dekiDurumu, GOÜ, ZiraatFakültesiDergisi, 28(1), 27-36.

Ferreras L., Gomez E., Toresani S., Firpo I., Rotondo R., 2006. Effect of organic amendments on some physical, chemicaland biological properties in a horticultural soil. Bioresource Technology 97, 635–640.

Franzluebbers A.J., 2002. Water infiltration and soil structure related to organic matter and its stratification with depth. Soil Till. Res. 66, 97–205.

GTHB, 2017. www.tarım.gov.tr Date of Access: 27.01.2017

Herencia J.F., Ruiz-Porrasa J. C., Meleroa S.,Garcia-Galavisa P. A., Morillob E. and Maqueda C., 2006. Comparison between Organic and Mineral Fertilization for Soil Fertility Levels, Crop Macronutrient Concentrations, and Yield. Vol. 99 No. 4, p. 973-983.

Karaman S., Karahan H. and Özsayın, D., 2013. Geleneksel ve Organik Kiraz Üreten İşletmelerin Verimlilik ve Etkinlik Analizi, Tarım Bilimleri Araştırma Dergisi 6 (1): 79-82.

Kızıltuğ T. and Fidan, H. 2016. Contributions of Organic Agriculture to the Turkish Economy, IBANESS Conference Series, March 12-13, Plovdiv, s. 37-45

Lampkin N. 1998. Agriculturaecolo´ gica. Mundi-Prensa, Madrid.

Merdan K., 2014. Türkiye'de Organik Tarimin Ekonomik Analizi: Doğu Karadeniz Uygulaması. Doktora Tezi. İktisat Anabilim Dalı. Atatürk Üniversitesi, Erzurum. F-84/00/22.02.2012.

Ortas I., 2002. Biological, degradation. In: Lal, R. (Ed.),Encyclopedia of Soil Science. Marcel Dekker, USA,pp. 264–267.

Shiralipour A., Mc Connell W., Smith W.H., 1992. Physical andchemical properties of soil as affected by municipal solid wastecompost application. Biomass Bioenergy 3, 195–211.

Sönmez İ., Kaplan M. and Sönmez, S., 2008. KimyasalGübrelerinÇevreKirliliğiÜzerineEtkileriveÇözümÖnerileri, BatıAkdenizTarımsalAraştırmaEnstitüsüDerimDergisi, 25 (2): 24-34.

Tan S., Atak Ş., Şengül Ü. and Tan, S. S., 2014. Türkiye'de Son On Yıllık Süreçte Tarım Sektöründeki Değişimlerin Genel Ekonomik Göstergelerle Değerlendirilmesi, Uluslarasası Avrasya Ekonomileri Konferansı, Üsküp, Makedonya, 1-3 Temmuz, pp. 688-694.

TÜİK, 2017. www.tüik.gov.tr Date of Access: 27.01.2017.

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BIOTA OF LEACHED CHERNOZEMS OF THE CENTRAL ZONE OF THE REPUBLIC OF MOLDOVA IN ASPECT OF ITS EVOLUTION AND RECOVERY

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Abstract

The influence of different land use management on the modification of the biological properties of leached chernozem located in the central zone of the Republic of Moldova has been investigated. Database of invertebrates, microorganisms and enzymatic activities has been formed. The current status of biota of the old-arable leached chernozem is characterized by the reduction in comparison with the level of the 1960s and with soil's standards that are in conditions of natural ecosystems. The values of most soil biological indices decrease in the sequence: old fallow land → arable land under organic system with farming manure and incorporation of crop residues → arable unfertilized land → arable land with mineral fertilization of N_{90-300}. The highest values of biota's abundance were registered in fallow soils in the woodland belt and on plots with manure application with plant residues additives. Biological indices in soil profiles decreased with the depth and depended of the form of farming system. The negative effects on biota and humus status have been observed as a result of the long-term land management practices without organic fertilizers. Annual losses due to mineralization processes constitute 0.019%. The growth of humus-mineralizing microorganisms has been noticed. Trends and regression equations describing the growth of humus-mineralizing microorganisms and the fall of humus content in old-arable leached chernozems have been calculated.

Key words: *biota, humus, leached chernozem, organic and mineral fertilizers, trends.*

INTRODUCTION

In the past decade, the idea of ecological agriculture has become significant in the Republic of Moldova (Boincean, 1999, 2013). Enhancing the carbon sink to agricultural land, the creation of stable soils with the high level of biodiversity and the enzymatic activity are the major advantages in ecological agriculture. There is a growing interest in developing valuable and sensitive indicators of soil quality, which will be able to reflect the effects of land management and ensure a long-term sustainability of soil fertility. In this context, soil biological indices can be used for the evaluation and comparison of mineral and organic farming systems. In addition, the study of the evolution of soils, which are under different land management, is also interesting from the point of view of the national soil quality standards.

One of the main problems in predicting soil biological status is that it is influenced by a multitude of interacting factors, including soil carbon quantity and quality, physical and chemical soil properties, nutrient status, vegetation type, climatic conditions and etc. Therefore, reliable differences can be found in the experimental data of several years in conditions of long-term stationary experiments. Long-term monitoring researches carrying out on site experiments made it possible to produce data bases of biota state of zonal soils, their statistical processing and the elaboration of evaluation system of degradation and recovery processes.

The purpose of the research was to determine the state and temporary variability of biota in the leached chernozem under different land management practices aiming to develop the methods of soil quality restoration of old arable soils.

MATERIALS AND METHODS

The experimental site is located in the central zone of the Republic of Moldova, in the wooded steppe of the central - Moldovan forest province, in the district No. 8 of gray forest soils and leached chernozems of the wooded steppe of hilly Kodru Forests (Figure 1), in the Ivancha village, Orhei district (lat. 47° 18′ N, long. 28° 54 ′ E, elevation 170-180 m). Leached chernozem occupies more than 395,000 ha of the coutry in the north and central regions (Andriesh et al., 2014).

Figure 1. Fragments of natural and agricultural landscapes located in the central zone of the Republic of Moldova

Biota's state in the leached chernozem in the condition of long-term arable has been investigated in comparison with fallow soils in the 60 years-old woodland belt.

Sampling for microbiological and enzymatic indicators was carried out in 2 profiles per soil horizons to a depth of 200 cm and from 0-30 cm layer separately during 1988-1998 and 2005-2016. Additionally, some microbiological and enzymatic indicators were compared with the level of the 1960s. Invertebrates sampling was carried out from 5-32 soil semi-profiles to a depth of 60 cm over the period 1991-2010.

Status of invertebrates was identified from test cuts by manual sampling of the soil layers to the depth of soil fauna occurrence (Gilyarov and Striganova, 1987).

Microbiological properties. The microbial biomass carbon was measured by rehydration method (Blagodatsky et al., 1987). Counts of culturable microorganisms (heterotrophic bacteria, humus-mineralizing microorganisms, actinomycetes, bacteria from the family of the *Azotobacter* and fungi) were obtained on agar plates (Zvyagintsev, 1991).

Enzymatic activity. The urease activity was measured by estimating the ammonium released on incubation of soil with buffered urea solution by colorimetric procedure (Haziev, 2005). The catalase activity was determined by the volumetric method by the rate of hydrogen peroxide's decomposition during its interaction with the soil and by the volume of released oxygen (Galstyan, 1978). The dehydrogenase activity was determined by the colorimetric technique on the basis of triphenylformazan (TPF) presence from TTC (2,3,5-triphenyltetrazolium chloride) added to soil (Haziev, 2005). The polyphenoloxidase and peroxidase activities were determined by the colorimetric technique using hydroquinone as a substrate (Karyagina and Mikhailovskaya, 1986).

Soil chemical properties. Organic carbon was determined by dichromate oxidation; the humus content was estimated using the coefficient 1.724 (Arinushkina, 1970).

Soil biological indices were evaluated by analysis of variance and correlation. Statistical parameters of soil invertebrates were calculated taking into account the depth of soil fauna occurrence, microorganisms and enzymes – for the layer of 0-30 cm.

RESULTS AND DISCUSSIONS

The state of biota in fallow and arable leached chernozem. The current state of biota in the leached chernozem is the result of a long-term influence of human activity, through agricultural land management. The average abundance and biomass of invertebrates and *Lumbricidae* family in the fallow and old arable chernozem were approximately the same (Table 1). The diversity of invertebrates was different depending on the soil management. The soil under 60-year-old fallow is characterized by a greater diversity of invertebrates. In addition to the *Lumbricidae* family, species of the *Formicidae, Glomeridae, Cerambycidae, Apidae, Araneae, Coccinellidae, Forficulidae* and *Carabidae* families were found. The abundant presence of the *Formicidae* family representatives is observed. In general, the soil under fallow contains 8-10 families of invertebrates, while the soil under arable only 3-5 families of edaphic fauna. According to the average statistical data, the weight of one individual of the earthworm in the soil under arable management practices is 0.16 g, which is 1.5 times lower than in the fallow land.

Conventional tillage practices are generally unfavorable to heterotrophic bacteria, various fungi and enzymatic activities (Table 1). Soil microbial biomass decreased on average from 492.5 to 314.7 µg C g^{-1} soil as a result of a long-term arable land management without application of organic fertilizers. The long-term use of the soil under arable affected the structure of soil microbial communities. The ratio between bacteria and fungi increased from 90 to 142.

There was a 3.6 - fold increase in the number of humus - mineralizing microorganisms.

A similar trend in decrease has been noticed in the number of the heterotrophic bacteria and fungi. Activities of soil enzymes reduced: urease - by 2.8, catalase - 2.1, dehydrogenase - by 1.6, polyphenoloxidase - by 1.4 times and peroxidase - by 20.3 %.

Biological indices of investigated soils are characterized by the medium and considerable variability. There is a tendency of increase in the variation coefficient from the old fallow to the arable chernozem on some indicators. Taking into consideration the decrease in the total level and increase in the amplitude of the biological parameters oscillations in degraded soils, this testifies the decline of soil's ecological resistance to anthropogenic impacts. The level and size of homeostasis zones and therefore the biota stability reached the maximum levels in the fallow soil.

The highest level of the microbial biomass has been determined in the A_1 horizon of the soils under natural vegetation and whereas the lowest – in the BC and C horizons of both profiles (Figure 1). Microorganisms in leached chernozems under fallow are concentrated in 0-60 cm layer, the biomass index decreases sharply in the soil profile to a depth of 70-100 cm. The concentration of microorganisms in the top layer reaches 1512.2 µ C g^{-1} soil.

Table 1. Statistical parameters of biota in the leached chernozem under different land management in the Central zone of the Republic of Moldova

Index	Fallow leached chernozem					Arable leached chernozem				
	min	max	mean value	V,%	confidence interval ($P \leq 0.05$)	min	max	mean value	V,%	confidence interval ($P \leq 0.05$)
Invertebrates (n=5-32)										
Number of invertebrates, ex m^{-2}	40.0	168.0	81.6	61	19.6-143.4	32.0	152.0	84.9	41	74.6-95.3
Biomass of invertebrates, g m^{-2}	4.5	26.4	11.5	75	0.7-22.2	4.9	18.7	9.8	47	8.1-11.5
Number of *Lumbricidae* fam., ex m^{-2}	16.0	56.0	28.8	54	9.4-48.2	21.0	128.0	61.3	51	52.0-70.5
Biomass of *Lumbricidae* fam., g m^{-2}	1.6	15.2	6.8	75	11.5-10.7	4.2	18.2	9.7	44	8.1-11.4
Microorganisms (n=3-33)										
Microbial biomass, µ g C g^{-1} soil	459.9	525.1	492.5	7	411.6-573.4	191.0	434.0	314.7	21	286.8-342.6
Heterotrophic bacteria, CFU g^{-1}soil*10^6	4.8	6.0	5.4	11	3.9-6.9	2.6	6.8	4.3	32	3.5-5.2
Humus-mineralizing microorganisms, CFU g^{-1} soil*10^6	2.5	2.9	2.7	7	2.2-3.2	4.6	15.5	9.6	32	7.8-11.4
Actinomycetes, CFU g^{-1} soil*10^6	1.4	1.8	1.6	13	1.1-2.1	1.4	4.1	2.8	30	2.3-3.2
Fungi, CFUg^{-1} soil*10^3	54.6	65.4	60.0	9	45.6-72.4	21.0	39.0	30.2	19	26.9-33.5
Azotobacter gen., CFUg^{-1} soil	10.0	12.4	11.2	11	8.2-14.2	13.0	253.0	91.6	56	64.8-138.4
Enzyme activity (n=3-34)										
Urease, mg NH_3 10 g $^{-1}$soil 24 h^{-1}	7.5	9.7	8.6	13	5.9-11.3	1.4	5.1	3.1	43	2.1-4.1
Catalase, cm^3 O_2 g^{-1} soil min^{-1}	5.6	5.8	5.7	2	5.3-5.9	1.4	5.2	2.7	41	2.1-3.3
Dehydrogenase, mg TPF 10g^{-1} soil 24h^{-1}	2.13	2.50	2.31	8	1.85-2.77	0.75	2.63	1.47	43	1.23-1.71
Polyphenoloxidase, mg 1,4-p-benzoquinone 10 g^{-1} soil 30 min^{-1}	5.0	6.0	5.5	9	4.3-6.7	2.0	7.0	3.9	34	3.4-4.4
Peroxidase, mg 1,4-p-benzoquinone 10 g^{-1} soil 30 min^{-1}	35.0	37.0	36.0	33	33.5-38.5	15.0	37.0	28.7	19	26.8-30.6

In the arable chernozem the base mass of microbes is concentrated in 0-40 cm layer. Arable soils are characterized by the gradual decrease of biomass with the depth as compared to soils of natural ecosystems.

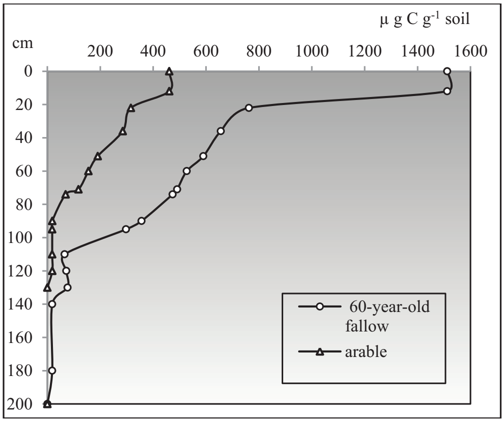

Figure 1. The profile distribution of microbial biomass in the leached chernozem in conditions of fallow and arable land

More intensive land-use involving of soil tillage stimulates the microbial decomposition of organic matter and tends to result in decrease in humus content in the arable chernozem. The soil layer of 0-10 cm is exposed by the highest mineralization. The humus content in 0-30 cm layer constitutes in average 4.05 % in the soil under fallow and 3.42 % in the arable soil (Table 2).

Table 2. Humus content* in the leached chernozem under different land management (%)

Depth, cm	Fallow land	Arable land
0-10	5.44	3.46
10-20	3.55	3.52
20-30	3.16	3.27
0-30	4.05	3.42

* mean values (n=10 for each layer)

Evolution of microorganisms and humus status in the arable leached chernozem. The current state of microbial community in arable leached chernozems is characterized by a decline of abundance compared to the level registered in 1960s (Figures 2, 3). The biological degradation of arable soils is interconnected with the dehumification processes, compaction and destruction of soil structure. A major reason for the deterioration of soil biological properties and for the decline of humus content under arable agriculture is annual tillage, which aerates soil, inevitably increases its oxygen content and breaks up aggregates where microbes are living. The selection process of species that can survive in conditions of a lower organic matter content and deterioration of physicochemical parameters of soil systems is taking place among the microorganisms.

A characteristic feature of long-term dynamics of arable leached chernozems is a significant decrease in the number of heterotrophic bacteria and fungi (Figures 2, 3). The time trend of the heterotrophic bacteria and fungi is described by polynomial function and reveals the moderate link ($R^2 = 0.67$ and 0.64).

The content of actinomycetes in soil, on the contrary, increases over time, which indirectly indicates the growing mineralization processes (Figure 4). The time trend is described by polynomial function and shows the moderate link ($R^2 = 0.48$).

During the 52 years of the utilization of arable leached chernozems the humus content decreased on average by 23.6% from its initial level. Annual losses due to mineralization processes account for 0.019%. Mineralization processes are dominated in soils, which are degraded as a result of long-term arable use. The growth of humus-mineralizing microorganisms has been noticed (Figure 5).

The database of humus-mineralizing microorganisms and the humus content was processed separately by the correlation and regression analysis during periods of observations. Regression equations with the highest correlation coefficients were chosen from all of the regression equations.

Humus-mineralizing microorganisms' trend is described by the power function. Trend has the moderate correlation coefficient: 0.59.

Trend of the humus content is described by the polynomial function. Correlation coefficient constitutes 0.88. These results indicate that the humus content was closely linked to the content of humus-mineralizing microorganisms in soil. The intensification of mineralization processes in arable leached chernozems leads to a steady decline in humus content and reserves.

The temporary long-term variability of the enzymatic complex of arable leached chernozems managed to trace to catalase activity (Figure 6). Soil has lost 68% of its catalase activity in comparison with initial level as a result of 52 years of arable use. Trend has the moderate correlation coefficient: 0.64. The time trend is described by logarithmic function.

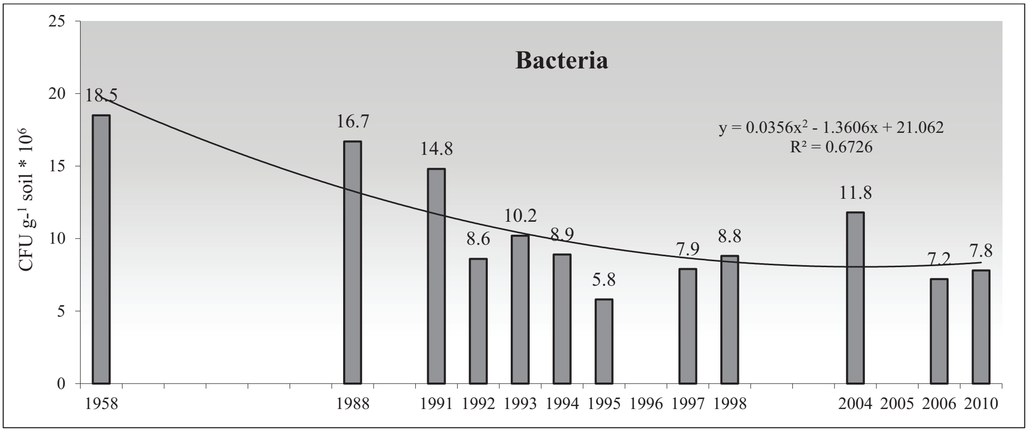

Figure 2. Dynamics of the bacteria's content in the arable leached chernozem

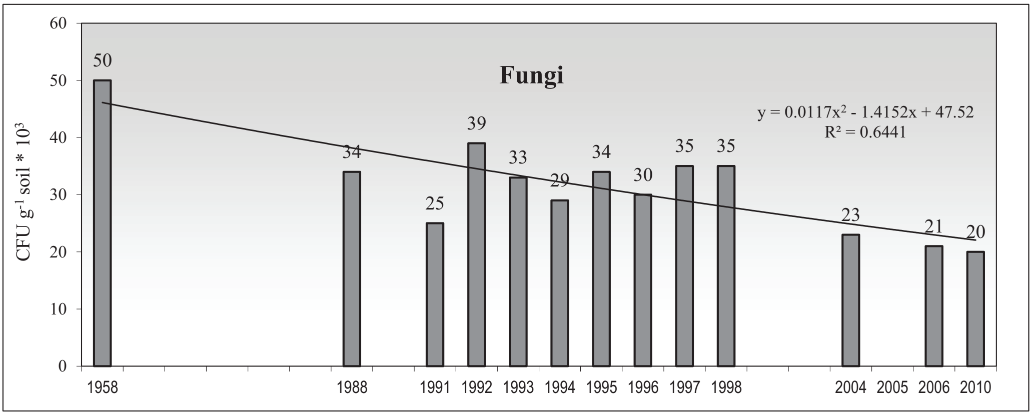

Figure 3. Dynamics of the fungi's content in the arable leached chernozem

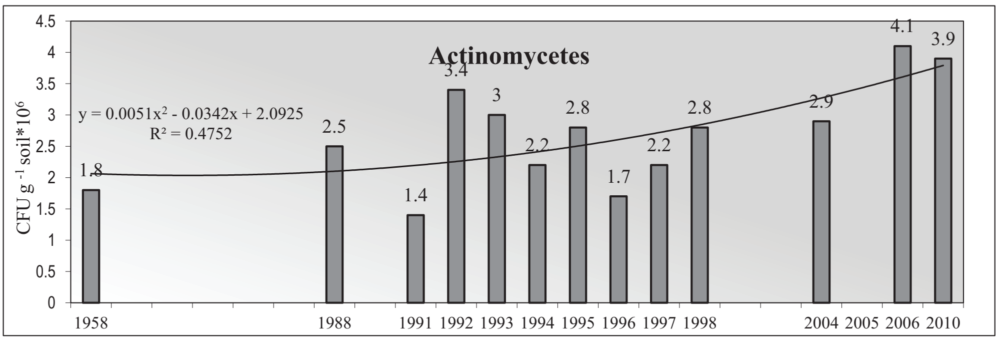

Figure 4. Dynamics of the actinomycetes content in the arable leached chernozem

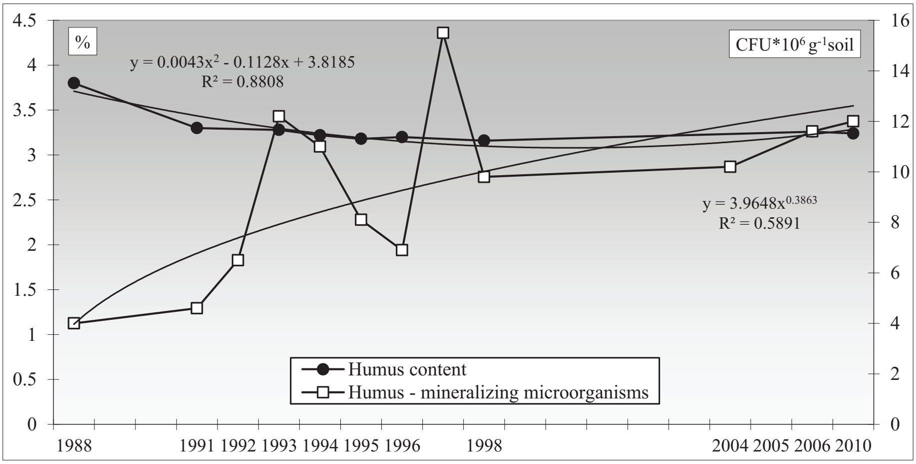

Figure 5. Dynamics of the humus and humus-mineralizing microorganisms' content in the arable leached chernozem

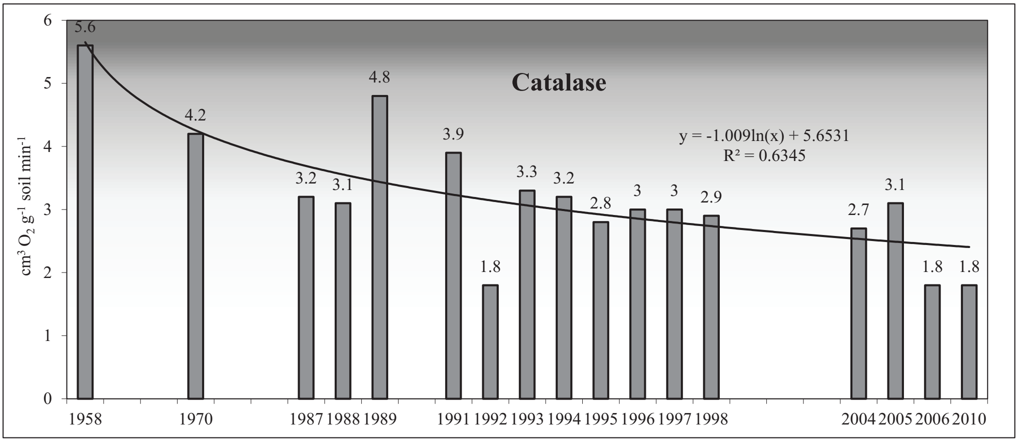

Figure 6. Dynamics of the catalase activity in the arable leached chernozem

Biota in conditions of mineral fertilizers application. Leached chernozem has changed its quality after prolonged cessation of inorganic fertilizers and that was reflected in all its properties. The soil acidification has been observed, as evidenced by decrease in pH from 6.7-6.8 in control plot to 6.3-6.5 in plot with $N_{90\text{-}300}P_{60}K_{60}$. Hydrolytic acidity raised significantly with the increase of doses of mineral fertilizers, in average from 2.7 me 100 g^{-1} soil in the control to 4.7 me 100 g^{-1} soil in the plot with $N_{90\text{-}300}P_{60}K_{60}$. Mineral fertilizers are one of the main factors that regulate the activity of soil biota. The abundance and activity of soil biota are determined by doses of fertilizers. Prolonged use of moderate doses of fertilizers ($N_{60}P_{60}K_{60}$) on the leached chernozem does not significantly impair ecological equilibrium and changes in majority of faunal and microbiological parameters are in the range of the soil system homeostasis and can be classified as reversible.

The long-term use of high doses of fertilizers ($N_{90\text{-}300}P_{60}K_{60}$) leads to the inhibition of invertebrates in the leached chernozem. The total number decreased by 1.9 times and biomass – by 2.1 times, mainly due to reduction in 4-5 times the amount of saprophagous (Table 3). The widespread occurrence phytophagous' larvae of *Melolontha melolontha* have been observed. The diversity of soil fauna, especially species of the *Lumbricidae* and *Enchytraeidae* families is significantly reduced. The largest part of soil fauna (75%) and all *Lumbricidae* fam. (100%) are concentrated in the 20-40 cm layer. The profile distribution of *Lumbricidae* fam. representatives exhibits a peak family activity in a layer of 30-40 cm in contrast to controls where their maximum number has been registered in slightly higher profile – in 20-30 cm layer. Thus, migration of earthworms to subsoil layers is typical for leached chernozems which were fertilized by $N_{90-300}P_{60}K_{60}$ for a long time.

Table 3. Influence of the long-term application of mineral fertilizers on invertebrates in the leached chernozem

Variant	Number of invertebrates, ex m^{-2}		Biomass of invertebrates, g m^{-2}	
	total	*Lumbricidae* fam.	total	*Lumbricidae* fam.
Control	168.0 ± 58.8	108.0 ± 22.0	13.2 ± 5.2	8.3 ± 3.5
$N_{60}P_{60}K_{60}$	152.0 ± 29.4	40.0 ± 29.4	16.6 ± 4.8	9.1 ± 6.8
$N_{90-300}P_{60}K_{60}$	88.0 ± 44.1	44.0 ± 7.4	6.4 ± 1.5	4.7 ± 0.9

The share of fungi in the microbial community increased, the number of species phytotoxic grew by 23-33%. The ratio between hydrolytic and redox enzymes has been broken. Polyphenoloxidase and dehydrogenase activeties significantly inhibited (1.7-2.1 times) as a result of the prolonged application of mineral fertilizers in high doses (Figure 7).

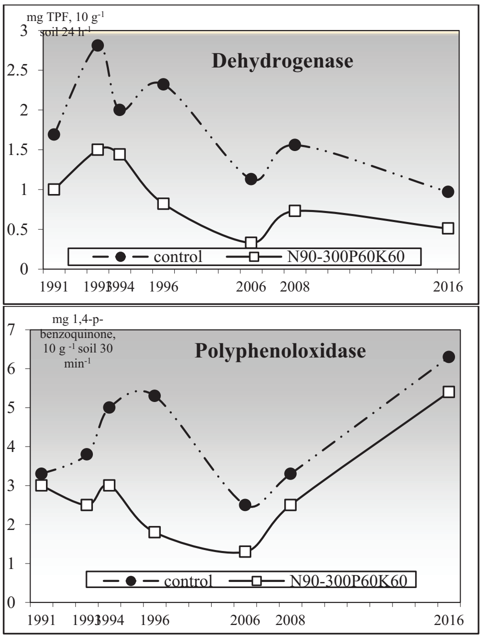

Figure 7. Dynamics of enzyme activities of the arable leached chernozem in the long-term application of mineral fertilizers in high doses

The inhibition becomes irreversible, as evidenced by long-term dynamics of the activity of these enzymes.

Enzyme activities were lower than the optimum level, providing the soil system stability. Negative shifts in the state of enzymes were accompanied by an increase in the soil acidity, disturbance in the humification–mineralization equilibrium and by soil degradation in the whole. Enzyme activities under mineral system with maximum doses were suppressed even in 10 years after the cessation of inorganic fertilizers use. The use of high doses of nitrogen fertilizers has a long after-effect and persists for some indicators on the organic fertilizers backgrounds.

Restoration of biota in leached chernozem by using organic amendments. The process of natural recovery of the soil biota composition and activity in soil with the mineral fertilizers after-effect has been determined as slow. The biomass of biota is restored quicker, its diversity and enzymatic activity – to a lesser extent (Senicovscaia, 2012).

The organic farming system with a long-term application of 60 t ha^{-1} of manure (once a crop rotation) and incorporation of crop residues returns the organic matter to the soil and creates conditions for carbon sink. This can be important in the light of the mitigation of carbon losses, the compensation of the CO_2 emissions by soils and in maintaining the soil microorganisms' nutrition.

According to statistical parameters the content of microbial biomass in leached chernozem increases by 1.5 times, dehydrogenase activity raises from 1.47 to 1.99 mg TPF 10 g^{-1} soil 24 h^{-1}. A similar trend was evident in catalase, polyphenoloxidase and peroxidase activities (Figure 8).

The humus content level was higher under application of organic fertilizers by 0.25%. The manure application with plant residues additives and $N_{60}P_{60}K_{60}$ restores the biota of old arable leached chernozem to the homeostasis zone. The decline of humus-mineralizing microorganisms and the activation of enzymes have been registered. However, the use of this technique on the soil, where were introduced higher doses of mineral fertilizers ($N_{90-300}P_{60}K_{60}$) had a softening effect only.

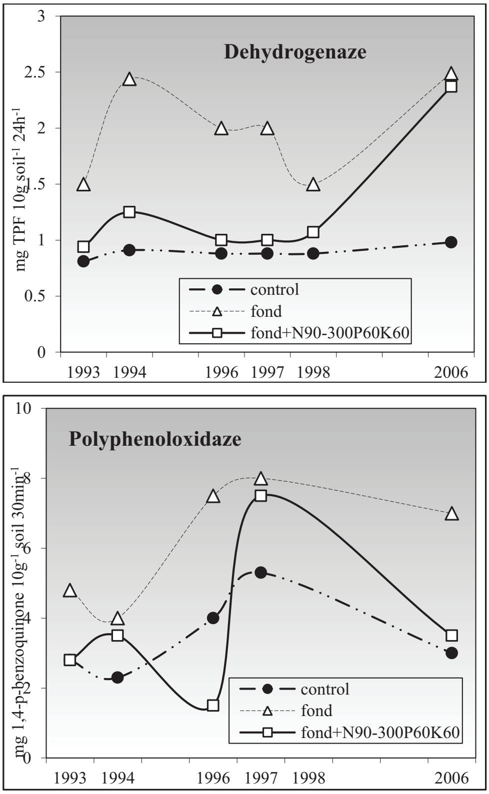

Figure 8. Dynamics of enzyme activities of the arable leached chernozem in the long-term application of organic and mineral fertilizers in high doses

Thus, the organic farming system greatly improves the enzymatic status and fertility of arable leached chernozem, but areas with high doses of inorganic fertilizers require the more radical recovery techniques of soil biota.

CONCLUSIONS

The evolution of biota in the old-arable leached chernozem is characterized by the significant reduction in its number, biomass, activity and diversity in comparison with the level of 1960s and with soil's standards that are in conditions of natural ecosystems. Time trends are described by the polynomial, power and logarithmic function with moderate and high correlation coefficients.

The values of most soil biological indices decrease in the sequence: 60 years-old fallow land → arable land under organic system with farming manure and incorporation of crop residues → arable unfertilized land → arable land with mineral fertilization of N_{90-300}.

Biological indices of investigated chernozems are characterized by the medium and considerable variability. The level and size of homeostasis zones and therefore the biota stability reached the maximum levels in the old fallow soil.

The negative effects on biota and humus status have been observed as a result of the long-term land management practices without organic fertilizers. Annual losses due to mineralization processes constitute 0.019%.

The long-term use of high doses of fertilizers ($N_{90-300}P_{60}K_{60}$) alters the habitat of soil biota. The soil changes its quality that leads to the inhibition of biota in leached chernozem.

Management of old-arable chernozems with the use of organic fertilizers and crop residues contributes to the restoration of biota. However, its parameters do not reach the level of the soil under old fallow.

REFERENCES

Andriesh S., Lungu V., Leah N., 2014. Long-term field experiments as a foundation for conserving and enhancing soil fertility. Soil as World Heritage (Ed. David Dent), Springer Science + Business Media Dordrecht, p. 201-207.

Arinushkina E.V., 1970. Guide for chemical analysis of soils. MGU, Moscow.

Blagodatsky S.A., Blagodatskaya E.V., Gorbenko A.J., Panikov N.S., 1987. Rehydration method for the determining of the microbial biomass in the soil. Pochvovedenie, Moscow, 4: p. 64-71.

Boincean B. Ecological restructuring of agriculture in the Republic of Moldova, 2013. In: "Chernozems of Moldova - evolution, protection and restoration of their fertility". Kishinev, p. 81-85.

Boincean B.P., 1999. Organic agriculture in the Republic of Moldova (crop rotation and soil organic matter). Stiinta, Chisinau.

Galstyan A. Sh., 1978. Determination of soil enzyme activity (methodical instructions). Yerevan: B.p.

Gilyarov M.S., Striganova B.R. (Ed.), 1987. Quantitative methods in soil zoology. Nauka, Moscow.

Haziev F.H., 2005. Methods of soil enzymology. Russian Academy of Sciences, Ufa.

Karyagina L.A., Mikhailovskaya N.A., 1986, Determination of polyphenoloxidase and peroxidase activities in the soil. Journal of the Academy of Sciences of BSSR, 2: p. 40- 41.

Senicovscaia Irina, 2012. Biota of degraded soils and methods for its restoration. AGROLIFE, scientific journal, volume 1, Bucharest, Romania, p. 78-83.

Zvyagintsev D.G. (Ed.), 1991. Methods of soil microbiology and biochemistry. MSU, Moscow.

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INFLUENCE OF SOIL TILLAGE SYSTEM ON WEEDING, PRODUCTION AND SEVERAL PHYSIOLOGICAL CHARACTERISTICS OF PEA CROP

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Abstract

Pea is a plant sensitive to weeding, during the first stages of vegetation, with a high risk of losing the production should an integrated plan of controlling weeding is missing. The production obtained depends on one hand on the soil characteristics and the microclimate in the area, but also on the tillage system applied, the biological material used and its capacity to adapt, including recent climate changes. Thermal stress and high temperatures affect the physiological and biochemical processes from the plants, their research being necessary in relation to the technology applied. The paper presents the influence of the soil tillage system (conventional and minimum tillage) and of the experimental years 2015-2016 (differentiated as climate conditions) upon the degree of weeding, physiological characteristics and production of the pea crop. After having applied the two soil tillage systems, a number of 12 species of weeds was determined, and the annual dicotyledonous weeds are the biggest weeding source. The application of the minimum tillage system leads to a smaller production by 88 kg/ha, representing 97.7% of the conventional system, in the case of main production and 1643 kg/ha (79%) in the secondary production. The determination made upon pea plants and upon the most important crop weeds (Chenopodium album and Xanthium strumarium) led to different results for each physiological parameter. When applying the minimum tillage system, the values of the physiological parameters were lower for the pea crop and higher for Chenopodium album and Xantium strumarium than the values recorded in conventional soil tillage system. The CO_2 assimilation rate was 17.89 $\mu mol.m^{-2}s^{-1}$ at the conventional system and 16.15 $\mu mol.m^{-2}s^{-1}$ at the minimum tillage system, and the average efficiency values of using water in photosynthesis were 3.32 $\mu mol\ mol^{-1}$ at the conventional system and 2.77 $\mu mol.mol^{-1}$ at the minimum tillage system.

***Key words**: soil tillage, weeding, physiological parameters, production, pea.*

INTRODUCTION

Pea has several characteristics and useful advantages for its introduction in agricultural crop rotations: it is a plant tolerant to different environment conditions; it is suitable for different types of soil; as it is a vegetable, it can fix atmospheric nitrogen into the soil; it has a short period of vegetation. Due to the reduced competition capacity with weeds, especially during the first development stages, pea has a high risk of losing the production upon weeding (Karkanis et al., 2016).
Weeds affect efficiency but also the quality of the production obtained, pea is sensitive to weeding during the whole period of vegetation (Patel et al., 2003). Thus, ensuring constant and quality productions supposes adequate control of weeds. Physical and mechanical control of weeds from pea crops has certain specific limitations (Khan et al., 2004). The use of herbicides can be a useful alternative in fighting weeds by eliminating hoeing and necessary working time and it is essential in the case of conservative systems, with minimum tillage and no-tillage. The chemical strategies of fighting weeds may comprise herbicides with pre-emergent and post-emergent application.
The production obtained depends on one hand on the soil characteristics and microclimate in the area, but also on the technological system applied, crop rotations, fighting diseases, weeds and pests, biological material used and the fertilization level (Dobre et al., 2008; Rusu, 2014). The production differences by applying different soil tillage systems results from choosing the best variant for certain pedo-climate conditions (Rusu et al., 1999; Gus et al., 1995). The application of the minimum tillage system at pea crop, under the conditions from the Transylvanian Plain determined a production 204 kg/ha smaller compared to the

conventional system (Simon and Rusu, 2016). The research of the conservative soil tillage systems targets both nationally and internationally, both productivity aspects, water preserve, carbon management etc., but also aspects related to physiological and biochemical processes in plants, in relation to the technology applied (Liu et al., 2016).

Global climate changes are determined by the increase of CO_2 level in the atmosphere. The CO_2 concentration grew from 280 ppm in 1950 up to 385 ppm now (by approximately 38%) (IPCC, 2014). Adapting to climate changes supposes the creation of new vegetal genotypes with large ecological plasticity to ensure: crop stability; long resistance against the attack of pathogen agents, pests, weeds; improved quality by high content of active biological substances, valuable for the nutrition and health of animals and humans.

Thermal stress and high temperatures affect the physiological and biochemical processes in plants: they accelerate the ongoing of phenological phases; the vegetation period is shortened; leaf surface and radiation are reduced; reduction of biomass; decrease of growth of terminal roots (T> 35°C), which have a higher sensitivity compared to the air part to daily temperature fluctuations; production is affected more by short episodes of really high temperatures than by the average growth of temperature in the area (Yeboah et al., 2016).

The paper presents the results of the researches made under the conditions from the Agricultural Research and Development Station Turda (ARDS Turda), situated in the Transylvanian Plain, the influence of the soil tillage system upon weeding, the production and certain physiological characteristics at pea crop.

MATERIALS AND METHODS

The researches were made during 2015-2016, on a vertic Phaeozem type of soil (SRTS, 2012), with neutral pH, clayey-loamy texture, average humus content, good supply of mobile phosphorus and potassium.

Pea was sowed in the third decade of March, with a quantity of 100 seeds per 1 m^2, with a distance among lines of 18 cm, with Gaspardo Directa 400 sower.

The experimental factors were:

Factor A - The soil tillage system:

a_1- The conventional tillage system (CS) which includes plowing 25 cm deep after the harvest of the preceding crop and the soil processing with rotary harrow before sowing;

a_2-The minimum tillage system (MT) with chisel 30 cm deep after the harvest of the preceding crop and the soil processing with rotary harrow before sowing.

Factor B - experimental years: b_1-2015, b_2-2016.

The biological material was an afila pea genotype: Tudor. The pea was cultivated on a 3 year rotation crop system, the preceding plant was winter wheat.

After sowing a pre-emergent herbicidation was done with Gliphosate (4 l/ha) in all three systems. The control of monocotyledonous and dicotyledonous weeds per vegetation was done with Tender (1.5 l/ha), Pulsar (1.0 l/ha) and Agil (1.0 l/ha) herbicides in the rosette phenophase of dicotyledonous weeds and 3-4 leaves at monocotyledonous.

For the protection of pea crops against pests, in the stage of beginning of blooming, a treatment with the insecticide Calypso (0.1 l/ha) was made and ten days after blooming the treatment was repeated.

The determination of the number of weeds was made by using the meter frame ($0.25m^2$) before the harvest of the pea crop.

For the determination of physiological parameters CIRAS-3 leaf gas analyzer was used, which determines several physiological and environment indicators, the method is non-destructive for the plants. The determinations were made both for plants and for weeds during blooming-formation of pea pods and an average of these determinations was made. The results obtained were statistically processed by the method of analyzing the variant and establishing the limit differences (DL, 5%, 1% and 0.1%) (PoliFact, 2015).

The climate conditions during 2015 and 2016 are presented in table 1. The average of multi-annual temperatures during the last 60 years was 9^0C and the sum of rainfall was 520.6 mm. The average of temperatures recorded in the vegetation period at pea crop during the two research years (2015-2016) is higher than the multiannual average by 1.1^0C in 2015 and by 1.2^0C in 2016, being considered warm years.

The sum of rainfall was lower in the first trimester of 2015, pea reacting negatively to the spring drought; in 2016 rainfall was higher than the multiannual average, being considered a very rainy year. Although in 2015 rainfall was higher than the multiannual average, its absence in the best moments for the formation of the production (blooming-pod formation) resulted in the decrease of the production. In 2016 temperatures and rainfall recorded were beneficial for the pea crop, the productions obtained are the result of interaction among favourable climate conditions.

Table 1. Thermal and rainfall regime during the vegetation period of pea crop,Turda 2015-2016

Year		Month					Average/sum
		March	April	May	June	July	
Air temperature (^{0}C)	2015	5.5	9.6	15.8	19.4	22.3	14.5
	2016	5.9	12.4	14.3	19.8	20.5	14.6
	Average 60 years	4.5	9.9	15.0	17.8	19.7	13.4
Rainfall (mm)	2015	12.8	32.2	66.0	115.7	52.2	278.9
	2016	47	62.2	90.4	123.2	124.9	89.5
	Average 60 years	19.3	44.4	67.1	83.4	72.9	57.4

RESULTS AND DISCUSSIONS

In the experimental years 2015 and 2016 after having applied the two soil tillage systems (conventional and minimum tillage), 12 species of weeds were determined (Table 2); the biggest number is determined in 2016; their number is influenced by the favourable environment conditions. Out of the total of species recorded, only 3 species were found in the two years and in the two soil tillage systems, these weeds: *Chenopodium album, Setaria glauca, Xanthium strumarium,* are considered problem weeds on the fields from ARDS Turda, as they are hard to fight in the vegetable crops, especially in the case of minimum tillage systems.

The new environment conditions created by the conservative soil tillage technologies determines the change almost entirely of the weed spectrum, the species adapted to loosening soils are replaced by the species adaptd to more compact soils (Dobre et al., 2008).

The number of weeds from the pea crop was higher in 2016 when the quantity of water in the soil was bigger and the weed seeds germinated better than in 2015; the lack of water from the soil influenced negatively the number of growing weeds (Simon et al., 2016); the differences appear also in the case of tillage systems (Tabel 3); the number of pea plants is bigger in the conventional system, the field was better covered and the weeds couldn't develop like in the minimum tillage system. The annual dicotyledonous weeds are the biggest weeding source, the greatest number of weeds (9) is determined in 2016 in the minimum tillage system.

Cultivators who take into account the introduction of pea into crop rotation should develop a plan of integrated management of peas, which should take into account the entire life cycle of crops from sowing until after harvest. Proceeding thus, they must take advantage of the cultural, physical and chemical practices in order to reduce the spreading and effect of weeds (Menalled, 2012), the efficient fighting of weeds from agricultural crops being a significant factor of production.

The application of minimum tillage leads to a significant decrease of production of over 88 kg/ha (Table 4), the difference representing 97.7% from the one of the conventional system, in the case of main production and over 1643 kg/ha (79%) in the secondary production. From the experiences made by Marin and colab. (2015) during 2008-2010, at Moara Domnească, it results that in the variants worked with the chisel were obtained productions which represent 98.2-98.5% from the one of the conventional variant.

The climate conditions in the two experimental years (Table 5) influenced differently the grain production, the difference of 2622 kg/ha registered in 2016 being considered as very important compared to the production registered in 2015, when only 2401 kg/ha were obtained. The secondary production was also influenced by the climate conditions, the difference of 3963 kg/ha between the two years being very significant in favour of 2016.

Table 2. Number of weeds/m^2 determined before the harvest of the pea crop

No.	Species of weeds	Conventional system		Minimum tillage	
		2015	2016	2015	2016
1	*Agropyron repens*	-	1	-	-
2	*Amaranthus lividus*	-	1	-	-
3	*Chenopodium album*	1	2	2	2
4	*Echinochloa crus-galli*	-	-	1	-
5	*Hibiscus trionum*	-	-	-	1
6	*Polygonum convolvulus*	-	1	-	-
7	*Rubus caesius*	1	-	-	-
8	*Setaria glauca*	1	1	2	1
9	*Silene noctiflora*	-	1	-	1
10	*Sinapis arvensis*	-	1	-	-
11	*Sonchus asper*	1	-	-	-
12	*Xanthium strumarium*	1	1	2	5
Total, weeds / m^2		5	9	7	10

Table 3. Weeding of the pea crop, Turda 2015-2016

Tillage system	Year	Annual Dicotyledonous	Perrenial Dicotyledonous	Annual Monocotyledonous	Perrenial Monocotyledonous
		No. weeds/m^2	No. weeds /m^2	No. weeds /m^2	No. weeds /m^2
Conventional system	2015	3	1	1	-
	2016	7	-	1	1
Total		10	1	2	1
Minimum tillage	2015	2	-	3	-
	2016	9	-	1	-
Total		11	-	4	-

The determinations made with CIRAS-3 leaf analyzer upon pea plants and the most important weeds from the crop (*Chenopodium album* and *Xanthium strumarium)* led to different results for each physiological parameter.

The intensity of photosynthesis decreases during the reproductive phase, the leaf surface is limited and production suffers significant depreciations due to the hydric stress from the vegetation period of pea crop. The quantity of reserve substances stored in seeds is determined by the efficiency of the photosynthesis process, respectively by the absorption capacity of active photosynthethic radiations.

The climate differences in the two years influence very much the CO_2 assimilation rate for the three plants studied, the highest values are recorded for *Chenopodium album*; the structure of this plant being the element which determines the increase of these values compared to pea, which has a shorter leaf surface.

In the minimum tillage system, the CO_2 assimilation rate is lower in the case of the pea crop than the one from the conventional system, being in direct report with the secondary production; the situation is comparable with the two species of weeds where the assimilation rate is higher in the minimum tillage system (where the leaf surface is also bigger than in the conventional system).

One can notice from table 7 that the average value of the CO_2 concentration from the stomatal cavity is a physiological parameter determined by the favourable environmenmt conditions in 2016. For all three plants studied the CO_2 concentration is bigger, the difference compared to 2015 is very significant. When applying the minimum tillage system, a slow increase of the value of CO_2 concentration at pea crop can be noticed, and in the case of the two plants *Chenopodium album* and *Xanthium strumarium,* the difference compared to the conventional system is distinctly significant.

A big number of weeds can reduce a lot the production being in direct competition for light, moisture and nutrients, also weeds from the crop are an important source of disease and pests.

In 2016 the water reserve was higher than in 2015, as it results from table 8, in the photosynthesis process water is used more efficiently; the difference of average values registered in the two years studied is very significant for all three plants studied.

The more developed radicular and leaf system of *Xanthium strumarium* plants from the minimum tillage system determined an important increase of the efficiency to use water in photosynthesis (WUE) compared to the ones from the conventional system. Pea plants used water more efficiently in the photosynthesis process if they were cultivated in the conventional system, the difference compared to the minimum tillage system is very important.

The intensity of the breathing process and of fixing nitrogen depend on temperature and moisture, thus at high tempratures and relatively low moisture, photosynthesis is reduced and the process of transpiration at leaf level is reduced. From table 9 one can observe that in 2016 the transpiration rate was higher than in 2015 both for the pea crop and for the weeds in the crop. In the conventional system the values of the determinations made for *Chenopodium album* and *Xanthium strumarium* were significantly lower than the ones from the minimum tillage system, and in the case of pea the values were higher in the conventional system, the difference is not statistically ensured.

Table 4. Influence of the soil tillage system upon the pea production, Turda 2015-2016

Soil tillage system	Main production		Secondary production	
	Production (kg/ha)	Dif. ±	Production (kg/ha)	Dif. ±
Conventional system	3756	-	7824	-
Minimum tillage	3668^{00}	- 88	6181^{000}	-1643
DL (p 5%)	40		324	
DL (p 1%)	73		596	
DL (p 0.1%)	163		1320	

Table 5. Influence of experimental years upon the pea production, Turda 2015-2016

Experimental year	Main production		Secondary production	
	Production (kg/ha)	Dif. ±	Production (kg/ha)	Dif. ±
2015	2401	-	5021	-
2016	5023***	+ 2622	8984***	+ 3963
DL (p 5%)	81		110	
DL (p 1%)	123		166	
DL (p 0.1%)	197		266	

Table 6. Influence of experimental factors upon the average values of CO_2 assimilation rate

Experimental factor	Pea		*Chenopodium album*		*Xanthium strumarium*	
	Assimilation ($\mu molm^{-2}s^{-1}$)	Dif. ±	Assimilation ($\mu molm^{-2}s^{-1}$)	Dif. ±	Assimilation ($\mu molm^{-2}s^{-1}$)	Dif. ±
Soil tillage system						
Conventional system	17.89	-	20.16	-	18.63	-
Minimum tillage	16.15^{000}	-1.74	24.75***	+4.59	19.61*	+0.99
DL (p 5%)	0.23		0.85		0.87	
DL (p 1%)	0.42		1.56		1.61	
DL (p 0.1%)	0.93		3.46		3.56	
Experimental year						
2015	16.38	-	20.60	-	15.58	-
2016	17.66***	+1.29	24.31**	+3.71	22.66***	+7.09
DL (p 5%)	0.22		2.04		0.46	
DL (p 1%)	0.33		3.09		0.70	
DL (p 0.1%)	0.53		4.96		1.12	

Table 7. Influence of experimental factors upon the average values of CO_2 concentration of substomatal cavity

Experimental factor	Pea				*Xanthium strumarium*	
	CO_2 concentration (mmol $m^{-2}s^{-1}$)	Dif. ±	CO_2 concentration (mmol $m^{-2}s^{-1}$)	Dif.±	CO_2 concentration (mmol $m^{-2}s^{-1}$)	Dif. ±
Soil tillage system						
Conventional system	298.3	-	286.8	-	348.1	-
Minimum tillage	307.3	+9	305.3**	+18.5	363.78**	+15.6
DL (p 5%)	15.17		5.95		6.79	
DL (p 1%)	27.88		10.93		12.47	
DL (p 0.1%)	61.78		24.21		27.62	
Experimental year						
2015	290.9	-	280.1	-	344.9	-
2016	314.9***	+24	311.9**	+31.8	367.0***	+22.1
DL (p 5%)	8.72		20.11		5.23	
DL (p 1%)	13.20		30.46		7.92	
DL (p 0.1%)	21.20		48.93		12.72	

Table 8. Influence of experimental factors upon the average values of efficiency of using water in photosynthesis (WUE)

Experimental factor	Pea		*Chenopodium album*		*Xanthium strumarium*	
	WUE (µmol mol^{-1})	Dif.±	WUE (µmol mol^{-1})	Dif.±	WUE (µmol mol^{-1})	Dif.±
Soil tillage system						
Conventional system	3.32	-	4.07	-	1.67	-
Minimum tillage	2.77^{000}	-0.55	4.39	+0.32	1.92**	+0.25
DL (p 5%)	0.07		0.37		0.14	
DL (p 1%)	0.12		0.68		0.25	
DL (p 0.1%)	0.27		1.51		0.55	
Experimental year						
2015	2.17	-	3.67	-	1.08	-
2016	3.92***	+1.75	4.79***	+1.12	2.51***	+1.43
DL (p 5%)	0.04		0.25		0.07	
DL (p 1%)	0.06		0.38		0.10	
DL (p 0.1%)	0.10		0.62		0.16	

Table 9. Influence of experimental factors upon the average values of transpiration rate at leaf level (E)

Experimental factor	Pea		*Chenopodium album*		*Xantium strumarium*	
	Transpiration (mmol $m^{-2}s^{-1}$)	Dif.±	Transpiration (mmol $m^{-2}s^{-1}$)	Dif.±	Transpiration (mmol $m^{-2}s^{-1}$)	Dif. ±
Soil tillage system						
Conventional system	4.80	-	6.15	-	7.91	-
Minimum tillage	4.73	-0.08	6.59*	+0.44	8.18*	+0.26
DL (p 5%)	0.25		0.29		0.19	
DL (p 1%)	0.45		0.52		0.34	
DL (p 0.1%)	1.01		1.16		0.76	
Experimental year						
2015	3.93	-	5.69	-	7.84	-
2016	5.60***	+1.68	7.05***	+1.36	8.25***	+0.41
DL (p 5%)	0.12		0.17		0.06	
DL (p 1%)	0.18		0.26		0.09	
DL (p 0.1%)	0.29		0.42		0.14	

CONCLUSIONS

In the experimental years 2015 and 2016 after having applied the two soil tillage systems 12 species of weeds were determined, the biggest number is determined in 2016, their number is influenced by the favourable environment conditions. Out of the total of species recorded, only 3 species (*Chenopodium album, Setaria glauca, Xanthium strumarium)* were found in the two years and in the two soil tillage systems.

The application of minimum tillage systems at pea crop leads to a drop in production, representing 97.7% from the one of the conventional system, in the case of main production and 79% in secondary production.

The climate conditions in the two experimental years influenced differently the production: in 2016 were 2622 kg/ha more than in 2015; the difference is very significant compared to 2015 when 2401 kg/ha were obtained in the main production; in the secondary production the difference of 3963 kg/ha between the two years is very significant in favour of 2016.

The values of the physiological parameters determined in the 2 years were significantly higher in 2016 compared to 2015 both for the pea crop and for the species of weeds, as the climate conditions in this year were favourable for the development of plants.

When applying the minimum tillage system, the values of the physiological parameters were lower for the pea crop and higher for *Chenopodium album* and *Xanthium strumarium* than the values recorded in the conventional soil tillage system.

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REFERENCES

Dobre M., Berechescu C., Susinscki M., Grecu F., Dodocioiu A. M., 2008.Change the spectrum of weeds in no-tillage technology.Soil Minimum Tillage Systems, Ed. Risoprint Cluj-Napoca, 104-106.

Gus P., Sebok P., Mester Al., 1995. Minimum tillage and its influences. Soil Tillage – Present and Future, Cluj-Napoca, (2): 295-300.

Karkanis A., Ntatsi G., Kontopoulou C. K., Pristeri A., Bilalis D., Savvas D., 2016. Field pea in european cropping systems: adaptability, biological nitrogen fixation and cultivation practices. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 44(2): 325-336. doi: 10.15835/nbha44210618.

Khan I.G., Hassan M.I., Khan M.I., Khan I.A., 2004. Efficacy of some new herbicidal molecules on grassy and broadleaf weeds in wheat-II. Pakistan Journal of Weed Science Research,10: 33-38.

Liu C.A., Zhang S., Hua S., Rao X., 2016. Effects of nitrogen and phosphorus fertilizer on crop yields in a field pea-spring wheat-potato rotation system with calcareous soil in semi-arid environments. Spanish Journal of Agricultural Research, 14(2): e1101. doi: 10.5424/sjar/2016142-7347.

Marin D. I., Rusu T., Mihalache M., Ilie L., Nistor E., Bolohan C., 2015. Influence of soil tillage system upon the yield and energy balance of corn and wheat crops. Agrolife Scientific Journal, 4(2): 43-47.

Menalled F., 2012. Integrated management of weeds in dry peas, agriculture and natural resources (weeds). Montana State University. http://ipm.montana.edu.

Patel M.M., Patel A.I., Patel I.C., Tikka S.B.S., Henry A., Kumar D., Singh N.B., 2003. Weed control in cowpea under rain fed conditions. In: Proceedings of the National Symposium on Arid Legumes, for Food Nutrition. Security and promotion of Trade. Advances in Arid Legumes Research. Hisar, India, 203-206.

Rusu T., Gus P., Bogdan I., Mester Al., 1999. Influence of different soil tillage systems upon the yield in the case of winter-wheat crops. In: Systems of Minimum Soil Tillage, Cluj-Napoca, 87-92.

Rusu T., 2014. Energy efficiency and soil conservation in conventional, minimum tillage and no-tillage. International Soil and Water Conservation Research, 2(4): 42-49, doi:10.1016/S2095-6339(15)30057-5.

Rusu T., Bogdan I., Marin D.I., Moraru P.I., A.I. Pop, B.M. Duda, 2015. Effect of conservation agriculture on yield and protecting environmental resources. Agrolife Scientific Journal, 4(1): 141-145.

Sımon A., Rusu T., Chetan C., 2016. Influence of soıl tıllage systems on some characterıstıcs morpho-productıve and yıeld to pea. AgroLife Scientific Journal, 5(1): 194-198.

Simon A., Rusu T., Chetan F., 2016. Influence of the tillage system on the degree of weeding in peas culture at ARDS Turda. Research Journal of Agricultural Science, 48(4): 280-287.

Yeboah S., Zhang R. Z., Cai L. Q., Song M., Li L. L., Xie J. H., Luo Z. Z., Wu J., Zhang J., 2016. Greenhouse gas emissions in a spring wheat-field pea sequence under different tillage practices in semi-arid Northwest China. Nutrient Cycling in Agroecosystems, 106(1): 77-91. doi: 10.1007/s10705-016-9790-1.

IPCC, 2014. Climate Change 2014: Synthesis Report.Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, p. 151.

PoliFact, 2015. ANOVA and Duncan's test pc program for variant analyses made for completely randomized polifactorial experiences. USAMV Cluj-Napoca.

SRTS, 2012. Romanian System of Soil Taxonomy. Ed. Estfalia, Bucharest.

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PREDICTING PLANT-AVAILABLE NITROGEN PROVIDED BY ORGANIC FERTILIZERS AND COVER CROPS USING AN ONLINE CALCULATOR

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Abstract

Satisfying crop nitrogen (N) requirements efficiently in organic agriculture requires an accurate estimate of plant-available N (PAN) release from organic inputs. PAN is the sum of the mineral N present in the organic material at the time of application, plus net N mineralized (sum of NH_4-N and NO_3-N) in soil. We verified several regression equations for accuracy in predicting PAN release from organic inputs (manures, composts, and cover crop residues) for summer vegetable crop production in the Willamette Valley of Oregon, USA. An Excel spreadsheet version of the regression equations was prepared and is distributed online as the Oregon State University (OSU) Organic Fertilizer and Cover Crop Calculator.

Using the Calculator requires the user to specify the organic input application rate, its total N concentration (dry matter basis), and whether the organic input is fresh or composted. We verified the accuracy of the Calculator equations via aerobic incubation of organic inputs in moist western Oregon soils in the laboratory (sandy loam, loam, or clay loam textures; pH 5.5 to 6.5; 20 to 25^{o}C). Fertilizer equivalency trials, where PAN from organic inputs was determined relative to PAN from mineral N fertilizers, were also used to verify Calculator predictions. Outreach publications have been developed to accompany the Calculator, in order to explain its function and to encourage farmers and farm advisors to use it.

Key words: *nitrogen, manure, compost, cover crops.*

INTRODUCTION

Organic crop production in the USA has increased in the past decade. Farmers using organic methods in USA often have no livestock (as a source of manure), so they rely on purchased organic inputs. The *OSU Organic Fertilizer and Cover Crop Calculator* (Andrews et al., 2012) was developed to assist farmers in comparing and choosing organic inputs, based on the quantity of PAN provided.

Nutrient management guidance for fertilizer use in organic crop production is usually less precise than that provided for conventional mineral fertilizer use. Often only total nitrogen analyses for organic inputs with no estimate of PAN are provided (Kuepper, 2003), or generalized PAN predictions are provided for each category of organic material (Bary et al., 2016).

Numerous regression equations that predict PAN from total N or C:N ratio of organic materials have been reported (Vigil and Kissel, 1991; Trinsoutrot et al., 2000). This paper reports data from a number of experiments that developed or verified prediction equations for use in the OSU Calculator. We chose to base the prediction equations on the total N analyses of organic inputs, instead of C:N ratio for several reasons.

First, C analyses of most organic inputs are relatively constant, while N analyses vary widely among organic materials.

Second, organic fertilizers are marketed with guaranteed N analyses, but not C analyses.

MATERIALS AND METHODS

OSU Calculator data input requirements

The OSU Calculator requires users to specify application rate, dry matter content, and total N analysis of the organic input (organic fertilizer, compost, or above-ground cover crop biomass). The Calculator assumes that for fresh organic materials, C concentration is relatively constant (near 40%), so that total N concentration is a useful indicator of C:N ratio.

Cover crop biomass sampling is often needed to obtain an accurate estimate of cover crop biomass and its N concentration (Sullivan and Andrews, 2012).

Predicting PAN from fresh (uncomposted) organic fertilizers (e.g. manure and specialty products)

For organic fertilizers, the Calculator uses linear regression equations with two time steps (28 and 70 d; Figure 1). The time steps are equivalent to approx. 600 and 1500 degree days (0 ^{o}C base temperature) after soil incorporation:

Prediction equation for PAN at 28 d after soil incorporation (Equation 1):

When fertilizer total N < 6% dry wt. basis,

% PAN = -30 + 15 (fertilizer total N%)

When fertilizer total N ≥ 6% dry wt. basis,

% PAN = 60%

Prediction equation for PAN at 70 d after soil incorporation (Equation 2):

% PAN = 28 d PAN + 15%

Prediction of PAN from Cover Crop Residues

The Calculator uses a regression equation (Vigil and Kissel, 1991) for estimating PAN after soil incorporation (Equation 3):

% PAN = -53.44 + 16.98 (cover crop %N x 10)$^{1/2}$

Prediction of PAN from compost

The Calculator does not use a regression equation to predict compost PAN (Table 1).

Table 1. Predicted PAN from compost. OSU Calculator[1]

	OSU Calculator PAN prediction	
Compost total N	28 d	70 d
% dry wt	% of total N	% of total N
Less than 1%	0	0
1-2%	0	5
2+ %	5	10

[1]PAN estimates valid only for finished composts that are biologically stable. Some organic materials marketed as "compost" do not meet this criteria (e.g. dry stacked poultry litter)

Data from field and laboratory trials did not show a strong correlation between compost total N percentage and PAN (Gale et al., 2006). We prefer to estimate first year PAN from a compost analysis that includes total C and N, and mineral N (NH_4-N and NO_3-N). Most of the first year PAN supplied by compost is present as mineral N in compost at the time of application (Gale et al., 2006). Predictions of PAN from compost are included in the OSU Calculator primarily for the purpose of demonstrating that compost is a poor choice for supplying PAN.

Determination of PAN in laboratory incubations

Laboratory incubations were used to verify the appropriateness of Calculator PAN predictions. In laboratory incubations, PAN released from the organic input was determined experimentally by difference from a soil-only control treatment:

% PAN from organic input =

(Amended - Control)/Input N x 100

where: % PAN = percentage of total input N that is recovered from soil as NO_3-N after incubation; Amended = Soil NO_3-N *with* organic input after incubation (mg/kg); Control = Soil NO_3-N *without* organic input after incubation (mg/kg); Input N = concentration of total N added to soil via organic input (organic fertilizer, compost, or cover crop; mg/kg)

Soil was analyzed for both NH_4-N and NO_3-N, but NH_4-N concentrations were always insignificant after 4 weeks of incubation. Therefore, only soil NO_3-N was used to estimate PAN for organic inputs.

RESULTS AND DISCUSSIONS

Calculator assumptions and limitations

The Calculator does not account for NH_3 that may be volatilized from organic fertilizers following field application. It also assumes that PAN is not lost via leaching or denitrification. In our field trials, PAN loss was apparently minimal, because PAN determined in lab and field were similar (Gale et al., 2006). Our field trials were conducted in summer in a Mediterranean climate under sprinkler irrigation, so leaching from the root zone was minimized. Organic fertilizers were incorporated within a few hours after application to minimize N loss via NH_3 volatilization. Our predictions are based on a soil temperature of approximately 22^{o} C. Soil temperature may not be as important in controlling the rate of N mineralization from fresh organic inputs, as it is in controlling the rate of N mineralization from soil organic matter (Hartz and Johnstone, 2006).

PAN from fresh organic materials

For fresh organic materials, we found a linear correlation between organic fertilizer total N % (dry weight basis) and PAN measured in field trials and in laboratory incubations (Figure 2;

Gale et al., 2006). We found that dry-stacked poultry litter (sold as "compost", but not actually composted) had cumulative decomposition and PAN that was similar to that of fresh organic materials (Gale et al., 2006). To evaluate PAN release from organic specialty products, we performed a 28 d laboratory incubation using fertilizers offered for sale to organic farmers in Portland, Oregon, including: seed meals, fish byproducts, and animal byproducts (Table 2). Most of the specialty products decomposed rapidly. Specialty products containing more than 6% total N released 60^{+}% PAN in 28 d. For speciality fertilizers with high N concentrations (6+% total N in DM), the amount of C lost by decomposition (% of applied C) and the amount of PAN (% of total N) was of similar magnitude.

PAN from cover crops

We verified the predictive value of the regression equation (Equation 3) published by Vigil and Kissel (1991) in cover crop incubation trials (Table 3 and Figure 3; Sullivan et al., 2011; Sullivan and Andrews, 2012) and in a field trial (Figure 4). We have the greatest amount of verification data for the Calculator prediction equation for cover crops that contain 2 to 4% N (dry weight basis).

The Calculator prediction equation for PAN worked well for single cover crop species, or for mixed cover crop species (Figure 3). The Calculator prediction equation for cover crops over-predicted PAN at 4 weeks incubation time (Table 3 and Figure 3). At 10 weeks, Calculator PAN predictions were less than or equal to the PAN measured in incubations.

Calculator PAN predictions had reasonable accuracy in a no-till field trial, where the cover crop residue decomposed on the soil surface (data not shown). PAN values for organic materials did not differ when evaluated in soils differing in texture (silt loam vs. sandy loam vs. clay loam; data not shown).

PAN from compost

Field trials and laboratory incubations showed that well-composted organic materials provided little or no PAN during the year following application (Gale et al., 2006). A few composts, derived from animal manure (no bedding) or from green, leafy crop residues, had total N percentage greater than 2%, and provided PAN. Woody composts with PAN less than 1% had negative PAN values during the first weeks after incorporation into soil. Overall, we do not recommend compost for short term supply of PAN. This recommendation is supported by other research reports (Hartz et al., 2000; Prasad, 2009). Compost should be regarded as a source of organic matter and mineral P and K for building soil reserves, not a rapidly-available N source.

Table 2. Decomposition and PAN from organic fertilizers in a 28 d aerobic incubation in Chehalis silt loam soil (fine-silty, mixed, superactive, mesic Cumulic Ultic Haploxeroll)

Fertilizer N source[1]	Fertilizer		PAN	Decomposition	
	Total N	C:N	28 d	7 d	28 d
	%		% of fertilizer N	% of fertilizer C	
seaweed extract	1	29	0	21	38
kelp meal	1	26	-6	8	14
alfalfa meal	2	17	4	32	48
ground fish bone	5	3	33	20	33
meat and bone meal	8	5	44	41	53
soybean meal	8	5	68	49	69
fish/feather/alfalfa meal	8	5	58	43	59
bone meal	9	5	58	49	59
feather meal, bone meal	9	4	63	27	54
fish meal	9	4	62	50	65
corn gluten meal	10	5	72	49	69
granulated feather meal	11	4	65	31	55
fish protein digest	12	4	64	52	61
feather meal	13	4	63	41	59
blood meal	14	4	63	39	57

[1]Organic fertilizers contained additional salts supplying other nutrients in addition to N (blended fertilizers). Fertilizers were added at rate of 300 mg total N kg^{-1} dry soil, incubated at 22° C, 250 g kg^{-1} soil moisture

Table 3. Plant-available N measured in cover crop incubations vs. PAN predicted by the OSU Calculator regression equation[1]

Cover crop N concentration	PAN measured in cover crop incubation				PAN Predicted by OSU Calculator
	2008	2009	2010	3-yr Average	
% dry wt.	.-----------------PAN (% of cover crop total N)--				
		28 d at 22° C			
2.0	13	23	15	17	22
2.5	21	30	23	25	31
3.0	30	36	31	32	40
3.5	39	43	39	40	47
		70 d at 22° C			
2.0	27	37	41	35	22
2.5	33	43	48	41	31
3.0	38	49	54	47	40
3.5	44	55	61	53	47

[1]OSU Calculator regression (Equation 3). Cover crop biomass included legumes: crimson clover (*Trifolium incarnatum*), common vetch (*Vicia sativa*), and non-legumes: cereal rye (*Secale cereale*), oats *(Avena sativa*), or phacelia (*Phacelia tanacetifolia*)

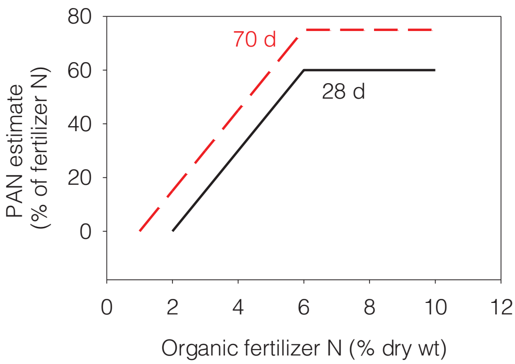

Figure 1. Regression equations implemented within the OSU Calculator for "fresh" organic materials that have not been stabilized by composting (Equations 1 and 2). The Calculator estimates PAN at approximately 28 d and 70 d following application at 22° C

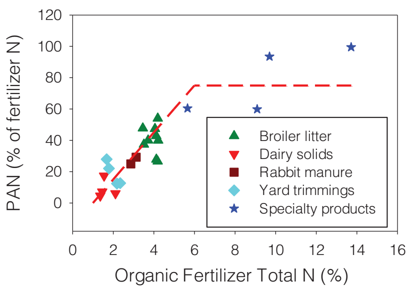

Figure 2. Plant-available N provided by fresh manures and other organic inputs in a series of four field trials. PAN determined via N fertilizer equivalency vs. urea-N (Gale et al., 2006). Dotted line is the equation chosen for implementation as 70 d predicted PAN in OSU Calculator (Equation 2)

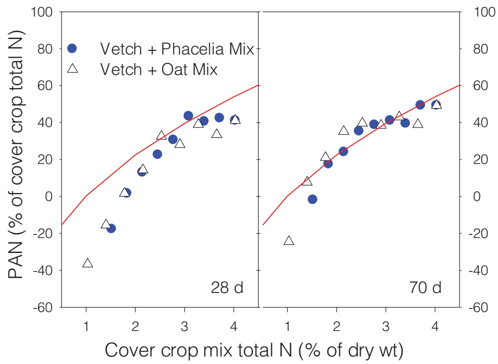

Figure 3. Plant-available N after 28 d (left) and 70 d (right) following addition of mixtures of cover crop residues to Chehalis silt loam soil (Garrett, 2009) vs. predicted PAN (solid line; Vigil and Kissel, 1991; Equation 3) in an aerobic laboratory incubation (22° C; 250 g kg^{-1} soil moisture). Cover crop total N concentrations (dry wt. basis) were 40 g kg^{-1} for vetch (*Vicia sativa*), 10 g kg^{-1} for oat (*Avena sativa*), and 15 g kg^{-1} for phacelia (*Phacelia tanacetifolia*). Cover crop mixtures were added to soil at a total dry matter rate of 5 g kg^{-1} soil, with variable proportions of vetch in the mix (0, 12, 25, 37, 50, 62, 75, 87 and 100% by weight)

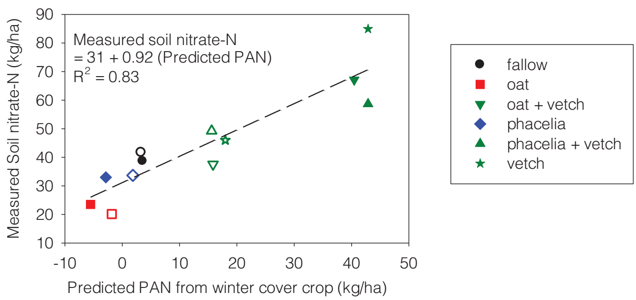

Figure 4. Predicted PAN (Vigil and Kissel, 1991; Equation 3) from cover crop residues vs. soil nitrate-N (0-30 cm depth; Garrett, 2009) measured in mid-July (approximately 65 d after cover crop incorporation). Soil samples collected between rows where crop (broccoli; *Brassica oleracea* var. *italica*) roots were absent. Filled symbols = 2007 data; open symbols = 2008 data

CONCLUSIONS

The OSU Calculator is available online for free download (Andrews et al., 2012). Calculator predictions can be verified in the field by soil sampling early in the growing season, prior to significant crop N uptake or opportunity for PAN loss. Verification studies conducted in the field require characterization of organic inputs (application rate, total N percentage and dry matter), and replicated fertilized and unfertilized treatment areas within the same field.
Verification can also be accomplished by laboratory incubation experiments as outlined in this paper. We welcome collaborations to verify the suitability of the OSU Calculator in diverse environments.

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REFERENCES

Andrews N., Sullivan D.M., Julian J., and Pool K., 2012. Oregon State University Organic Fertilizer and Cover Crop Calculator (West of the Cascades). http://smallfarms.oregonstate.edu/calculator.

Bary A.I., Cogger C.G., and Sullivan D.M., 2016. Fertilizing with manure and other organic omendments. PNW 533. Washington State University Cooperative Extension Service. Pullman, WA.

Gale E.S., Sullivan D.M., Hemphill D., Cogger C.G., Bary A.I., and Myhre E.A., 2006. Estimating plant-available nitrogen release from manures, composts, and specialty products. J. Environ. Qual. 35: p. 2321-2332.

Garrett A., 2009. Improving nitrogen management with cover crops in organic broccoli production. M.S. thesis. Oregon State University, Corvallis, OR. http://hdl.handle.net/1957/12109.

Hartz T.K., Mitchell J.P., and Giannini C., 2000. Nitrogen and carbon mineralization dynamics of manures and composts. HortScience 35: p. 209-212.

Hartz T.K. and Johnstone P.R., 2006. Nitrogen availability from high-nitrogen-containing organic fertilizers. HortTechnology 16: p. 39-42.

Kuepper G., 2003. Manures for organic crop production. Appropriate Technology Transfer for Rural Areas (ATTRA). Fayetteville, AR. http://attra.ncat.org/attra-pub/PDF/manures.pdf.

Prasad M., 2009. A literature review on the availability of nitrogen from compost in relation to the nitrate regulations SI-378 of 2006. Environmental Protection Agency, Wexford, Ireland. http://erc.epa.ie/safer/iso19115/displayISO19115.jsp?isoID=146.

Sullivan D.M. and Andrews N.D., 2012. Estimating plant-available nitrogen release from cover crops. Pacific Northwest Extension Publication 636. Oregon State University Extension Service. Corvallis, OR. https://catalog.extension.oregonstate.edu/pnw636.

Sullivan D.M., Datta R., Andrews N., and Pool K.E., 2011. Predicting plant-available nitrogen release from cover crop residues. p. 55-60. In: Proc. Western Nutrient Management Conference, 3-4 March 2011. http://smallfarms.oregonstate.edu/sites/default/files/WNMC11_Sullivan_p55.pdf.

Trinsoutrot I., Recous R., Bentz B., Lineres M., Cheneby D. and Nicolardot B., 2000. Biochemical quality of crop residues and carbon and nitrogen mineralization kinetics under nonlimiting nitrogen conditions. Soil Sci. Soc. Am. J. 64: p. 918-926.

Vigil M.F. and Kissel D.E., 1991. Equations for estimating the amount of nitrogen mineralized from crop residues. Soil Sci. Soc. Am. J. 55: p. 757-761.

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EFFECT OF SOWING DATE ON OCCURRENCE AND SEVERITY OF BARLEY YELLOW DWARF VIRUS (BYDV) IN DIFFERENT WHEAT CULTIVARS

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Abstract

Barley yellow dwarf virus (BYDV) is considered as the most important viral disease of cereal crops in several Asian countries including Iran. Field studies were conducted to determine the effect of planting date on naturally occurring barley yellow dwarf virus (BYDV) incidence in different wheat genotypes. The experimental design was a split-plot arrangement in a randomized complete block with three replications. Eight seeding dates (SD) at one month intervals were assigned to main plots. Fourteen cultivars (Twelve bread wheat, one durum wheat and one triticale cultivar) were subplots that randomized within each main plot. The effect of sowing date, cultivar and the interaction between sowing date and cultivar grain yield and KTW was statistically significant. Our results indicated that wheat genotypes showed different level of BYDV infection in different sowing dates. There was a high correlation between the growth habit and the level of BYDV severity. In general, the spring wheat cultivars, except the durum cultivar, Behrang, showed more BYDV infection than the winter cultivars. Most of the susceptible cultivars showed their highest level of infection in the first sowing date. Our results demonstrated the role of planting date in the level of BYDV infection and can be used to recommend modifying the sowing dates as a means to escape the disease in the BYDV hot spot regions.

Key words: *BYDV, disease incidence, disease severity, sowing date, wheat genotypes.*

INTRODUCTION

Barley yellow dwarf virus (BYDV; genus *Luteovirus*, family *Luteoviridae*) is the most destructive and the most widespread viral disease of the grass family (*Poaceae*), including the commercially most important cereal crops, wheat, barley, rice and maize. BYDV also infect many perennial weeds and forage grasses. Early infection of BYDV in wheat usually result in stunting and reddening or yellowing at the tip of the flag leaves. As the virus infection progresses, entire leaves are discolored and may die prematurely. Yield loss caused by BYDV infection is reported to be varied depending on the used cultivar, virus strain, time of infection, and environmental conditions. In wheat, yield losses due to BYDV infection have been reported to be as high as 40-50% (Herbert et al., 1999; Riedell et al., 1999). Herbert et al. (1999) reported that fall infection of winter wheat and winter barley significantly reduce tiller height, spike number, number of seed per spike, 1000 kernel weight (TKW), and yield but spring infection significantly reduce number of seed per spike and TKW, but not the other yield components. BYDV is a disease complex that results from the interaction between many cereal-feeding aphid species, different strains of the pathogen, many vector and virus hosts, different reaction of cultivars and environmental conditions. Recently, the taxonomy of Yellow Dwarf viruses of cereals is revised based on the variations in genomic organization. BYDV - PAV and BYDV - MAV are grouped in the genus *Luteovirus* while Cereal yellow dwarf virus strain RPV (previously known as BYDV-RPV) is grouped in the genus *Polerovirus* (van Regenmortel et al., 2000). BYDV is not transmitted mechanically but exclusively transmitted by several aphid species in a persistent circulative manner. BYDV is over season in perennial grasses and volunteer plants which are deserve as the main sources of the pathogen and the aphid vectors and their spread to the host crops (Jones et al., 1990; McKirdy and Jones, 1993).

The virus is often spread in the fall but the spring infection can also occur. The incidence of barley yellow dwarf virus is reported be related to a range of crop and field characteristics including sowing date (e.g. Foster et al., 2004; Cowger et al., 2010; Chapin et al., 2010). In cereal crops, planting date and variety selection is considered important tasks for wheat producers. The choice of planting date and variety might reduce the risk of frost damage at anthesis, meet requirements of exposure to low temperatures (vernalization), and favor the accumulation of temperature and precipitation by the plant throughout the growing season (Tapley et al., 2013). Early sowing dates in fall might increase the risk of BYDV epidemic, some other important viral pathogens including wheat streak mosaic virus and Soil-borne wheat mosaic virus, the take-all disease caused by the fungal pathogen, *Gaeumannomyces graminis* var. *tritici* and hessian fly pest (*Mayetiola destructor*) (Ortiz, 2012; Gibb, 2014). On the other hand delayed planting in wheat could cause yield losses (Chen et al., 2003).

BYDV is considered as the most important viral disease of cereal crops in Iran. The disease have been reported from the major wheat and barley cultivation areas across the country including Khorasan, Fars, Mazandaran, Alborz, Chaharmahal va Bakhtiari and Zanjan and is tough to be present in other parts of the country (Sahragard et al., 2010). The Khorasan Razavi province is one of the main cereal production regions in Iran. PAV and MAV serotypes of BYDV are identified to be present in the region using serological and molecular methods (Nazari et al., 2008).

Our objectives in the present study were to evaluate the level of BYDV resistance in major wheat cultivars under the natural epidemic of disease and to investigate the effect of planting date on incidence of BYDV in the Mashhad area to determine the optimum seeding dates to avoid BYDV infection.

MATERIALS AND METHODS

This study was part of a three-year field experiment to determine the photo-thermo periodic reaction and phonological plasticity of different wheat cultivars to environmental changes in different sowing dates. Field trials were conducted at the Torogh Agricultural Research Station (36°13' N, 59°40' E), located near Mashhad in three consecutive growing seasons (2012-2015). The experimental design was a split-plot arrangement in a randomized complete block with three replications. Eight seeding dates (SD) at one month intervals were assigned to main plots. In the 2012-2013 cropping season, the first sowing date was on 5 September 2012 and the 8th sowing date was on 5 April 2013 (Table 2). Fourteen cultivars (Twelve bread wheat, one durum wheat and one triticale cultivar, table 1) were subplots that randomized within each main plot. Each subplot was 1.2 meter wide by 2 meter long. The area of each subplot was 2.4 m^2 (1.2 × 2) and sown at a rate of 450 seeds m^2. Standard agronomic practices were followed throughout the studies. Each Plot received a basal application of nitrogen, phosphorus and potassium based on the recommendations of the stations' soil analysis laboratory. 2-4-D and Granstar herbicides were used at dose of 1.5 litter and 20 gram per hectare respectively at the late tillering stage. Statistical analysis of variance performed by using computer program (MSTATC). Duncan multiple range tests applied to separate the differences between means.

Table 1. Description of the cultivars used in this study

Cultivar Name	Species*	Growth habit	Year of release	Reference
Pishgam	BW	W	2009	Mahfoozi et al., 2009
Gascogne	BW	W	1991*	http://wheatpedigree.net
Falat	BW	S	1990	Wheat Atlas: http://wheatatlas.org/varieties
Chamran	BW	S	1998	Esmaeilzadeh Moghaddam et al., 2014
Rooshan	BW	S	1958	Esmaeilzadeh Moghaddam et al., 2014
Parsi	BW	S	2009	Amin et al., 2010
Pishtaz	BW	S	2003	Esmaeilzadeh Moghaddam et al., 2014
Sirvan	BW	S	2011	Najafian et al. 2012
Mihan	BW	W	2010	Seed and Plant Improvement Institute: http://www.spii.ir
Oroom	BW	W	2011	Yazdansepas et al., 2011
Bezostaya	BW	W	1969	Wheat Atlas: http://wheatatlas.org/varieties
Behrang	DW	S	2010	Seed and Plant Improvement Institute: http://www.spii.ir
Baz	BW	S	-	Mousavi et al., 2014
Sanabad	T	S	2013	Ghodsi et al., 2013

*BW, bread wheat; DW, durum wheat; T, triticale

Table 2. BYDV disease severity on commercial wheat and triticale cultivars in different planting dates (2012-2013)

	BYDV disease severity (0–5 scale)							
Cultivar	D1	D2	D3	D4	D5	D6	D7	D8
Pishgam	0.7	0.3	1.3	0.0	0.3	0.3	1.3	0.7
Gascogne	4.0	2.0	2.0	0.7	0.0	0.7	1.3	0.3
Falat	0.0	0.0	0.0	0.0	0.3	0.7	0.3	0.0
Chamran	1.0	0.3	0.3	0.0	0.3	0.0	0.3	0.0
Rooshan	1.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0
Parsi	0.3	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Pishtaz	1.0	0.3	0.7	0.3	0.0	0.3	0.3	0.3
Sirvan	0.0	0.0	0.0	0.3	0.0	0.0	0.7	0.0
Mihan	1.7	0.0	0.0	0.3	0.3	0.0	1.3	0.3
Oroom	0.3	0.3	0.0	0.0	1.7	1.3	0.3	0.3
Bezostaya	2.0	1.7	1.0	2.3	0.0	0.3	0.0	0.0
Behrang	4.0	2.3	1.7	1.7	2.0	1.0	1.3	1.7
Baz	0.3	0.3	0.0	0.7	0.0	0.0	0.7	0.0
Sanabad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7

Table 3. Summary of Analysis of variance on grain yield and KTW

Sources of variation	df	KTW (Ms)	Grain yeild (Ms)
Replication	2	30.691**	ns 0.346
Sowing date	7	4316.976**	210.779**
Error a	14	0.569	0.479
Cultivar	13	297.676**	12.812**
Sowing date * cultivar	91	**93.488	4.931**
Error a	208	0.233	0.217
Coefficient of variation (CV)%		5.2%	12.73%

Table 4. Mean of grain yield and KTW on different sowing dates

Treatment	Grain yield (DMRT 5%)*	KTW (DMRT 5%)
D1	3.245 E	38.28 D
D2	6.388 B	44.64 B
D3	7.049 A	46.01 A
D4	5.542 C	40.16 C
D5	3.615 D	31.77 E
D6	3.450 DE	31.93 E
D7	2.153 F	27.81 F
D8	0.349 G	15.03 G

Duncan multiple range test at α = 0.05

Table 5. Mean of grain yeild of different cultivars on different sowing dates

Cultivar	Sowing dates							
	D1	D2	D3	D4	D5	D6	D7	D8
Pishgam	5.3	8.6	8.4	7.3	4.2	3.8	1.0	0.0
Gascogne	7.3	7.0	6.0	4.4	1.5	0.9	0.0	0.0
Falat	1.3	5.5	7.4	5.6	4.0	5.1	3.2	0.7
Chamran	1.6	6.3	7.2	5.3	4.2	3.6	3.3	0.7
Rooshan	3.1	4.7	4.3	3.5	3.0	3.0	2.3	0.4
Parsi	1.0	5.4F	8.6	5.5	4.2	4.9	3.4	0.5
Pishtaz	2.8	6.6	8.3	6.4	4.7	4.1	3.5	0.4
Sirvan	2.5	6.0	6.2	5.6	4.3	4.1	3.5	0.8
Mihan	4.6	9.0	8.9	7.4	4.4	4.3	1.0	0.0
Oroom	3.7	8.0	8.3	6.5	3.2	2.8	0.5	0.0
Bezostaya	6.0	6.9	5.2	3.5	0.6	0.6	0.0	0.0
Behrang	0.9	3.6	5.1	4.4	3.3	2.5	1.5	0.4
Baz	1.0	4.9	7.7	5.9	3.7	4.6	3.8	0.8
Sanabad	4.6	7.1	7.3	6.4	5.4	4.1	3.3	0.3

EVALUATION OF BYDV INFECTION

Visual assessments of typical BYDV symptoms was observed and scored based on the proportion of infected plants and the severity of the symptoms in the plot on a 0–5 Scale (Niks et al., 2004). In this scale score 0 represented no visible BYDV symptoms in the plot; score 1 represented a few plants showing some leaf yellowing and discoloration; score 2 represented about 10% of the plants showing yellowing and mild dwarfing; score 3 represented 30% of plants showing yellowing and dwarfing; score 4 represented about 50% of the plants showing severe dwarfing; score 5 represented nearly complete dwarfing with few or no spikes emerging. Disease evaluation was done on 19 April. Diseases scorings were averaged over the three replicates. Samples were taken from the infected plants to confirm presence of the virus and to distinguish its serotype by Enzyme-linked Immunosorbent Assay (ELISA).

RESULTS AND DISCUSSION

Results of Analysis of variance on grain yield and Kernel thousand weights (KTW) in 2012-2013 cropping season are presented in Table 3. As can be seen in Table 3, the effect sowing date, cultivar and the interaction between sowing date and cultivar grain yield and KTW was statistically significant. The results showed that the highest grain yield was related to the third sowing date (D3, 05-Nov) and the lowest grain yield was related to the last sowing date (D8, 05-Apr). The same trend was observed on KTW data. The triticale cv. Sanabad had the highest grain yield and KTW compared to the other tested cultivars. As can be seen from the results of interaction between sowing date and cultivar (Table 5) some cultivars had a very low grain yield or had no grain yield when planted on the last date because these cultivars did not entered the flowering stage. Some cultivars had a very low grain yield when planted on the first date since due to severe frost damage the secondary tillers had delayed flowering. The wheat cultivars, Gascogne and Bezostaya when sown in D7 (05-Mar) and Pishgam, Gascogne, Mihan, Orum and Bezostaya when sown in D8 did not entered the flowering stage and had no grain yield (table 5). In D1 sowing date, Falat, Chamran, Roshan, Parsi, Pishtaz, Sirvan, Behrang and Baz where totally damaged by frost and their secondary tillers had delayed flowering. The grain yield obtained from these cultivars is related to the secondary tillers. The best sowing date for the winter and facultative cultivars was D2 (05-Oct), D3 (05-Nov) respective. The best time to sow the spring cultivars was on D2 (05-Oct) or D3 (05-Nov) depending on the cultivar.

In 2012-2013 cropping season, the first year of the trial, climatic conditions were more conducive to disease development and severe BYDV infection was observed in the experiment plots of susceptible cultivars. The results of ELISA tests that carried out in the Plant Virology Research Center (PVRC), Shiraz University, confirmed the presence of Barley yellow dwarf virus-PAV serotype (BYDV-PAV) in the samples taken in 2013 (Yasaei personal communications). In the second year (2013-2014) BYDV infection appeared only sporadically in the experiment plots due to unfavorable climatic conditions including severe freezing during the winter time. The results of BYDV disease severity on wheat genotypes in different planting dates is presented in Table 2. The wheat genotypes planted in different dates, showed different level of BYDV symptom expression. There was a high correlation between the growth habit and the level of BYDV severity. In general, spring wheat cultivars showed more BYDV infection than the winter cultivars. The spring durum wheat cultivar, Behrang was an exception. Behrang and the French winter wheat cultivar, Gascogne showed the highest level of infection especially in the earlier sowing dates (Figure 1).

Figure 1. Severe infection of BYDV on Goscogne cultivars in the first sowing date

Most of the susceptible cultivars showed their highest level of infection in the first (earlier) sowing date. The only triticale tested genotype, Sanabad showed no symptoms in almost all sowing dates. Our results demonstrated the role of planting date in the level of BYDV infection.

In agreement with other reports, our results highlights that the early planted wheat is prone to attack by the barley yellow dwarf virus infection. Delayed planting date is considered in some regions as the most important and reliable management practice for the farmers. Management of vector-borne viral diseases including BYDV is very complex. Using cultivars carrying genetic resistance to the virus or the aphid vectors is considered as the most economical and practical methods of BYDV control (Ayala et al., 2001). However, the wheat gene pool showed to be not rich regarding BYDV resistance genes so little sources of resistance/tolerance is available in wheat. In addition to resistance breeding other major strategies recommended to manage BYDV are avoidance of early planting, use of insecticide treated seed and application of foliar insecticide. Efficacy of each strategy varies between localities (Bowen et al*.,* 2002; Van Riessen, 2002; Flanders et al., 2006). Optimization of the planting date should be considered always as a strategy to manage the disease.

Wheat and barley are typically planted in the Khorasan region with the intent of being used as a dual-purpose crop especially in small-scale farming systems. In this region, wheat may be planted over a wide range of dates from late October to late December depending upon location, cultivar and the availability of the land due to agricultural practices of the previous crop. Planting wheat early for use as a dual-purpose crop significantly increases the prevalence of the BYDV infection.

Corn (*Zea mays* L.) is considered as an important BYDV reservoir and a host to the aphid vectors. Corn is mostly grown in the region as a forage crop.The majority of corn fields are being planted by early April to mid May in the region. Forage corns are generally harvested early to late in the fall (September-November). So there is relatively long overlapping period between wheat and corn.

By the time wheat planting season begins, corn is still in the ripening stage. Due to the long overlapping period between corn and wheat, corn fields may play an important role in the epidemiology of BYDV in the region. At the beginning of autumn, when most of winter wheat and barley fields are already emerged, the vector aphids leave corn and infest young seedlings potentially transmitting viruses. In southern parts of the region where winter frost is moderate and usually spring or facultative cultivars are being planted, the vectors may overwinter parthenogenetically in cereal crops and multiply again during the spring when temperature rises. During spring and early summer depending on the location, aphids may leave maturing barley and wheat and transmit viruses to the young corn crops. Insecticide treatments aimed at controlling other pests of the corn field the aphids which transmit BYVD.

Barley yellow dwarf resistance or tolerance is reported to be associated with a number of agronomic characteristics including growth habit and earliness. Winter wheat and winter triticale cultivars are reported to be more resistant or tolerant to BYDV infection than the spring cultivars (Comeau and Jedlinski, 1990). However, our data contradict the other reports since most of the spring wheat cultivars tested in our study showed a high level of resistance under the field conditions. Field resistance to BYDV is defined as reduced symptoms of disease infection independent of the virus concentration in the infected plants (Kosová et al., 2008). The cultivars that showed field resistance may contain substantial amounts of virus particles despite their phenotype of infection. Further experiments needed to determine the genetic basis of the resistance reported here.

CONCLUSIONS

Our results can be used by the local extension services to recommend modifying the sowing dates as a means to escape the disease in the BYDV hot spot regions. However, in the long term, further investigation is needed to determine the effects of aphid vectors as well as the wild host grasses in the regional epidemiology of BYDV to arrange a forecasting system or at least estimate disease severity.

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REFERENCES

Amin H.F.A, Pazhomand M., Dadaeen M., Zakeri A., Yasaie M., et al., 2010. Parsi, A New Bread Wheat Cultivar, Resistant to Stem Rust (Race Ug99) with Good Bread Making Quality for Cultivation under Irrigated Conditions of Temperate Regions of Iran. Seed and Plant Improvment Journal. 26 (2) :289-292

Anonymous, 2014. Agricultural statistics of Khorasan Razavi province (2012-2013). Statistics and Agricultural information office. Khorasan Razavi Agricultural Organization. 22 pp.

Ayala L., Henry M., Gonzalez-de-Leon D., Van Ginkel M., Mujeeb-Kazi A., Keller B., Khairallah M., 2001. A diagnostic molecular marker allowing the study of Th. intermedium-derived resistance to BYDV in bread wheat segregating populations. Theor. Appl. Genet. 102:942-949.

Chapin J.W., Thomas J.S., Gray S.M., Smith D.M., Halbert S.E., 2001. Seasonal abundance of aphids (Homoptera: Aphididae) in wheat and their role as barley yellow dwarf virus vectors on the South Carolina coastal plain. Journal of Economic Entomology. 94: 410-421.

Chen C., Payne W.A., Smiley R.W., Stoltz M.A., 2003. Yield and water-use efficiency of eight wheat cultivars planted on seven date in northeastern Organ. Agron. J. 95:836-843.

Comeau A., Jedlinski H., 1990. Successful breeding for barley yellow dwarf resistance or tolerance: a systematic approach related to other agronomic characteristics. Pages 441-451 in: World Perspectives on Barley Yellow Dwarf. P. A. Burnett, ed. CIMMYT, Mexico, D.F., Mexico.

Cowger C., Weisz R., Anderson J. M., Horton J.R., 2010. Maize Debris Increases Barley Yellow Dwarf Virus Severity in North Carolina Winter Wheat Agronomy Journal. 102: 688-696.

Esmaeilzadeh Moghaddam M., Jalal Kamali M.R., Anet Z., Roshani M., Ghodsi M., 2014. Temporal variation in phenological characteristics, grain yield, and yield components of spring bread wheat (*Triticum aestivum* L.) cultivars released in Iran between 1952 and 2009. Crop Breeding Journal 4 (1): 57-64.

Foster G.N., Blake S., Tones S.J., Barker I., Harrington R., 2004. Occurrence of barley yellow dwarf virus in autumn-sown cereal crops in the United Kingdom in relation to field characteristics. Pest Management Science. 60:113–125.

Gibb T., 2015. Contemporary Insect Diagnostics: The Art and Science of Practical Entomology. Academic Press. Oxford, UK.

Henry M., McNab A., 2002. Barley Yellow Dwarf Disease: Recent Advances and Future Strategies. Mexico, D.F.: CIMMYT.

Herbert D.A., Stromberg E.L., Chappell G.F., Malone S.M., 1999. Reduction of yield components by barley yellow dwarf infection in susceptible winter wheat and winter barley in Virginia. Journal of Production Agriculture 12:105-109.

Flanders K.L., Herbert A., Buntin D., Johnson D., Bowen K., Murphy J.F., Chapin J., Hagan A., 2006. Barley yellow dwarf in small grains in the southeast. Circular ANR-1082. Ala. Coop. Ext. Syst. Auburn, USA.

Jones R.A. C., McKirdy S.J., Shivas R.G., 1990. Occurrence of barley yellow dwarf viruses in over-summering grasses and cereal crops in Western Australia. Aust. Plant Pathol. 19:90-96.

Ghodsi M., Vahabzadeh M. Nazeri M., Khodarahmi M. Ghasemi M. Koohkan Sh., et al., 2013. Sanabad, A New Triticale Cultivar Suitable for Temperate and Cold-Temperate Regions of Iran. Research Achievements for Field and Horticulture Crops. 2 (2):143-153.

Kosova K., Chrpova J., Sip V., 2008. Recent advances in breeding of cereals for resistance to barley yellow dwarf virus - A review. Czech Journal of Genetics and Plant Breeding 44: 1-10.

Mahfoozi S., Akbari A., Chaichi M., Sanjari A., Nazeri S., Abedi-Oskooee S., et al., 2009. Pishgam, A New Bread Wheat Cultivar for Normal Irrigation and Terminal Stage Deficit Irrigation Conditions of Cold Regions of Iran. Seed and Plant Improvment Journal. 25 (3) :513-517.

McKirdy S.J., Jones R.A.C., 1993. Occurrence of barley yellow dwarf virus serotypes MAV and RMV in over-summering grasses. Aust. J. Agric. Res. 44:1195-1209.

Mousavi S., Siadat S., Alami-Saeid K., Zand E., Bakhshandeh A., 2014. Tolerance Mechanism of Spring Bread Wheat (*Triticum aestivum*) Cultivars to Wild Oat (*Avena lodoviciana*) Competition. Journal of Crop Production and Processing .4 (12):97-110.

Najafian G., Khodarahmi M., Amini A., Afshari F., Malihipour A., Ahmadi Gh. et al., 2012. Sirvan, New Bread Wheat Cultivar, Tolerant to Terminal Drought with Good Bread Making Quality Adapted to Irrigate Conditions of Temperate Regions of Iran. Research Achievements for Field and Horticulture Crops. 1 (1):1-10.

Nazari N.k., Jafarpour B., Falahati Rastegar M., 2008. Identification of barley yellow dwarf virus, PAV and MAV serotypes by using serological and molecular methods. Proceedings of 18th Iranian Plant Protection congress. 24-27 Agu. 2008, Hamadan, Iran. p. 524.

Niks R.E., Habekuß A., Bekele B., Ordon F., 2004. A novel major gene on chromosome 6H for resistance of barley against the barley yellow dwarf virus. Theor Appl Genet 109: 1536-1543.

Ortiz B.V., 2012. Alabama winter wheat production guide 2012-2013. Alabama Cooperative Extension System. http://www.aces.edu.

Ranieri R., Mezzalama M., Burnett P.A., Lister R.M., 1993. Seasonal occurrence of barley yellow dwarf virus serotypes in small-grain cereals in the valley of Mexico. Plant Disease. 77: 623-626.

Riedell W.E., Kieckhefer R.W., Haley S.D., Langham M.A.C., Evenson P.D., 1999. Winter wheat responses to bird cherry-oat aphids and barley yellow dwarf virus infection. Crop Science 39:158-163.

Sahragard N., Izadpanah K., Babaee Gh., Eshaghe R., Afsharifar A.R., Masumi M., 2010. Integrated management of viral diseases of winter wheat in chahar mahal va bakhtiari province. Iran. J. Plant Path., 46: 43-45.

Tapley M., Ortiz B.V., Santen E. van, Balkcom K.S., Musk P., Weaver D.B., 2013. Location, seeding date, and variety interactions on winter wheat yield in Southeastern United States. Agronomy Journal 105:509-518.

Van Regenmortel M.H.V., Fauquet C.M., Bishop D.H.L., Carstens E.B., Estes M.K., Lemon S.M., Maniloff J., Mayo M.A., McGeoch D.J., Pringle C.R., Wickner R. B., 2000. Virus Taxonomy. Seventh Report of the International Committee on Taxonomy of Viruses. Academic Press, San Diego.

Yazdansepas A., Najafimirak T., Golkari S., Rezaei M., et al., 2011. Oroum, A New Bread Wheat Cultivar for Irrigated Condition in Cold Regions of Iran. Seed and Plant Improvment Journal .27 (3) :445-448.

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EVALUATION OF VITAMIN C CONTENT IN SAMPLES FROM TEN POTATO CULTIVARS INOCULATED WITH POTATO VIRUS Y *(Necrotic strains)*

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Abstract

Providing basic nutrition to many people, being a staple food, potato tubers with higher levels of bioactive compounds (as vitamin C) could have a positive impact on the people health. This study aimed to evaluate the behaviour of 10 potato varieties with different L ascorbic acid content after inoculation with potato virus Y necrotic strains (PVY^N). Another goal of this research work was to elucidate the biochemical basis responsible for different reaction to infection with potato virus Y among several varieties which differ in their susceptibility or resistance to this pathogen. The potato cultivars evaluated were: Christian, Roclas, Red Lady, Marvis, Castrum, Brasovia, Hermes, Sante, Riviera and Carrera. The vitamin C content was estimated in the flesh matter only, using an enzymatic method. Significant differences in total ascorbic acid content were observed across the varieties before and after virus inoculation, the variety Hermes showing the highest content (746 $mg.kg^{-1}$ DW) in tubers after inoculation. Excepting the cultivars Christian, Riviera and Sante, which were very resistant and resistant to mechanical inoculation, all the other samples tested presented 48.6 - 100% infected plants.

***Key words**: total ascorbic acid content, potato, potato virus Y, necrotic strains.*

INTRODUCTION

For solving food shortages at the beginning of this millennium, the potato proves to be a product with promising perspectives.
Considered by some a common product, cheap food, poor people's food and the plant of poor areas, the potato is actually a product that helps improving the daily diet being rich in carbohydrates, vitamins and minerals. For Romania, the potato is a strategic food, contributing to the national food safety system. Our country is ranked on the third position in Europe in terms of area cultivated with potatoes (after Poland and Germany) (Bădărău et al., 2015c). Potato is the third most consumed food, after rice and maize (FAO, 2015) and their tubers are recognized as a good source of carbohydrates, vitamin B_1, B_3 and B_6, potassium, phosphorus and magnesium. It has a moderate content of iron, but its high L ascorbic acid levels promote iron absorption. Potato is rich in essential amino acids. It also contains pantothenic acid, folate and riboflavin (Camire et al., 2009). While 50 years ago more than half of the global annual production output was concentrated in Russia, Poland and Germany, now, around 40% comes from China, India and Russia. China and India have seen a dramatic increase, with both countries doubling their production in the last 20 years (FAO, 2015).
Vitamin C is the most abundant vitamin in potato and it is estimated that about 18% of the recommended daily allowance (RDA) of vitamin C in Australia and 21% in the UK are provided by potatoes (Camire et al., 2009; Cahil et al., 2009). Three main biological functions have been identified for L ascorbic acid enzyme cofactor, free radical scavenger and donor/acceptor of electrons al the plasma membrane. Humans have lose ability to synthesize L ascorbic acid and depend on the diet to acquire the necessary amounts required to maintain good health. Deficiency of the vitamin C could cause the disease scurvy characterized by spots on the skin, spongy gums and bleeding from mucous membranes. Is caused by deficient synthesis of collagen in which L ascorbic acid is cofactor (Camire et

al., 2009; Cahil et al., 2009; Schleicher et al., 2009). Although, nowadays, scurvy is considered rare in developed nations, the vitamin C intake of significant part of the population of some of these countries may be below RDA (80 mg per day in European Union EC) (EC, 2008). About 13% of the population in the USA or 1 in 7 young adults in Canada have been reported to be deficient in vitamin C with certain groups such as smokers, pregnant women and people of low socioeconomic status at a higher risk of deficiency is common. L ascorbic acid is particular important because it can reduce the chelating effect that compound phytic acid has on iron, increasing its bioavailability (Camire et al., 2009).

Distributed worldwide, *potato virus Y* (PVY, *Potyvirus* genus, family *Potyviridae*) is a major economic disease agent for the crops. This pathogen causes losses in solanaceous crops such potato (*Solanum tuberosum*), tobacco (*Nicotiana tabacum*) and tomato (*Lycopersicum esculentum)* (Kerlan et al., 2009). PVY in potato received (in the last period) a special attention because this pathogen is one of the most economically important problems in seed potatoes in the world. This virus is responsible for serious decreases yield and quality tubers, but the main problem in seed potato production is the requirement for a strict PVY tolerance limits for certified lot of seed. High levels of PVY are responsible for the rejection of many seed potato lots. Also, a significant reduction of the crop value was noticed and in a certified seed's shortage, too, especially for certain varieties highly susceptible to PVY infection (Crosslin et al., 2006; Gray et al., 2010; Karasev et al., 2011).

In the last three decades new PVY strains have emerged, some of them (e.g. $PVY^{(N)W}$) induce barely visible symptoms during the growing season (often being unnoticed during visual inspection) and others (e.g. $PVY^{(N)NTN}$) produce symptoms on tubers, causing the so-called the necrotic ring staining of tubers**.** Due to the fact that these viral strains may affect the resistance of some potato varieties compared to other strains of the virus Y (PVY^{o} and PVY^{c}) numerous varieties that were considered resistant passed into the category of sensitive ones, which affected the production of the potato in our country. The damage caused by this pathogen agent is both quantitative (significant reduction of production) and qualitative (commercial depreciation of tubers). In case of cultivation of sensitive varieties under favourable conditions, financial losses can be important both for potato consumption (it can become unmarketable) as for seed potatoes (it will be downgraded or rejected from certification). Being very aggressive, the PVY necrotic strains can overcome existing resistance to infection with other strains of potato virus Y (PVY^{o} and PVY^{c}) (Singh et al., 2008; Boonham et al., 2002a; 2002b).

The goal of this study was to quantify the levels of L ascorbic acid in 10 potato varieties with different L ascorbic acid content before and after inoculation with potato virus Y necrotic strains (PVY^{N}).

Potato with high increase content of vitamin C could have an important impact on human health, especially in populations where potato is the main staple food crop and therefore, would be of interest to consumers, producers and policymakers.

MATERIALS AND METHODS

Biological material

Ten potato varieties were chosen for this study. The biological material included:

- commercial cultivars such as Riviera, Carrera, Red Lady, Hermes and Sante which represented about 40% of the production area in Romania in 2015 (Bădărău et al., 2015a).
- Christian and Roclas, Romanian varieties very appreciated in Romania for their nutritional quality (data not show)
- Sarmis, Marvis, Castrum, Brasovia (new Romanian varieties).

The health tubers were obtained from the Breeding Department, National Institute of Research and Development for Potato and Sugar Beet Brasov (NIRDPSB Bv). From each variety, 6 pots (with 1 eye pieces) in three repetitions were planted. Plants were grown in 18 cm pots in green house conditions. After emergence, plants have been mechanical inoculated, using a PVY^{N} source (secondary infection Record variety).

After the inoculation, disease symptoms were observed and ELISA tests have been made, in the aim to confirm the infection. At harvesting, we select 2 tubers from each pot and there were tested 3 samples (4 tubers/samples) for each variety. The other tubers were keep and the percentage of tubers with necrotic symptoms was estimated at harvesting time and later (after 3 months storage at 4-8°C).

Detection of PVY^N infections

The analysis was performed following the protocol Clark and Adams (1977). The absorbance values were estimated at 405 nm (A_{405}) using a Tecan SunRise reader (software Magellan). In the first stage, the material was tested for Potato virus Y (polyclonal antibodies) and only the PVY infected material was used, for identify the samples infected with necrotic strains (PVY^N). This biological material was retested using monoclonal antibodies (mAb) or polyclonal (PCA). The plates were coating with anti PVY-NOC mAb (Bioreba, Switzerland, antibodies that could recognize all the PVY strains excepting the PVY^o) and the virus was detected using alkalin phosphatase (AP) linked to anti–PVY-NOC mAb (Bioreba, Switzerland, specific for the strains PVY^N).

Sample preparation

For the healthy material, composite samples were prepared by pooling tubers. Tubers were peeled with a potato peeler, the flesh of each tuber quartered from stem to bud and one of the quarters sliced. Flesh tissues were dried, ground to a fine powder (using a coffee grinder), stored to -20°C until analysis.

Vitamin C analysis

Dry matter (at 105°C), vitamin C (a spectrophotometric method, L ascorbic acid test kit, Megazyme, Bioreba) were determined on healthy tubers before planting them in the pots. A representative sample of tubers per plot was used. The sample for these analysis was used from each 2 tubers (2 tubers/sample). The characteristics determination was made in 3 repetitions (Bădărău et al., 2015b).

Statistical interpretation

Analysis of variance (ANOVA) and Duncan's multiple range test were used.

RESULTS AND DISCUSSIONS

After the inoculation, about half of plants presented mosaic symptoms on leaves (Carrera, Red Lady and Hermes) or with necrosis on leaves, veins, petioles and stems followed by wilting of leaves (Marvis, Castrum). The first foliar symptoms from primary infections on the leaves have been observed on Hermes, Carrera and Red Lady varieties and later on cv. Castrum and Marvis.

Table 1. Percent of PVY^N infected material and of tubers with necrotic symptoms

Variety	% PVY^N infected plants after inoculation**	% PVY^N infected tubers (with necrotic symptoms)***	
		At harvest	After 3 months from harvest
Riviera	0.00 ± 0.000	0.00 ± 0.000	0.00 ± 0.000
Christian	0.00 ± 0.000	0.00 ± 0.000	0.00 ± 0.000
Sante	0.00 ± 0.000	0.00 ± 0.000	0.00 ± 0.000
Roclas	44.44 ± 10.000	0.00 ± 0.000	8.20 ± 6.000
Brasovia	66.66 ± 0.000	0.00 ± 0.000	8.20 ± 6.000
Marvis	83.33 ± 0.000	5.152± 1.533	34.700 ± 15.000
Castrum	83.33 ± 0.000	7.180± 1.203	34.700 ±15.000
Red Lady	100.00 ± 0.000	15.667 ± 2.887	69.200 ± 10.000
Carrera	100.00 ± 0.000	30.244 ± 15.248	87.633 ± 2.300
Hermes	100.00 ± 0.000	48.267 ± 12.648	98.267 ± 1.700

* Data represents the mean values (3 repetitions, 6 pots for each repetition) ± standard deviation

** ELISA test made after 4 weeks after inoculation (for identify PVY^N infected plants)

*** Tuber symptoms characterized by raised or sunken necrotic lesions, were scored at harvest and after 3 months storage at 4-8°C

In several plants, the virus began to multiply in the leaves six days after PVY^N inoculation. As we observed in other paper (Bădărău et al., 2015b), simultaneously, the virus spread to the stem, followed by the upper, green parts of the plants. In this way, the virus multiplied vigorously in the potato variety Carrera and Red Lady similar phenomena observed to the extremely susceptible variety Hermes, the percentage of infected plants being maximal in these situations. As waited, the virus did not multiply in the cultivars Riviera, Sante and Christian. Excepting these three cultivars, which were very resistant and resistant to mechanical inoculation, all the other varieties presented 44.4 - 100% infected plants.

After 3 months from harvesting, the frequency of tubers with symptoms was between 8.2 - 34.7% for varieties Roclas, Brasovia, Marvis, Castrum and for Red Lady, Carrera, Hermes cultivars this percentage was higher (69.2-98.2%) (Table 1).

The vitamin C percentages (% from dry matter) of tubers planting in the pots were very different. As shown in table 2, these values were significantly low to the varieties resistent and very resistent to the inoculation like cv. Riviera, Christian and Sante compared with the sensible cultivars Hermes, Carrera and Red Lady.

The simple correlation coefficient Pearson revealed significantly higher values regarding the vitamin C content (as compared to the percent of infected material for the most resistents potato varieties) both in healthy tubers (before virus inoculation) and in tubers harvested from PVY^N inoculated plants (table 3). As shown in figure 1(A, B), there is a correlation between the vitamin C content of tubers planted in the pots and the behaviour of inoculated material. So, the variants which started in vegetation with low percentage of vitamin C were resistent to the PVY^N inoculation (Riviera, Christian, Sante, Roclas, Brasovia). Concerning these cultivars, the percentage of tubers with necrotic symptoms visible fast after harvesting and after 3 months from the harvest was 0.0%.

The variants which started in vegetation with high content of vitamin C were sensible to the virus inoculation (Hermes, Red Lady and Carrera) (Figure 1 A,B). In our study, the total vitamin C content in the flesh tissues were investigated in 10 varieties of potato grown under uniform greenhouse cultural conditions. Values reported for this compound contents were, in general, lower to those found in the literature (Hamouz et al., 2007; Mazurczyk, 2001; Kolbe et al., 1997; Han et al., 2004) maybe because of the cultural conditions, especially the soil composition. A previous study also found higher ascorbic acid levels in potatoes grown in basic soil (Burgos et al., 2009).

Significant differences were seen between varieties vitamin C content and for behaviour to PVY^N inoculation (necrotic symptoms on the tubers at harvest and on the material stored 3 months at 4-8^{o}C).

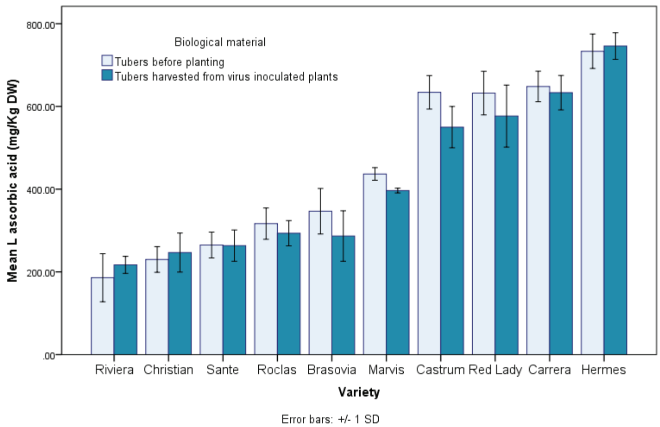
Table 2. Dry matter and vitamin C content of the biological material

Variety	Before inoculation* Dry matter (% FW)	Before inoculation* Vitamin C content (mg/kg DW) ±SD**	After virus inoculation, at harvest** Dry matter (% FW)	After virus inoculation, at harvest** Vitamin C content (mg/kg DW) ±SD**
Riviera	24.2±0.050	186.000±58.2068 (f)***	22.2±0.054	217.000±20.663 (e)***
Christian	25.1± 0.130	230.000±31.225(fg)	23.1± 0.132	246.6667±47.258(e)
Sante	24.8±0.070	265.000±82.004 (ef)	24.8±0.057	263.333±37.8593(e)
Roclas	21.8±0.080	316.667±37.859 (de)	20.8±0.0248	293.333± 30.55 (e)
Brasovia	24.6±0.010	346.667±55.075 (d)	22.6±0.016	286.6667± 61.101 (e)
Marvis	23.6±0.049	436.667±15.275 (c)	21.6±0.097	396.6667±5.773 (d)
Castrum	24.4±0.121	634.167±40.324 (b)	22.4±0.141	550.000±500 (c)
Red Lady	23.8±0.020	632.333±52.595(b)	20.8±0.402	576.667±75.055 (bc)
Carrera	23.6±0.140	648.333±36.855 (b)	21.6±0.121	633.333±41.633 (b)
Hermes	24.2±0.080	733.333±43.633(a)	21.2±0.088	746.000±31.187 (a)

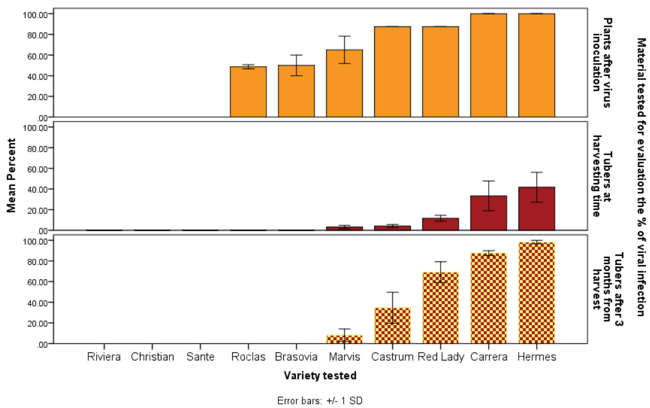
* These analysis were made using tubers before planting them in the pots. Tissue was taken from tubers stored at 6-8^{o}C. Half of every tuber was tested and the other one was planted in the pot.

** For testing vitamin C in tubers harvested from the inoculated plants (6x3 pots for each variety), 2 tubers from each pot were selected and there were tested 3 samples (4 tubers/samples) for each variety.

*** Values not followed by the same letter are significantly different (P=0.05) according to Duncan's test. Abbreviation: FW= fresh weight; DW = dry weight; SD=standard deviation.



A.



B.

Figure 1. Vitamin C content for the material tested before planting (healthy tubers) and at harvesting time (from plants inoculated with PVY^N) (A). The potato cultivars behavior to diseases induced by mechanic inoculation with an isolate PVY^N from Record secondary infected (B).

Table 3. The correlation between content of vitamin C (in tubers, before and after PVY^N inoculation) and the percentage of the infected material at harvest and after 3 months (for 10 varieties tested)

Variables	Statistical indicators	Percent of PVY^N infected tubers (for the 10 varieties tested)	
		at harvest	after 3 months
Vitamin C content (mg/Kg DW) Healthy tubers **before** planting	Correlation coefficient Pearson	**0.742****	**0.886****
	Significance threshold	0.000	0.000
	N	90	90
Vitamin C content (mg/Kg DW) Tubers **harvested** from inoculated plants	Correlation coefficient Pearson	**0.808****	**0.945****
	Significance threshold	0.000	0.000
	N	90	90

** Correlation is significant for p<0.01.
N =90 (3 samples x 10 varieties x 3 repetitions)

CONCLUSIONS

The variety and the vitamin C content (% dry weight) of tubers used for the experiment influenced the behaviour of the material after the inoculation with potato virus Y (Y^N strain-variety Record).

The samples with significantly lower vitamin C content (cv. Carrera, Sante and Christian) were resistant to PVY^N inoculation. Thus, after 3 months from harvest, the stored tubers didn't have visible tuber necrotic disease symptoms.

Results of this study show a significant difference between the total vitamin C content of the healthy and PVY^N infected tubers from the varieties tested (cultivars with different behaviour to inoculation with necrotic strain of PVY). However, it must be considered that the results presented in this paper arise from working with only a few of biological material and upper greenhouse growing conditions. Also, extended field trials would be made to confirm our research results.

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REFERENCES

Bădărău C.L., Damșa F., Olteanu Gh., Chiru S.C., 2015a. Tulpinile necrotice ale virusului Y al cartofului - permanenta provocare pentru fermieri si producatori. Cartoful in Romania 24(1): 105-114.

Bădărău C.L., Damșa F., Olteanu Gh., Mărculescu A., 2015b. Total ascorbic acid content in 10 varieties of potato different resistant to PVY necrotic strains. In: Floroian L. and Badea M. Challenges in medicine, food control and environmental. Transilvania University from Brașov Publisher, 189-203.

Bădărău C.L., Rakosy E., Damșa F., Olteanu Gh., Chiru S.C., 2015c. Investigation of the potato virus Y status in seed potatoes in Romania (preliminary studies). In: The 18th Joint Meeting of the EAPR Breeding and Varietal Assessment Section and the EUCARPIA Section Potatoes", Vico Equense, Italia, 15-19 november 2015.

Boonham N., Walsh K., Preston S., North J., Smith P. and Barker I., 2002a. The detection of tuber necrotic isolates of Potato virus Y, and the accurate discrimination of PVY°, PVYN and PVYc strains using RT-PCR. Journal of Virological Methods 102: 103-112.

Boonham N., Walsh K., Hims M., Preston S., North J. and Barker I., 2002b. Biological and sequence comparisons of Potato virus Y isolates associated with potato tuber necrotic ringspot disease. Plant Pathology 51: 117-126.

Burgos O., Augui S., Amoros W., Salas E., Bonjerbale M., 2009. Ascorbic acid concentration of native Andean potato varieties as affected by environment, cooking and storage. Journal of Food Composition and Analysis 22(6): 533-538.

Cahill L., Corey P.N. and EI-Sohemy A., 2009. Vitamin C deficiency in a population of young Canadian adults. American Journal Epidemiology 170(4): 464-471.

Camire M.E., Kubow S. and Donnelly D.J., 2009. Potatoes and human health. Critical Reviews in Food Science Nutrition 49(10): 821- 840.

Clark M.F. and Adams A.N.,1977. Characterization of the microplate method of the enzyme-linked immunosorbent assay for the detection of plant virus. Journal of General Virology 34: 475-483.

Crosslin J.M., Hamm P.B., Hane D.C., Jaeger J., Brown C.R., Shiel P.J., Berger P.H., and Thornton R.E., 2006. The occurrence of PVY°, PVYN, and PVYN.° strains of Potato virus Y in certified potato seed lot trials in Washington and Oregon. Plant Disease 90, 1102-1105.

EC, 2008. Commission directive 2008/1001EC of 28 October 2008. Official Journal of the European Union. http://eur-Iex.europa.eulLexUriServ/LexUriServ.do?uri=0J:L:2008:285:0OO9:0012:EN:PDF.

FAO Statistical Pocketbook World Food and Agriculture 2015 http://www.fao.org/3/a-i4691e.pdf.

Gray S., De Boer S., Lorenzen J., Karasev A., Whitworth J., Nolte P., Singh R., Boucher A., and Xu H., 2010. Potato virus Y. An evolving concern for potato crops in the United States and Canada. Plant Disease 94: 1384-1397.

Han J.S., Kozukue N., Young K.S., Lee K.R., Friedman M., 2004. Distribution of ascorbic acid in potato tubers and in home-processed and commercial potato foods. Journal of Agricultural Food Chemistry 52(21):.6516-6521.

Hamouz K. Lachman J., Dvorak P., Duskova O., Cizek M. and Vyzkurnny Ustav Bramborarsky H.B., 2007. Effect of conditions of locality, variety and fertilization on the content of ascorbic acid in potato tubers. Plant Soil Environ 53(6): 252.

Karasev A.V., Hu X., Brown C.J., Kerlan C., Nikolaeva O.V., Crosslin J.M., and Gray. S.M., 2011. Genetic diversity of the ordinary strain of Potato virus Y (PVY) and origin of recombinant PVY strains. Phytopathology 101: 778-785.

Kolbe H., Stephan-Beckmann S., 1997. Development, growth and chemical composition of the potato crop (*Solanum tuberosum* L.) II. Tuber and whole plant. Potato Research 40(2): 135-153.

Mazurczyk W.L.B., 2001. Variation of chemical composition of tubers of potato table cultivars grown under deficit and excess of water. Polish Journal Food Nutrition Science 10(51): 27-30.

Schleicher R.L., Carroll M.D., Ford E.S. and Lacher D.A., 2009. Serum vitamin C and the prevalence of vitamin C deficiency in the United States: 2003-2004 National Health and Nutrition Examination Survey (NHANES). American Journal Clinic Nutrition 90(5): 1252-1263.

Singh R.P., Valkonen J.P., Gra S.M., Boonharn N., Jones R.A., Kerlan C., Schubert J., 2008. Discussion paper:The naming of Potato virusY strains infecting potato. Archives of Virology 153: 1-13.

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SORGHUM BIOMASS YIELD AT DIFFERENT PLANT DENSITIES

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Abstract

Sorghum (Sorghum bicolor (L.) Moench) is among the most important energy crops used for biomass production as substrate for obtaining biogas which is converted by combustion into power energy and heat. The importance of sorghum as an energy crop is given by some advantages such as the drought tolerance, the great potential to produce biomass even under less favorable growing conditions, and the easiness to be cultivated.
For sorghum energy crops aimed to produce biomass, already there are created specialized hybrids for this purpose, but there is necessary also a specific crop technology according to this purpose. Among the important elements of the crop technology there are counted the plant density. From this perspective, the aim of this paper is to present the biomass yields of two sorghum hybrids at different plant densities. In view to accomplish this aim, a field experiment was performed in the specific conditions from South Romania and under the climatic conditions of 2016, with two sorghum hybrids (BMR Gold X and EUG 542 F) sown under three plant densities: 22 plants.m^{-2}, 28 plants.m^{-2}, and 34 plants.m^{-2}. The biomass determinations were performed in the early dough – dough plant growth stage. For each experimental variant, there was calculated the fresh and dry biomass yield which was expressed in tons.ha^{-1}.

***Key words**: biomass, sorghum, yield, plant density.*

INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench) is an important fodder crop for both arid and semi-arid regions of the world (Tookalloo, 2014). Also it is used as food in Africa, India, China, and Central America, as well as in the food industry for starch, alcohol and beer production (Oprea et al., 2015). Moreover, sorghum is among the most important energy crops used for biomass production as substrate for obtaining biogas which is converted by combustion into power energy and heat.
Biomass, as a renewable energy source, is an important substitute for fossil fuels (Trulea et al., 2016). In fact, biomass is the most common form of renewable energy (McKendry, 2002). In the biogas production from biomass, sorghum may constitute an alternative for maize, which is characterised by a relatively high methane yield in biogas (Sałagan et al., 2012; Mahmood et al., 2013).
Compared to sorghum, the methan potential of maize was about 10% higher according to the "Baserga-model" (Zeise, 2014). But, in a field experiment performed in US in 2008 and 2009, sorghum bioenergy crops yielded more aboveground dry matter than maize in both years and in both irrigation and conservation tillage conditions; thus, in some production scenarios, sorghum may be superior to maize for cellulosic biomass (Rocateli et al., 2012).
The importance of sorghum as an energy crop is given by some advantages such as the drought tolerance, the great potential to produce biomass even under less favourable growing conditions, and the easiness to be cultivated. Therefore, in more arid areas, it could replace maize as a biofuel feedstock (Mekdad and Rady, 2016).
Sorghum as an energy crop is important especially in a system specialised for biomass production used as source of energy, which cannot rely only on maize because of the specific problems that could appear in a long term monoculture (Bășa et al., 2014).
Energy crops used for biogas production have to be easy to be cultivated and they have to be

not too much demanding for inputs (Dicu et al., 2016). For sorghum energy crops aimed to produce biomass, already there are created specialized hybrids for this purpose, but there is necessary also a specific crop technology. Among the important elements of the crop technology there are counted the plant density.

The optimum average seeding rate for sorghum grown for biomass is 247,000 seeds.ha^{-1}, but this value can be as high as 296,000 seeds.ha^{-1} and as low as 185,000 seeds.ha^{-1} depending on input and management scenarios (Kludze et al., 2011). In two field experiments carried out at three experimental stations in Germany in years 2008 and 2009, in most cases dry matter yield was not significantly affected by plant density as well as by row spacing (Mahmood, 2011).

Considering the importance of the plant density, the aim of this paper is to present the biomass yields of two sorghum hybrids at different plant densities.

MATERIALS AND METHODS

Our research was performed in a field experiment located in South Romania (44°29' N latitude and 26°15' E longitude) and under the climatic conditions of 2016, with two sorghum hybrids (BMR Gold X and EUG 542 F) sown under three plant densities: 22 plants.m^{-2}, 28 plants.m^{-2}, and 34 plants.m^{-2}.

The soil from the area where the field experiment was located is reddish preluvosoil, which is characterised by a humus content between 2.2 and 2.8%, clay loam texture, and pH between 6.2 and 6.6.

The climatic conditions in 2016 for the period April-August were characterised by the average temperature of 20.1°C and by the sum of rainfall of 284 mm. For the same period (April-August), the multiannual average temperature is 18.5°C and the multiannual average rainfall is of 313.2 mm. Thus, the year 2016 was warmer and drier than normal years for the studying area.

The preceding crop was maize. The ploughing was performed on 30th of October 2015. In the spring of 2016, the soil tillage consisted of a harrow work performed on 18th of March, which was followed by a combinator work performed on 28th of March. The sowing was performed on 20th of May 2016. The fertilization was performed after sowing with 80 kg of nitrogen per hectare applied as ammonium nitrate. Immediately after sowing and nitrogen fertilization, there was performed the weed control by the help of herbicide Glyphogan 480 SL based on active substance glyphosate 360 g.l^{-1} as isopropylamine salt, which was applied in a rate of 4 l.ha^{-1}.

The biomass determinations were performed in the early dough-dough plant growth stage, respectively in the moment when the sorghum biomass can be used as substrate for biogas production. The sorghum plants from one square meter in each experimental variant were cut at soil level and they were weighed immediately. The samples were taken in four replications. One sorghum plant for each variant and replication was taken into the laboratory for the determination of the dry biomass by oven drying at 80°C for 24 hours. For each experimental variant, there was calculated the average fresh and dry biomass yield which was expressed in tons.ha^{-1}. For each hybrid, the obtained data at different plant densities were statistically processed by analysis of variance (ANOVA), the control being taken the variants with 22 plants.m^{-2}.

RESULTS AND DISCUSSIONS

Increasing the plant density from 22 to 28 and respectively to 34 plants.m^{-2} leaded to an increase in the biomass yields at both sorghum hybrids (Figures 1 and 2). The increases were more consistent for fresh biomass yields then for dry biomass yields. However, increasing the plant density determined differences statistically significant only at the hybrid BMR Gold X, while at the hybrid EUG 542 F the differences were not statistically significant.

Even the hybrid BMR Gold X obtained important increasing in biomass yields determined by the increasing of plant density, the differences registered for the fresh biomass yields were statistically significant at both plant density, respectively at 28 and 34 plants.m^{-2}, while the differences registered for the dry biomass yields were statistically significant only for the plant density of 34 plants.m^{-2}.

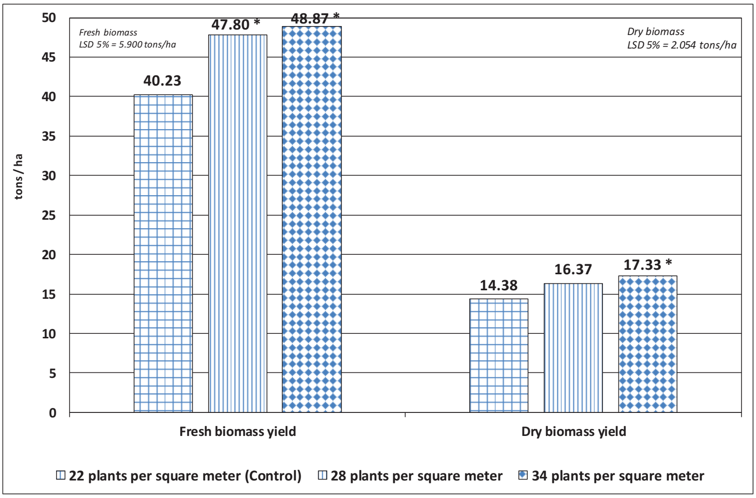

Figure 1. Fresh and dry biomass yields at different plant densities and at sorghum hybrid BMR Gold X

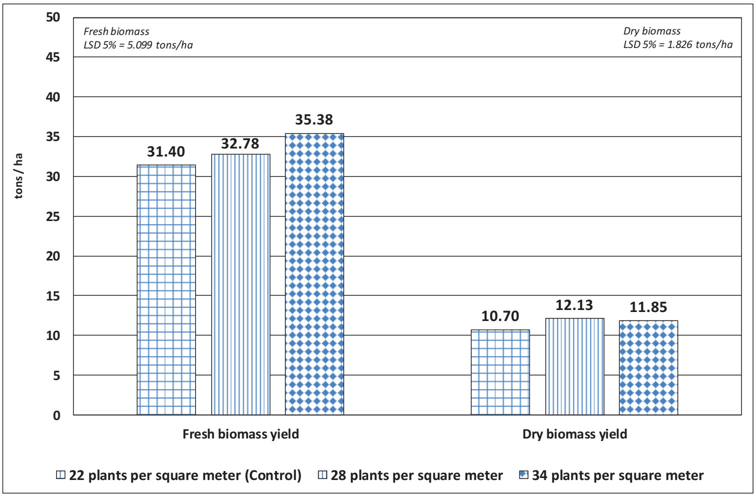

Figure 2. Fresh and dry biomass yields at different plant densities and at sorghum hybrid EUG 542 F

The fresh and dry biomass yields registered higher values at sorghum hybrid BMR Gold X (Figures 3 and 4).

Thus, average fresh biomass yield was of 45.63 tons.ha^{-1} at hybrid BMR Gold X, while at hybrid EUG 542 F it was of 33.19 tons.ha^{-1}.

The average dry biomass yield was of 16.03 tons.ha^{-1} at hybrid BMR Gold X, while at hybrid EUG 542 F it was of 11.56 tons.ha^{-1}.

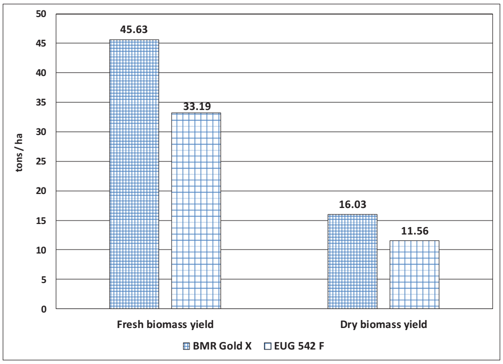

Figure 3. Fresh and dry biomass yields as average values at studied hybrids (BMR Gold X and EUG 542 F)

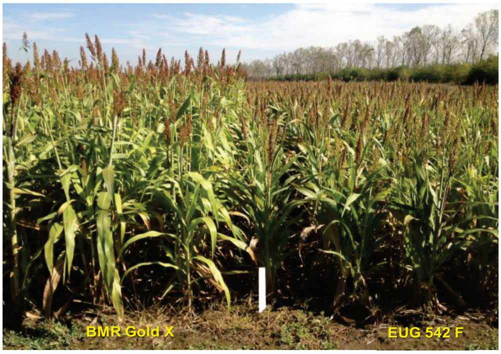

Figure 4. The field experiment with the two studied sorghum hybrids (BMR Gold X and EUG 542 F)

CONCLUSIONS

In our research, the hybrid BMR Gold X was more performant concerning the biomass yield compared to the hybrid EUG 542 F, and increasing of plant density leaded to the significant positive differences only for the hybrid BMR Gold X. These findings show that for biomass production, there is important the cultivated hybrid but also the choosing of the proper plant density according to the cultivated hybrid.

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REFERENCES

Bășa A.Gh., Ion V., Dumbravă M., Dicu G., State D., 2014. Biomass yield at sorghum at different distances between rows in the conditions of South Romania. 14th International Multidisciplinary Scientific GeoConference (SGEM), Energy and Clean Technologies Conference Proceedings, Vol. 1 - Renewable Energy Sources & Clean Technologies, p. 69-76.

Dicu G., Ion V., Horhocea D., State D., Ion N., 2016. Results regarding biomass yield at maize under different plant density and row spacing conditions. AgroLife Scientific Journal, Vol. 5, Nr. 2, p. 59-64.

Kludze H., Deen B., Dutta A., 2011. Report on Literature Review of Agronomic Practices for Energy Crop Production under Ontario Conditions. University of Guelph.

Mahmood A., 2011. Performance of Sorghum (*Sorghum bicolor* L. Moench) as an Energy Crop for Biogas Production. Thesis submitted for the requirement of doctoral degree in agriculture from Faculty of Agricultural and Nutritional Sciences, Home Economics and Environmental Management, Justus Liebig University Giessen, Germany.

Mahmood A., Ullah H., Ijaz M., Javaid M.M., Shahzad A.N., Honermeier B., 2013. Evaluation of sorghum hybrids for biomass and biogas production, Australian Journal of Crop Science, 7(10):1456-1462.

McKendry P., 2002. Energy Production from Biomass (part 1): Overview of Biomass. Bioresource Technology, 83, p. 37-46.

Mekdad A.A.A., Rady M.M., 2016. Productivity Response to Plant Density in Five Sorghum Bicolor Varieties in Dry Environments. Annals of Agricultural & Crop Sciences, 1(2):1009.

Oprea C.A., Marin D.I., Bolohan C., 2015. Influence of some technological factors on grain sorghum (*Sorghum bicolor* (L.) Moench var. *Eusorghum*) yield grown under the conditions of southeastern Romania. AgroLife Scientific Journal, Vol. 4, No 1, p. 123-130.

Rocateli A.C., Raper L.R., Balkcom K.S., Arriaga F.J., Bransby D.I., 2012. Biomass sorghum production and components under different irrigation/tillage systems for the southeastern U.S. Industrial Crops and Products, 36:589-598.

Sałagan P., Dobek T.K., Kołosowski P., 2012. Biogas yield from sorghum bicolor of Biomass 140 variety. Agricultural Engineering, Z. 4(140)T.2, p. 107-116.

Trulea A., Vintilă T., Popa N., Pop G., 2016. Mild alkaline pretreatment applied in the biorefinery of sorghum biomass for ethanol and biogas production. AgroLife Scientific Journal, Vol. 5, No 2, p. 156-159.

Tookalloo M.R., 2014. Effect of planting date and application of nitrogen on yield related traits of forage sorghum cultivars. Scientific Papers. Series A. Agronomy, Vol. LVII, p. 357-359.

Zeise K., 2014. Quality determining ingredients and methan potential of sorghum. Proceedings of 4th Central European Biomass Conference, 15-18 January, p. 247.

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RESEARCH REGARDING THE INFLUENCE OF MINERAL FERTILIZATION ALONG WITH *Bradyrhizobium japonicum* ON SOYBEAN GRAIN YIELD (*Glycine max* (L.) Merrill), UNDER THE CONDITIONS OF SOUTH - EAST ROMANIA

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Abstract

The research was conducted over two agricultural years 2014/2015 and 2015/2016, and aimed to assess the influence of mineral fertilization and seed inoculation with nitrogen fixing bacteria Bradyrhizobium japonicum on soybean grain yield. The research was based on a split plot experiment placed on a chromic luvisoil, which was previously cultivated with maize.

The results presented in this paper were obtained by analyzing the following factors: Factor A – soybean varieties from different maturity groups: Adsoy, Orion, Carla, Darina, PR92B63; Factor B – mineral fertilization levels $N_0P_{60}K_0$ *(Control),* $N_0P_{60}K_0$ *+ foliar fertilization;* $N_{45}P_{60}K_0$*;* $N_{45}P_{60}K_0$ *+ foliar fertilization;* $N_{45}P_{60}K_{45}$*;* $N_{90}P_{60}K_{45}$*; Factor C – soybean seeds inoculated with Nitragin Bac Soya (Bradyrhizobium japonicum); soybean seeds non-inoculated with Nitragin Bac Soya (Bradyrhizobium japonicum).*

The average grain yield of the soybean varieties was 1898.5 kg/ha, varying from 1319.80 kg/ha (Orion) to 2483.43 kg/ha (PR92B63), for variants where the soybean seeds were inoculated with Bradyrhizobium japonicum. In variants were soybean seeds weren't inoculated with nitrogen - fixing bacteria the average grain yield was 1829.80 kg/ha, varying from 1277.41 kg/ha (Orion) to 2483.43 kg/ha (PR92B63).

Mineral fertilization generated a grain yield increase of 30.2%. Seed inoculation with nitrogen fixing bacteria brought an increase of the grain the yield of 3.76%.

Key words*: soybean, grain yield, mineral fertilizer, Bradyrhizobium japonicum.*

INTRODUCTION

Soybean *Glycine max* (L.) Merrill is a valuable crop, highly appreciated due to seeds' high content in proteins 40% and oil 20 % (Mello Filho, 2005; Clemente, 2009; Subramanian, 2013). The agronomic importance of the crop is sustained by both, crop nutritional value and its ability to fix the molecular nitrogen from the atmosphere (Popescu, 2008).

Biological nitrogen fixation (BNF) has a direct contribution to improve the soil fertility (Cass, 1994; Tago, 2011; Matsumiya, 2013), replaces the use of synthetic nitrogen fertilizers (Peoples, 2009; Canfield, 2010; Kovačević, 2011) and has a positive influence on crops' grain yields (Van Kessel, 2000). Soybean crop has a high demand for nitrogen (N), thus for achieving 1000 kg grains, the crop is requiring 93 - 104 kg N (Diaconescu, 1971; Deac, 2013).

At the beginning of the growing season, soybean plants are getting about 50% of the required nitrogen (N) from the soil (Deac, 2013). After the installation of the symbiosis between plants' roots and nitrogen-fixing bacteria, *Bradyrhizobium japonicum* (Chețan, 2014), the rest of the required nitrogen (N) is achieved from the atmosphere (Deac, 2013). Specialized literature raises a lot of controversial results regarding the soybean crop nutrition with nitrogen (N) under field conditions (Kaschuk, 2016) mainly because of the plant's ability to acquire the required amounts of nitrogen from atmosphere (Salvagiotti, 2008; Caliskan, 2008). Some researches showed that nitrogen (N) fertilization is not necessary if soybean seeds are inoculated with *Bradyrhizobium japonicum* (Freeborn, 2001; Schmitt, 2001; Sogut, 2006). Other results showed that biological nitrogen fixation (BNF) is not enough, due to the fact that it can't supply the full requirements of the crop for nitrogen (N) (Wesley, 1998; Mahna, 2005; Caliskan, 2008, Janagard, 2013), thus it is required to apply mineral nitrogen (N) fertilizers to improve yield and quality of the harvest (Ray, 2006; Osborne, 2006; Gan, 2003; Caliskan, 2008).

Essential nutrients, nitrogen (N), phosphorus (P) and potassium (K) are playing a crucial role in increasing the productive potential of the soybean crop (Mohamed, 2011; Janagard, 2013). Applying nitrogen (N) fertilizers as a starter has a positive influence on soybean grain yields (Starling, 2000; Osborne, 2006; Janagard, 2013). Increases in production between 28% - 30% were reported when mineral nitrogen (N) was applied in stages R1-R3 (blooming) (Brevedan, 1978; Osborne, 2006).

Maximum nitrogen (N) requirements were recorded by the soybeans plants in reproductive phase (Hungria, 2006; Kaschuk, 2010; Kaschuk, 2016) and in the pods filling stage. An important role in soybean plants nutrition (Afzal, 2010; Jarecki, 2016) is owned by the availability of the macro and micro elements applied to soil or as a foliar fertilizer (Freeborn, 2001; Jarecki, 2016). Along with nitrogen (N), phosphorus (P) and potassium (K) are contributing efficiently in increasing the soybean grains yields.

Phosphorus has a positive influence on the nitrogen (N) biological fixation by increasing the number of active nodules per plant (Deac, 2013) and it improves soybean crop yield under drought conditions (Zheng, 2010; Kovačević, 2011).

Researches carried out in the West of Romania, showed the positive influence of phosphorus (P) on soybean grain yield. Applied in doses of 40 kg/ha and 80 kg/ha phosphorus (P) generated a growth between 183 kg/ha and 219 kg/ha compared to unfertilized.

Potassium (K) has a role in stimulating the plants in the vegetative growth period, increasing the plants' resistance to drought, pests, diseases and fall (Imas, 2007; Kovačević, 2011). It also has a major contribution in synthesizing the fats and depositing them in the grains (Giosan, 1986).

Potassium (K) fertilizers are more efficient when they are applied along with nitrogen (N), or with nitrogen (N) and phosphorus (P), KxN and KxNP (Burlacu, 2007). Some studies reported limitations of soybean grain yield (Imas, 2007) and a poor quality of the harvest due to the usage of potassium (K) fertilizers in inappropriate doses (Imas, 2007; Gill, 2008; Kovačević, 2011).

Absorption and assimilation of mineral fertilizers from the soil by soybean plants are highly dependent on climatic conditions during the growing season (Ranđelović, 2009; Mandić, 2015).

For correcting the nutritional deficiencies encountered by the plants during the vegetation period is recommended to apply foliar fertilizers (Ranđelović, 2009; Mandić, 2015). Application of urea as a foliar fertilizer at the beginning of the reproductive period (R2-R3) determined increases of soybean grain yields of 6-6.8% (Oko, 2003).

The purpose of this research was to determine the influence of mineral fertilization along with nitrogen fixing bacteria *Bradyrhizobium japonicum* on the grain yield of some soybean varieties, from different maturity groups *Glycine max* (L.) Merrill, in the field conditions of South-East Romania.

MATERIALS AND METHODS

The experiment was conducted at Moara Domneasca Didactic Farm, Ilfov County – (44°29'33''N, 26°15'20"E) during two agricultural years 2014/2015 - 2015/2016, placed on a chromic luvisoil. The research was based on the split plot method with three replications and the following factors tested:

Factor A – soybean variety: a_1 – Adsoy; a_2 – Orion; a_3 – Carla; a_4 – Darina;
a_5 - PR92B63;

Factor B – fertilization treatment with the following graduations: b_1 - $N_0P_{60}K_0$ (Control); b_2 - $N_0P_{60}K_0$ + Hortifor (foliar fertilizer); b_3 - $N_{45}P_{60}K_0$;b_4 - $N_{45}P_{60}K_0$ + Hortifor (foliar fertilizer); b_5 - $N_{45}P_{60}K_{45}$; b_6 - $N_{90}P_{60}K_{45}$;

Factor C — seeds inoculation before sowing: c_1 - inoculated seeds with Nitragin Bac Soya (*Bradyrhizobium japonicum*); c_2 – non-inoculated seeds.

Soybean varieties were sown at the distance of 50 cm between rows on 16th of April 2015 and on 9th of April 2016. Before sowing the soybean seeds were inoculated with Nitragin Bac Soya in a dose of 300 g/ha.

Seedbed preparation was made one day before sowing at 5-6 cm depth, using a pre-sowing combinator. Fertilizers were applied at the seedbed preparation and in vegetation. Foliar fertilization was made with Hortifor (N 30%; P_2O_5 20%; K_2O 10%; Fe 0,04%; Mn 0,025%; Cu 0,015%, Mo 0,001%), at 62 and 77 days after sowing in 2014/2015, and 67 and 84 days after sowing in 2015/2016.

In both years of research weeds were controlled in pre-emergence using the herbicide Dual Gold (1.5 l/ha) and after emergence with Basagran (2 l/ha) and Pantera (1.2 l/ha). The control of pests (*Tetranychus urticae)* was done using the insecticide Envidor 240 SC in a dose of 0.3 l/ha. In both years of experimentation the harvesting date for soybean varieties used in the research was different due to each variety maturity:

a_1 – Adsoy 0000, 17^{th} August 2015 (123 days after showing) and 12^{th} August 2016 (125 days after showing);

a_2 – Orion 0, 17^{th} August 2015 (123 days after showing) and 17^{th} August 2016 (125 days after showing);

a_3 – Carla 000 (ISTIS 2015), 07^{th} September 2015 (144 days after showing); 10^{th} September 2016 (154 days after showing);

a_4 – Darina 00, 07^{th} September 2015 (144 days after showing) 2015; 10^{th} September 2016 (154 days after showing);

a_5 – PR92B63 0, 19^{th} October 2015 (186 days after showing); 21^{th} October 2016 (195 days after showing).

Varieties belonging to different maturity group like Carla 000, and Darina 00, were harvested at the same date in the both years of research, 144 days after sowing in 2015 and 154 days after sowing in 2016 and for Orion 0, and Adsoy 0000 the harvest date was the same only in 2016, 125 after sowing.

RESULTS AND DISCUSSIONS

Variety influence on soybean grain yield, Moara Domnească

On average, in two years of research in variants where the soybean seeds were inoculated before sowing with Nitragin Bac Soya grain yield recorded was 1898.51 kg/ha, Table 1.

Carla, Darina and PR92B63 varieties recorded on average, positive grain yields ranging from + 3.4% to + 5.3% compared to Control (Average variety), without being statistically assured, Table 1. Adsoy and Orion varieties recorded on average the smallest grain yield values, representing 92.9% and 95% compared to Control. The highest grain yields were recorded in variants fertilized with $N_{45}P_{60}K_{45}$ + Nitragin Bac Soya and in $N_{90}P_{60}K_{45}$ + Nitragin Bac Soya with 115.29 kg/ha and 140.82 kg/ha.

Orion variety fertilized $N_{90}P_{60}K_{45}$ + Nitragin Bac Soya recorded 93.6% of Control, the difference of 155.29 kg/ha being distinct significantly negative.

The minimum grain yield was 1319.80 kg/ha (Orion, $N_0P_{60}K_0$ + Nitragin Bac Soya) and maximum was 2551.70 kg/ha (PR92B63, $N_{90}P_{60}K_{45}$ + Nitragin Bac Soya) statistically assured for both varieties (Table 1).

Table 1. Variety influence on soybean grain yield (GY, kg/ha) in variants inoculated with Soybean Nitragin Bac Soya, Average 2015-2016

	ADSOY		ORION		CARLA		DARINA		PR92B63		Average - Variety	
	GY kg/ha	Diff. %	GY kg/ha	Diff. %	GY kg/ha	Diff. %	GY kg/ha	Diff. %	GY kg/ha	Diff. %	GY kg/ha	%
$N_0P_{60}K_0$	1406.54^{ns}	96.1	1319.80^{0}	90.2	1533.01^{ns}	104.7	1523.09^{ns}	104.1	1535.94^{ns}	104.9	1463.68	Ct
$N_0P_{60}K_0$ + F	1486.34^{ns}	96.3	1397.93^{0}	90.6	1604.64^{ns}	104.0	1597.20^{ns}	103.5	1630.83^{ns}	105.7	1543.39	Ct
$N_{45}P_{60}K_0$	1705.22^{ns}	95.1	1675.93^{0}	93.4	1832.90^{ns}	102.2	1868.54^{ns}	104.2	1885.49^{ns}	105.1	1793.62	Ct
$N_{45}P_{60}K_0$+F	1825.05^{ns}	95.2	1813.25^{ns}	94.6	1956.68^{ns}	102.1	1977.50^{ns}	103.2	2008.84^{ns}	104.8	1916.26	Ct
$N_{45}P_{60}K_{45}$	2130.14^{0}	94.1	2114.86^{0}	93.4	2349.58^{ns}	103.8	2343.08^{ns}	103.5	2378.53^{*}	105.1	2263.24	Ct
$N_{90}P_{60}K_{45}$	2265.31^{0}	94.0	2255.59^{00}	93.6	2496.20^{ns}	103.5	2485.64^{ns}	103.1	2551.70^{*}	105.8	2410.89	Ct
Avg.	1803.10^{ns}	95.0	1762.89^{0}	92.9	1962.17^{ns}	103.4	1965.84^{ns}	103.5	1998.56^{ns}	105.3	1898.51	Ct
LSD 5% 110.18; LSD 1% 153.70; LSD 0.1% 216.68												
*Note: Ct – control, ns – not significant, * positive significance, 0 negative significance, F - Hortifor*												

In variants where only mineral fertilizers were applied, the average grain yield of varieties was 1829.80 kg/ha, lower with 68.71 kg/ha compared with variants where the seeds were inoculated with Nitragin Bac Soya before sowing (Table 2).

Compared to Control for the varieties Carla, Darina and PR92B63 the average yields increases were of 68.71 kg/ha (3.8%), 63.96 kg/ha (3.5%) and 90.96 kg/ha (5%) (Table 2). Orion and Adsoy had yield decreases between -9.1% and -3.4% (Table 2), compared with the average grain yield recorded by the tested varieties.

In variants fertilized with $N_{90}P_{60}K_{45}$ and $N_{45}P_{60}K_{45}$ Orion recorded a grain yield of 2063.27 kg/ha and 2194.79 kg/ha, with a difference distinctly negative compared to Control.

The maximum grain yield was achieved by PR92B63, 2483.43 kg/ha, in variants fertilized with $N_{90}P_{60}K_{45}$ and the lowest value was recorded by Orion in $N_0P_{60}K_0$, 1277.41 kg/ha. Compared to Control varieties recorded on average grain yield differences between -131.85 kg/ha and +90.96 kg/ha, Table 2.

Table 2. Variety influence on soybean grain yield (GY, kg/ha), in variants non-inoculated with Nitragin Bac Soya
Average 2015/2016

	ADSOY		ORION		CARLA		DARINA		PR92B63		Average – Variety	
	GY Kg/ha	%	GY Kg/ha	%	GY Kg/ha	%	GY Kg/ha	%	GY Kg/ha	%	GY Kg/ha	%
$N_0P_{60}K_0$	1358.21^{ns}	96.6	1277.41^{0}	90.9	1464.62^{ns}	104.2	1444.57^{ns}	102.8	1482.55^{ns}	105.5	1405.47	Ct
$N_0P_{60}K_0$ + F	1404.06^{ns}	95.1	1366.94^{0}	92.5	1535.58^{ns}	104.0	1523.47^{ns}	103.1	1555.16^{ns}	105.3	1477.04	Ct
$N_{45}P_{60}K_0$	1605.80^{ns}	95.3	1562.62^{0}	92.8	1746.43^{ns}	103.7	1744.23^{ns}	103.5	1764.34^{ns}	104.7	1684.68	Ct
$N_{45}P_{60}K_0$+F	1767.04^{ns}	95.5	1722.63^{0}	93.1	1922.55^{ns}	103.9	1910.51^{ns}	103.3	1927.18^{ns}	104.2	1849.98	Ct
$N_{45}P_{60}K_{45}$	2088.94^{0}	94.3	2063.27^{00}	93.2	2299.79^{ns}	103.8	2310.48^{ns}	104.3	2311.88^{ns}	104.4	2214.87	Ct
$N_{90}P_{60}K_{45}$	2204.11^{0}	93.9	2194.79^{00}	93.5	2422.07^{ns}	103.2	2429.29^{ns}	103.5	2483.43*	105.8	2346.74	Ct
Avg.	1738.02^{ns}	95.0	1697.95^{0}	92.8	1898.51^{ns}	103.8	1893.76^{ns}	103.5	1920.76^{ns}	105.0	1829.80	Ct

LSD 5% 108.76; LSD 1% 150.61; LSD 0.1% 209.81
*Note: Ct – control, ns – not significant, * positive significance, 0 negative significance, F – Hortifor*

Fertilization influence on soybean grain yield, Moara Domneasca

Table 3 presents the influence of fertilization on the grain yield, compared to Control $N_0P_{60}K_0$ + Bac Nitragin Soya.

The five varieties tested recorded an average grain yield increase between 5.4% and 64.7%. Fertilization with nitrogen doses of 45 kg/ha and 90 kg/ha, the usage of NPK complex fertilizers and foliar fertilizers had a very significant positive influence on the soybean varieties grain yield.

Regarding the treatment with $N_0P_{60}K_0$ + Hortifor + Nitragin Bac Soya the grain yield varied from 71.63 kg/ha (4.7%) and 94.88 kg/ha (6.2%), statistically unassured.

Fertilization with nitrogen in doses of 90 kg/ha brought yield increases of 858.76 kg/ha (Adsoy) and 1015.76 kg/ha (PR92B63) compared with Control (Table 3).

For variants where applied foliar treatments and nitrogen fertilizers in doses of 45 kg/ha were applied the average increase of yields was of 54.6%.

On average the mineral fertilizer along with Nitragin Bac Soya generated a grain yield increase of 29.7% for the soybean varieties tested at Moara Domneasca Didactic Farm.

Table 3. Fertilization influence on soybean varieties grain yields (GY, kg/ha) in variants inoculated with Nitragin Bac Soya, Average 2015-2016

	ADSOY		ORION		CARLA		DARINA		PR92B63		Average - Variety	
	GY Kg/ha	%	GY Kg/ha	%	GY Kg/ha	%	GY Kg/ha	%	GY Kg/ha	%	GY Kg/ha	%
$N_0P_{60}K_0$	1406.54^{ns}	Ct.	1319.80^{ns}	Ct.	1533.01^{ns}	Ct.	1523.09^{ns}	Ct.	1535.94^{ns}	Ct.	1463.68^{ns}	Ct.
$N_0P_{60}K_0$ + F	1486.34^{ns}	105.7	1397.93^{ns}	105.9	1604.64^{ns}	104.7	1597.20^{ns}	104.9	1630.83^{ns}	106.2	1543.39^{ns}	105.4
$N_{45}P_{60}K_0$	1705.22***	121.2	1675.93***	127.0	1832.90***	119.6	1868.54***	122.7	1885.49***	122.8	1793.62***	122.5
$N_{45}P_{60}K_0$+F	1825.05***	129.8	1813.25***	137.4	1956.68***	127.6	1977.50***	129.8	2008.84***	130.8	1916.26***	130.9
$N_{45}P_{60}K_{45}$	2130.14***	151.4	2114.86***	160.2	2349.58***	153.3	2343.08***	153.8	2378.53***	154.9	2263.24***	154.6
$N_{90}P_{60}K_{45}$	2265.31***	161.1	2255.59***	170.9	2496.20***	162.8	2485.64***	163.2	2551.70***	166.1	2410.89***	164.7
Avg.	1803.10***	128.2	1762.89***	133.6	1962.17***	128.0	1965.84***	129.1	1998.56***	130.1	1898.51***	129.7
*LSD 5% 98.23; LSD 1% 130.33; LSD 0.1% 168.89; Note: Ct – control, ns – not significant, * positive significance, 0 negative significance; F - Hortifor*												

Table 4. Fertilization influence on soybean varieties grain yield (GY kg/ha) in variants non-inoculated with Nitragin Bac Soya (Moara Domnească, Average 2014-2015)

	ADSOY		ORION		CARLA		DARINA		PR92B63		Average – Variety	
	GY Kg/ha	%	GY Kg/ha	%	GY Kg/ha	%	GY Kg/ha	%	GY Kg/ha	%	GY Kg/ha	%
$N_0P_{60}K_0$	1358.21	Ct.	1277.41	Ct.	1464.62	Ct.	1444.57	Ct.	1482.55	Ct.	1405.47	Ct.
$N_0P_{60}K_0$ + F	1404.06***	103.4	1366.94***	107.0	1535.58***	104.8	1523.47***	105.5	1555.16***	104.9	1477.04***	105.1
$N_{45}P_{60}K_0$	1605.80***	118.2	1562.62***	122.3	1746.43***	119.2	1744.23***	120.7	1764.34***	119.0	1684.68***	119.9
$N_{45}P_{60}K_0$+F	1767.04***	130.1	1722.63***	134.9	1922.55***	131.3	1910.51***	132.3	1927.18***	130.0	1849.98***	131.6
$N_{45}P_{60}K_{45}$	2088.94***	153.8	2063.27***	161.5	2299.79***	157.0	2310.48***	159.9	2311.88***	155.9	2214.87***	157.6
$N_{90}P_{60}K_{45}$	2204.11***	162.3	2194.79***	171.8	2422.07***	165.4	2429.29***	168.2	2483.43***	167.5	2346.74***	167.0
Avg.	1738.02***	128.0	1697.95***	132.9	1898.51***	129.6	1893.76***	131.1	1920.76***	129.6	1829.80***	130.2
*LSD 5% 109.62 kg/ha; LSD 1% 145.43 kg/ha; LSD 0.1% 188.46 kg/ha Note: Ct – control, ns – not significant, * positive significance, 0 negative significance, F – Hortifor*												

For non-inoculated variants, Table 4, the average grain yield recorded values between 1405.47 kg/ha ($N_0P_{60}K_0$, Ct.) and 2346.74 kg/ha ($N_{90}P_{60}K_{45}$).

Treatment with complex fertilizers $N_{90}P_{60}K_{45}$ determined a very significantly positive increase in yield, of 845.90 kg/ha (Adsoy) and 1000.88 kg/ha (PR92B63) (Table 4). All the tested varieties recorded increased grain yields very significantly positive between 45.85 kg/ha (+3.4%) and 89.53 kg/ha (+7%), in variants treated with $N_0P_{60}K_0$ + Hortifor. In variants treated with $N_{45}P_{60}K_0$+Hortifor grain yields varied compared to control from +30% to +34.9% (Table 4). The positive influence of fertilization on the grain yield was significant for all the five soybean varieties tested.

Inoculation with Bradyrhizobium japonicum (Nitragin Bac Soya) influence on soybean grain yields, Moara Domneasca

Inoculation with Nitragin Bac Soya before sowing, for the five varieties tested in South-East of Romania between 2014/2015 - 2015/2016 brought grain yield increases between 2.18% and 6.47%. The data in Table 4 highlights the influence of the treatment with Nitrogen Bac Soya inoculant, *Bradyrhizobium japonicum*, compared to non-inoculated, Control (Ct.). On average the seed inoculation with Nitragin Bac Soya, with nitrogen - fixing bacteria *Bradyrhizobium japonicum* generated a grain yield increase of 68.71 kg/ha (3.76%), statistically assured (Table 5).

Table 5. Mineral fertilization along with Nitragin Bac Soya inoculant influence on soybean varieties grain yield (GY kg/ha) (Moara Domnească, Average 2014-2015)

	Non – Inoculated (a_1)			Inoculated (a_2)		Diff.	
	GY Kg/ha	%	Signf.	GY Kg/ha	%	a2-a1 Kg/ha	Signf.
$N_0P_{60}K_0$	1405.47	100.00	Ct	1463.68	104.14	58.21	-
$N_0P_{60}K_0$ + F	1477.04	100.00	Ct	1543.39	104.49	66.34	+
$N_{45}P_{60}K_0$	1684.68	100.00	Ct	1793.62	106.47	108.93	++
$N_{45}P_{60}K_0$+F	1849.98	100.00	Ct	1916.26	103.58	66.28	+
$N_{45}P_{60}K_{45}$	2214.87	100.00	Ct	2263.24	102.18	48.37	-
$N_{90}P_{60}K_{45}$	2346.74	100.00	Ct	2410.89	102.73	64.15	+
Avg.	1829.80	100.00	Ct	1898.51	103.76	68.71	+

LSD 5% 58.94 kg/ha; LSD 1% 82.53 kg/ha; LSD 0.1% 121.22 kg/ha
*Note: Ct – control, ns – not significant, * positive significance, 0 negative significance, F – Hortifor*

The five varieties tested recorded a maximum grain yield statistically assured of 108.93 kg/ha (6.4%), and a minimum of 48.37 kg/ha, uninsured statistically.

Correlation between doses of active fertilizers on soybean grain yield

The grain yield of the five varieties tested was strongly influenced by the mineral fertilizers and by Nitragin Bac Soya inoculant, *Bradyrhizobium japonicum*.

The high positive correlation between fertilizer doses (a.s.) is supported by a coefficient with the value r = 0.98635, the increased grain yields are due in a proportion of 98% to the doses of active substance fertilizers applied, supported by the determination coefficient R^2 = 0.9729 (r*** = 0.98635 very significant positive) (Figure 1).

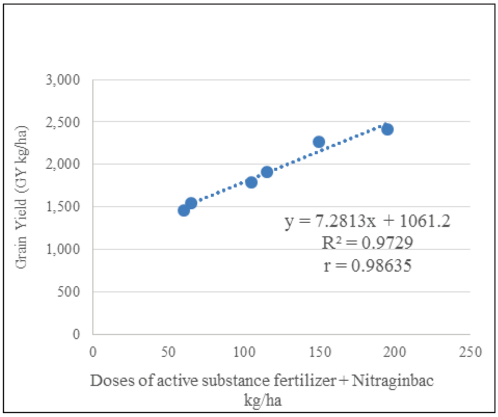

Figure 1. Correlation between the grain yield (GY kg/ha) of soybeans varieties and the doses of active substance fertilizers along with Nitragin Bac Soya (kg/ha)

Influence of active doses of fertilizer on the grain yields for the tested varieties (Figure 2) in non-inoculated variants is supported by a correlation coefficient with a value r*** = 0.9715 very significant positive.

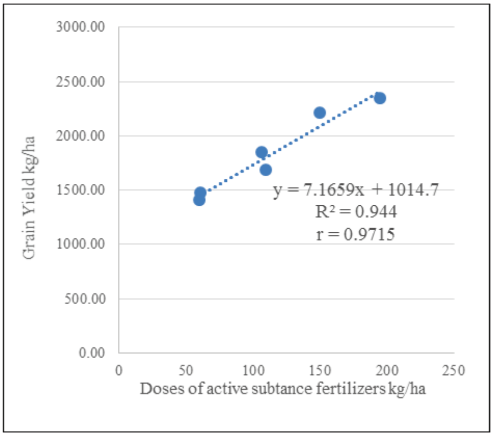

Figure 2. Correlation between the grain yield (GY kg/ha) of soybeans varieties and the doses of active substance (kg/ha) in variants non-inoculated, Nitragin Bac Soya

The relationship between grain yield and the amount of active substance applied is described by the regression line having a positive slope (Figure 2).
The increased grain yield was influenced in a proportion of 94% by the doses of active substance fertilizers applied, supported by the determination coefficient R^2 = 0.944.

CONCLUSIONS

Research conducted in South - East of Romania at Moara Domneasca Didactic Farm, Ilfov

County, during two agricultural years 2014/2015 - 2015/2016 highlights the positive influence of different doses of fertilizers along with inoculation with *Bradyrhizobium japonicum*, on the grain yields of five soybean varieties from different maturity groups.

Mineral fertilization along with inoculation with Nitragin Bac Soya, *Bradyrhizobium japonicum*, generated grain yields between 1319.80 kg/ha (Orion, $N_0P_{60}K_0$ + Nitragin Bac Soya) - 2551.70 kg/ha (PR92B63, $N_{90}P_{60}K_{45}$ + Nitragin Bac Soya). For non-inoculated variants, the grain yields ranged between 1277.41 kg/ha (Orion, $N_0P_{60}K_0$) - 2483.43 kg/ha (PR92B63, $N_{90}P_{60}K_{45}$).

For variants fertilized with $N_{45}P_{60}K_0$ + Nitrogen Bac Soya the five varieties tested recorded an average increase of grain yield of 108.93 kg/ha, compared with non-inoculated variants. Inoculation with Nitragin Bac Soya, nitrogen - fixing bacteria *Bradyrhizobium japonicum* generated a grain yield increase of 68.71 kg/ha (3.76%), statistically assured.

REFERENCES

Afzal A., Bano A., Fatima M., 2010. "Higher soybean yield by inoculation with N-fixing and P-solubilizing bacteria." *Agronomy for Sustainable Development 30* 487-495.

Brevedan R.E., Egli D.B., Leggett. J.E., 1978. "Influence of N nutrition on flower and pod abortion and yield of soybeans." *Agronomy journal, 70(1)* 81-84.

Burlacu G., Popescu. A., Maravela. V., 2007. "Rezultate ale cercetărilor in domeniul folosirii raționale a îngrășămintelor." *I.N.C.D.A. Fundulea, VOL. LXXV. Fertilizarea și nutriția plantelor. Volum Jubiliar* 287-307.

Caliskan S., Ozkaya I., Caliskan M., E., Arslan M. 2008. "The effects of nitrogen and iron fertilization on growth, yield and fertilizer use efficiency of soybean in a Mediterranean-type soil." *Field Crops Research, 108(2)* Field Crops Research, 108(2), 126-132.

Cass A., Gusli. S., Mac D., 1994. "Sustainability of Soil Structure Quality in Rice Paddy-Soya-Bean Cropping Systems in South Sulawesi Indonesia." *Soil and Tillage Research 31(4)* 339-52.

Cheţan F., Rusu T., Chetan C., Simon A., Ignea M., Deac V., 2014. "Rezultate de producţie obţinute la soia în sistemul de lucrări minime ale solului în perioada 2007-2012, la S.C.D.A. Turda." *I.N.C.D.A. Fundulea VOL. LXXXI* 216-226.

Clemente T.E., Cahoon E.B., 2009. "Soybean oil: genetic approaches for modification of functionality and total content." *Plant physiology, 151(3)* 1030-1040.

Deac V., Rotar I., Mălinaș A., 2013. "Basic Fertilization With Mineral Fertilizers in Soybean crop." *Bulletin UASMV serie Agriculture 70(1)/2013* 218-222.

Diaconescu O., Miclea E., 1971. *Soia.* București: Ceres.

Freeborn J.R., Holshouser., D.L. Alley M.M., Powell N.L., Orcutt D.M., 2001. "Soybean yield response to reproductive stage soil-applied nitrogen and foliar-applied boron." *Agronomy Journal, 93(6)* 1200-1209.

Galloway J.N., Schlesinger W.H., Levy H., Micaels A., Schnoor J.L., 1995. "Nitrogen fixation: Atmospheric enhancement-environmental response." *Global Biogeochem Cycles, Vol. 9* 235-252.

Gan Y., Stulen I., Van Keulen H., Kuiper P.J. 2003. "Effect of N fertilizer top-dressing at various reproductive stages on growth, N 2 fixation and yield of three soybean (Glycine max (L.) Merr.) genotypes." *Field Crops Research, 80(2)* 147-155.

Gill M.S., Singh V.K., Shukla A.A, 2008. "Potassium Management for Enhancing. Productivity in Soybean-based Cropping System." *Indian J. of Fertilizers, Vol. 4* 13-22.

Giosan N., Nicolae, I., Sin Gh., 1986. *Soia.* București: Ed. Academiei Române.

Hungria M., Franchini J.C., Campo R.J., Crispino C.C., Moraes J.Z., Sibaldelli R.N., Arihara J., 2006. "Nitrogen nutrition of soybean in Brazil: contributions of biological N2 fixation and N fertilizer to grain yield." *Can. J. Plant Sci., 86* 927–939.

Imas P., Magen H., 2007. "Role of potassium nutrition in balanced fertilization for soybean yield and quality-Global perspective." *World, 92(220.55)* 2-38.

ISTIS. 2015. *Catalogul oficial al soiurilor de plante de cultura din Romania.* Bucuresti: I.S.T.I.S.

Janagard M.S., Raei Y., Gasemi G.K., Aliasgarzad N. 2013. "Soybean response to biological and chemical fertilizers." *International Journal of Agriculture and Crop Sciences, 5(3)* 261.

Jarecki W., Buczek J., Bobrecka-Jamro D. 2016. "Response of soybean (Glycine max (L.) Merr.) to bacterial soil inoculants and foliar fertilization." *Plant Soil and Enviroment, 62(9)* 422-427.

Kaschuk G, Hungria. M., Leffelaar P.A., Giller K.E., Kuyper T.W., 2010. "Differences in photosynthetic behaviour and leaf senescence of soybean (Glycine max [L.] Merrill) dependent on N2 fixation or nitrate supply." 60-69.

Kaschuk G., Nogueira M.A., de Luca., M.J., Hungria M., 2016. "Response of determinate and indeterminate soybean cultivars to basal and topdressing N fertilization compared to sole inoculation with Bradyrhizobium." *Field Crops Research, 195* 21-27.

Kinugasa T., Takashi Sato, T., Oikawa S., Hirose T., 2012. "Demand and supply of Nin seed production of soybean (Glycine max) at different N fertilization levelsafter flowering." *J. Plant Res. 15* 275-281.

Kovačević V., Sudarić A., Antunović M., 2011. *Mineral nutrition.* Croatia: InTech Publisher.

Mahna S.K., 2005. "Soybean cultivation and BNF in China. Nitrogen Fixation in Agriculture, Forestry, Ecology and the Environment." 43-66. Netherlands, 2005: Springer.

Mandić V., Simić A., Krnjaja V., Bijelić Z., Tomić Z., Stanojković A., Ruzić-Muslić D., 2015. "Effect of foliar fertilization on soybean grain yield." *Biotechnology in Animal Husbandry, 31(1)* 133-143.

Matsumiya Y., Horii S., Matsuno T., Kubo M., 2013. *Soybean as a Nitrogen Supplier.* Croatia: INTECH Open Access Publisher.

Mello Filho O.L.D, Sediyama C.S., Moreira M.A., Reis M.S., Massoni G.A., Piovesan N.D. 2005. "Grain yield and seed quality of soybean selected for high protein content." *Pesquisa Agropecuária Brasileira, 39(5)* 445-450.

Mohamed A.M., Ananthi T., Subramanian K.S., Muthukrishnan P., 2011. "Influence of mycorrhiza, nitrogen and phosphorus on growth, yield and economics of hybrid maize." *Madras Agric. J. 98 (1-3)* 62-66.

Oko B.F.D., Eneji A.E., Binang W., Irshad M., Yamamoto S., Honna T., Endo T., 2003. "Effect of foliar application of urea on reproductive abscission and grain yield of soybean." *Journal of plant nutrition, 26(6)* 1223-1234.

Osborne S.L., Riedell W.E., 2006. "Starter nitrogen fertilizer impact on soybean yield and quality in the Northern Great Plains." *Agronomy Journal, 98(6)* 1569-1574.

Popescu E.M., Roman GH.V., 2008. "Cercetări privind biologia şi productivitatea culturii intercalate porumb-soia în condiţiile sistemului de agricultură ecologic." *Lucrări Ştiinţifice – vol. 51, seria Agronomie* 341-350.

Ranđelović V., Prodanović S., Prijić L., Glamočlija Đ., Živanović L., & Kolarić L. 2009. "Uticaj folijarnog prihranjivanja u stresnim uslovima na dve sorte soje različitih grupa zrenja." *Zbornik naučnih radova Instituta PKB Agroekonomik, 15* 1-2.

Ray J.D., Fritschi F.B., Heatherly L.G. 2006. "Large applications of fertilizer N at planting affects seed protein and oil concentration and yield in the Early Soybean Production System." *Field crops research, 99(1)* 67-74.

Salvagiotti F., Cassman K.G., Specht J.E., Walters D.T., Weiss A., Dobermann A. 2008. "Nitrogen uptake: fixation and response to fertilizer N in soybeans: areview." *Field Crops Res. 108* 1-13.

Schmitt M.A., Lamb J.A., Randall G.W., Orf J.H., & Rehm G.W., 2001. "In-season fertilizer nitrogen applications for soybean in Minnesota." *Agronomy Journal, 93(5),* 983-988.

Sogut T., 2006. "Rhizobium inoculation improves yield and nitrogen accumulation in soybean (Glycine max) cultivars better than fertiliser." *New Zealand journal of crop and horticultural science, 34(2)* 115-120.

Starling M.E., Wood C.W., Weaver D.B., 2000. "Late-planted soybeans respond to nitrogen starter." *Fluid J, 28* 26-30.

Subramanian S., Smith D.L., 2013. *A proteomics approach to study soybean and its symbiont Bradyrhizobium japonicum-a review.* INTECH Open Access Publisher.

Tago K., Ishii S., Nishizawa T., Otsuka S., Senoo K., 2011. "Phylogenetic and Functional Diversity of Denitrifying Bacteria Isolated from Various Rice Paddy and Rice-Soybean Rotation Fields." *Microbes and Environments, 26(1)* 30-5.

Van Kessel C., Hartley C., 2000. "Agricultural management of grain legumes: has it led to an increase in nitrogen fixation?" *Field Crops Research, 65(2)* 165-181.

Wesley T.L., Lamond R.E., Martin V.L., Duncan S.R., 1998. "Effects of late-season nitrogen fertilizer on irrigated soybean yield and composition." *Journal of Production Agriculture, 11(3)* 331-336.

Zambiazzi E.V., Bruzi A.T., de Carvalho M.L.M., Soares I.O., Zuffo A.M., de Rezende P.M., Miranda D.H. 2014. "(2014). Potassium fertilization and physiological soybean seed quality." *Agricultural Sciences, 5(11), 984* 984-990.

Zheng H., Chen L., Han X., Ma Y., Zhao X., 2010. "Effectiveness of phosphorus application in improving regional soybean yields under drought stress: A multivariate regression tree analysis." *African Journal of Agricultural Research, 5(23)* 3251-3258.

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DETERMINATION OF *Tobacco mosaic virus* IN TOBACCO FIELDS IN DENIZLI PROVINCE, TURKEY

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Abstract

This study was carried out to detect of Tobacco mosaic virus (TMV) in tobacco growing areas in Denizli province, Turkey. Total of 94 plant samples including mosaic, curling of leaves, chlorotic lesion and stunding symptoms were collected from the fields in Denizli province during 2015-2016 years. Presence of Tobacco mosaic virus was investigated using Double antibody sandwich enzyme linked immunosorbent assay (DAS-ELISA) method. As a result of DAS-ELISA, it was found 30.85% of leaf samples with TMV.

***Key words**: tobacco, TMV, DAS-ELISA.*

INTRODUCTION

Tobacco (*Nicotiana tabacum* L.) is an annual plant from the family *Solanaceae*. *Nicotiana tabacum* is one of more than 60 species in the genus *Nicotiana*. By selecting locally adapted plants many variations have been stabilised as cultivars and different tobacco types have developed namely Virginia, flue-cured, air-cured, fire-cured, burley, oriental also called Turkish tobaccos are world wide variations of the same species. Disease resistances have been transferred by various breeding techniques from the related species of this genus, many of which have only a very small leaf on a small shrub. The types of tobacco vary in their morphology, quality, taste, aroma and final use in the blending of mixtures for use as base material for cigars, cigarettes, chewing tobacco or snuff (Ergün and Uğurlu, 2006).

Tobacco can be used in pipe, cigarette, paint, soap industry, cologne and perfume making (Şahin and Taşlıgil, 2013).

The homeland of tobacco is stated to be Central America. China is the leader in worldwide tobacco production as of 2014 with 3,000,000 tons. It is followed by Brasilia, India and USA. Whereas Turkey is ranked tenth with 90,000 tons. Denizli province is important for tobacco production due to their soil and climatic properties and rich irrigation facilities. Especially, high quality tobacco is produced in Kale and Tavas districts of Denizli (Tüik, 2015).

Significant efficiency losses occur in tobacco cultivation due to wrong or insufficient agricultural applications as well as biotic and abiotic disease factors. There are many fungi, bacteria and virus based diseases in the tobacco cultivation areas which limit cultivation.

Virus diseases are significant among these factors due to their chemical and physical structures, sizes, types of infection, symptom formation, transport and the lack of an effective struggle against them (Agrios, 1997).

The viruses that are observed in tobacco which cause significant losses in efficiency are as follows: *Tobacco mosaic virus (*TMV*)*, *Tomato mosaic virus (*ToMV*)*, *Cucumber mosaic virus (*CMV*)*, *Potato Y virus (*PVY*)*, *Tobacco etch virus* (TEV) (Brunt et al., 1996; Zhu et al., 2002).

TMV belongs to the *Tobamovirus* type. Virus includes linear single helical RNA genome. It has a rod shaped particle structure. The virus has a length of about 300 nm and a width of about 18 nm. Virus particles consist of % 5 nucleic acid; % 95 protein. The genome is single pieced (Goelet et al., 1982).

Tobacco mosaic virus is an economically important disease infecting tobacco and other *Solanaceous* crops worldwide. TMV infects

199 different species from 30 families (Bagley, 2001).
TMV can be spread from plant to plant is on workers' hands, clothing or on tools.The disease is mechanically transmitted, resulting in quick and effective infection. TMV can be transmitted to seedlings from the contaminated seeds. First symptoms in infected plants is vein clearing. Soon after vein clearing, mosaic symptoms occur in the newer leaves. It was seen the malformation of leaves and stunting in tobacco plants (Baker and Adkins, 2000; Dawson, 1999).
TMV in different crops have previously been detected in Turkey (Yılmaz et al., 1983; Yılmaz and Davis, 1985; Bostan and Dursun, 2002; Arlı-Sökmen et al., 2005; Şevik and Köse-Tohumcu, 2011; Paylan et al., 2011; Sertkaya, 2012; Pazarlar et al., 2013).
The existence of virus diseases, their harms and their symptoms vary in accordance with the type of the tobacco plant as well as the environmental conditions. That is why, first the detection of the viruses in the culture plant that is cultivated should be made in order to minimize the damages caused by virus disease and to develop control methods. It is not correct to carry out diagnosis based only on observation for virus diagnosis.
The aim of this study is to determine TMV in the tobacco cultivation areas of Denizli province by DAS-ELISA method.

MATERIALS AND METHODS

The main material of this study consists of 94 leaf samples which show virus disease symptoms and which are thought to be infected with virus. The samples were collected from the tobacco cultivation areas (6 locations) during June-September in 2015-2016. The samplings were made from plants with leaf deformation, leaf curling, necrosis formation on the leaves, mosaic symptoms and stunting symptoms (Figure 1). The samples were labeled inside polyethylene bags and brought to the laboratory in ice boxes to be preserved in deep freezer (-20^{o}C) until the required tests were carried out.

Figure 1. Tobacco growing areas in Tavas District of Denizli province

ToMV-DAS-ELISA (Agdia, Inc, Elkhart, IN) commercial kit was used in the study. The application was carried out in accordance with the procedure of the commercial company. Accordingly, 100 µl of IgG was added to each of the hole of ELISA plate, which was diluted in the coating buffer at a ratio of 1:1000 which was then kept at +4º C for overnight.
Afterwards the ELISA plates were washed with the washing buffer. The washing was repeated 3 times. The plant extracts prepared by diluting at a ratio of 1/10 using extraction buffer was added to each hole as 100 µl and was kept overnight at +4º C. Washing was repeated the next day. After washing process, conjugated antibody was diluted at a ratio of 1:1000 in the conjugate buffer, 100 µl was added to each hole and was kept at 37ºC for 2 hours.
After the washing process, each substrate prepared as 1 mg/ml in the substrate solution was added to each hole as 100 µl and was left to wait at room temperature.
Values that give at least twice or higher readings in comparison with the negative control value according to the absorbance values read at 405 nm have been accepted as positive (Özaslan et al., 2006; Şevik and Köse-Tohumcu, 2011).

RESULTS AND DISCUSSION

Symptoms such as leaf deformation, leaf curling, decoloring of the leaves, necrotic local lesion on the leaves, mosaic symptoms, vein yellowing and stunting symptoms have been observed and these plants have been photographed during the survey (Figure 2; Figure 3). The symptoms were similar to those obtained in previous studies and support the suggestion that the virus may be TMV (Bagley, 2001; Khateri et al., 2008; Wei et al., 2014). DAS-ELISA tests were carried out on the leaf samples collected from 94 plants with virus infection symptoms in order to determine the existence of TMV. The results showed that 29 out 94 samples were infected with TMV. Whereas TMV infection rate for 94 of the collected samples was determined as 30.85% (Table 1).

Figure 2. Mosaic and leaf deformation symptoms on tobacco leaves

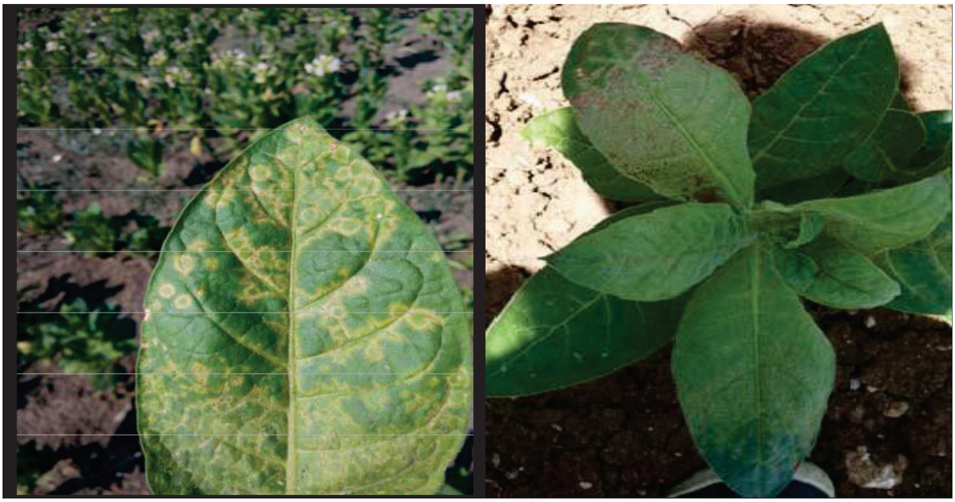

Figure 3. Ringspot and necrotic local lesion on tobacco leaves

Table 1. Samples tested, place where samples taken, number of infected samples determined by DAS-ELISA method, percentage of infection

Locations	Total Sample	TMV-infected samples	% TMV
Karaköy	35	6	17.14%
Altınova	22	9	40.91%
Sofular	6	2	33.33%
Gülözü	23	9	39.13%
Çalıköy	5	3	60.00%
Keçeliler	3	0	0.00%
TOTAL	94	29	30.85%

Nas et al. (1975) have used the sap inoculation method for identification of TMV of tobacco plants in Adana and Hatay provinces in Turkey. It has been found in this study as a result that the average disease ratio is 1.55% in Adana province and 2.04% in Hatay province.

Six tobacco samples collected from Karaköy location, nine tobacco samples collected from Altınova and Gülözü locations, two tobacco samples collected from Sofular location and three tobacco samples collected from Çalıköy location which tested positive for TMV by DAS-ELISA.

Samples collected from Keçeciler location were not found be infected with TMV (Table 1).

Virus based diseases are quite significant due to the facts that their control is mostly hard and indeed impossible, that there is no effective chemicals and that the viruses spread far and wide via vector insects.

It is essential to first diagnose the viruses found in the cultivated culture plant in order to minimize the damages due to viruses and to develop control strategies.

The symptomatologic studies that will be carried out based on observation for defining the viruses should be supported with serologic or molecular tests that will be carried out. It is possible to take precautions for the control of this virus disease only after carrying out the diagnosis of this factor (Agrios, 1997).

The ELISA tests used in the diagnosis work for many plant viruses have widely been used by researchers (Yılmaz and Davis, 1985; Khateri et al., 2008; Şevik and Köse-Tohumcu, 2011). The fact that it is fast, sensitive, economical and reliable makes this method a preference (Vinayarani et al., 2011).

In a survey conducted in the Azerbaijan and Guilan provinces of Iran for viruses infecting tobacco *Tobacco streak virus* (TSV), *Tomato spotted wilt virus* (TSWV), *Tobacco etch virus* (TEV), *Tobacco ringspot virus* (TRSV), *Potato virus Y* (PVY), *Cucumber mosaic virus* (CMV) and *Tobacco mosaic virus* (TMV) were detected among tobacco leaf samples, by ELISA.

It has been found that the most severe mosaic type symptoms including the deformation and blistering on leaves were mainly seen in the infections by CMV and TMV (Khateri et al., 2008).

Şevik and Köse-Tohumcu, (2011) reported that TMV was identified by DAS-ELISA in seed and seedling. It has been found in this study as a result of DAS-ELISA tests on the leaf samples that 93 of the 400 samples were infected with TMV.

In this study, the existence of TMV in tobacco cultivation areas at Denizli province have been found out using serological method. No study has been carried out previously in the region to detect TMV.

CONCLUSIONS

TMV can survive in seed and in soil. TMV contaminated soil should be discarded. During the growing season, infected plants should be removed from field.

Crop rotation is also very important. However, resistant plants or rotational crop should be employed to reduce the amount of inoculum in the field. Rotational crop should not belong to the *Solanaceous* family. Farmers should be informed about how viruses spread from plant to plant and the precautions for controlling virus transmission. The results of this study showed that DAS-ELISA can be used for TMV diagnosis and certification. However, ELISA is easier, less expensive and less time- consuming.

REFERENCES

Agrios G.N., 1997. Plant Pathology. Academic Press Inc. New York, USA. 635p.

Arlı-Sökmen M., Mennan H., Şevik M.A, Ecevit O., 2005. Occurence of viruses in field-grown pepper crops and some of their reservoir weeds hosts in Samsun, Turkey. Phytoparasitica, 33(4): 347- 358.

Bagley C.A., 2001. Controlling Tobacco mosaic virus in tobacco through resistance. Faculty of the Virginia Polytechnic Institute and State University. Master Thesis, 74p.

Baker C., Adkins S., 2000. Peppers, tomatoes, and Tobamo-viruses. Plant Pathology Section Circulars No: 400 (http:// freshfromfl.com/pi/enpp/ pathology/ pathcirc/ pp 400.).

Bostan H., Dursun A., 2002. Identification of some virus diseases in pepper production areas in Kemaliye and Yusufeli Districts. Atatürk University, Agriculture Faculty Journal, 33(4): 391-392.

Brunt A.A., Craptree K., Dolywitz M., Gibs A., Watson L., 1996. Viruses of Plant Description and Lists from the Vide Database. University Pres, Cambridge, U.K. 1444p.

Dawson W.O., 1999. Tobacco mosaic virus virulence and avirulence. Philosophical Transactions of the Royal Society of London, 354:645-651.

Ergün S.G., Uğurlu K.E., 2006. Tobacco planting in Turkey since 1935 to present, regional changes in production, and effects of the alternative product project. IV. National Geography Symposium, 25-26 May, 2006, Ankara, Turkey.

Goelet P., Lomonossoff G.P., Butler P.J.G., Akam M.E., Gait M.J., Karn J., 1982. Nucleotide sequence of tobacco mosaic virus RNA. Proceeding of the National Academy of Sciences of the USA, 79: 5818-5822.

Khateri H., Moarrefzadeh N., Mosahebi G., Koohi-Habibi M., 2008. Virus diseases in the tobacco fields of Guilan and Western Azerbaijan provinces of Iran. Communication in Agricultural Applied Biological Science, 73(2): 307-10.

Nas Y.Z., Tekinel N., Dolar M.S., 1975. Studies on the virus diseases and their ratio in tobacco in Adana and Hatay provinces. Plant Protection Bulletin, 15(1): 30-37.

Özaslan M., Baş B., Aytekin T., Sığırcı Z., 2006. Identification of Pepper Viruses by DAS-ELISA Assay in Gaziantep-Turkey. Plant Pathology Journal, 5(1): 11-14.

Paylan I.C., Erkan S., Ergün M., Çandar A. 2011. The Comparison of the sensitivity of viral detection methods in certain vegetable seeds. Journal of Turkish Phytopathology, 40(1-3): 21-31.

Pazarlar S., Gümüş M., Öztekin G.B., 2013. The effects of Tobacco mosaic virus infection on growth and physiological parameters in some pepper varieties (Capsicum annuum L.). Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 41(2): 427-433.

Sertkaya G., 2012. Studies onthe Tomato mosaic virus (ToMV) on red pepper production areas in Hatay, Turkey. 9th National Symposium on Vegetable. 12-14 September, Konya, 223.

Şahin G., Taşlıgil N., 2013. Le Developpement Historique Et La Dispersion Geographique De La Cultivation De Tabac En Turquie. Eastern Geographical Review. Vol. 18(30): 71-101.

Şevik M.A., Köse-Tohumcu E., 2011. The Elisa analysis results in tomato (Lycopersicon esculentum Mill.) seed health testing for Tobacco mosaic virus. Zemdirbyste= Agriculture, 98(3): 301-306.

Tüik, 2015. Agricultural structure production, price and value, Turkey, Government statistic Institute.

Vinayarani G., Madhusudhan K.N., Deepak S.A., Niranjand S.R., Prakash H.S., 2011. Detection of mixed Infection of Tobamoviruses in tomato and bell pepper by using RT-PCR and Duplex RTR-PCR. International Journal of Plant Pathology, 2(2): 89-95.

Wahyuni W.S., Hanapi M., Hartana I., 2008. The presence of tobacco mosaic virus in the compost extract of cigar tobacco debris. Hayati Journal of Biosciences, 15(3): 118-122.

Wei C., Ting H., Jin D., Wenting L., Julong C., Yunfeng W., 2014. Evaluations of tobacco cultivars resistance to Tobacco mosaic virus and Potato Virus Y. Plant Pathology Journal Faisalabad, 13(1): 37-43.

Yılmaz M.A., Davis R.F., Varney E.F., 1983. Viruses on vegetable crops along the Mediterranean coast of Turkey. Phytopathology, 73: 378.

Yılmaz M.A., Davis R.F., 1985. Identification of viruses infecting vegetable crops along the Mediterranean Sea coast in Turkey. Journal of Turkish Phytopathology, 14: 1-18.

Zhu X.C., Wang Y.T., Wang Z.F., 2002. Tobacco diseases of China. China Agricultural Press, Beijing.

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STABILITY EVALUATION OF SOME FOLIAR FERTILIZER AND GROWTH REGULATORS FOR THEIR INFLUENCE ON THE GRAIN YIELD OF DURUM WHEAT

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Abstract

In 2010-2012 was studied the influence of some foliar fertilizers and growth regulators on grain yield and its stability of durum wheat cultivar Victoria (Triticum turgidum conv. durum Desf. var. valenciae). Factor A included the years of investigation. Factor B included 5 foliar fertilizers - Vertex high-H34 – 3 l/ha, High-phos – 5 l/ha, Potassium thiosulfate (PTS) – 5 l/ha, Foliar extra – 2.5 l/ha and Trace elements for cereals (TEC) – 1 l/ha, a growth stimulator Amalgerol premium – 3 l/ha, an antitranspirant Pureshade - 20 l/ha and tank mixture Amalgerol premium – 3 l/ha + TEC – 1 l/ha. Foliar fertilizers and growth stimulator were treated during tillering stage of the durum wheat and antitranspirant was treated during ear emergence and grain development stages of durum wheat. The grain yields are increase by foliar fertilizers Vertex high-H34, High-phos, Potassium thiosulfate (PTS), Foliar extra and Trace elements for cereals (TEC) and the growth stimulator Amalgerol premium were treated during tillering stage of the durum wheat and the antitranspirant Pureshade was treated during ear emergence and grain development stages of the durum wheat. Antitranspirant Pureshade is the most unstable for grain yield by treatment in both stages - ear emergence and grain development. Pureshade must be treated during the occurrence of drought, not during special stage of the durum wheat development. Tank mixture Amalgerol premium + TEC, followed by foliar fertilizers Vertex high-H34, High-phos, TEC and stimulator Amalgerol premium are technological the most valuable. They combine high grain yield with high stability with relation to different years. Using of these preparations is being proposed as an element of the technology for growing of durum wheat.

Key words: *durum wheat, foliar fertilizers, growth stimulator, antitranspirant, grain yield*.

INTRODUCTION

Modern agriculture cannot successfully develop, if not more widely applied agro-technical and agrochemical activities aimed at increasing the yields of crops. In modern technologies for growing of field crops increasingly becomes important use of complex fertilizers for foliar application (Yuande et al., 1994; Barraclough and Haynes, 1996; Shuqing et al., 1998; Panayotova and Stoyanova, 2014). The main advantage of foliar application is that it acts directly on the leaves of the plant, and it is proved that they are absorbed by much better and more fully the nutrients. Complex fertilizers contain all necessary for the development of culture nutrients: nitrogen, phosphorus, potassium, several trace elements, amino acids and physiologically active substances connected by special biotech environment.

Foliar fertilization of field crops is essential reserve to supplement and correction of soil fertilization. In specific cases, such as soil drought or soil agrochemical unfitness, the use of foliar fertilization is an important link in the overall technology of cultivation of every crop. The appropriateness and effects of foliar application is an aim of study in works of many authors (El-Naga, 1995; Phillips et al., 1999; Taniguchi et al., 1999).

Growth regulators properly selected and used in appropriate level of fertilization, increase yield and quality of received production where classical methods and tools are less effective or almost exhausted their possibilities (Vildflush and Gurban, 1999; Delchev, 2003). There is data that common and durum wheat respond differently to treatment with the same preparations. According to some authors (Jürgens and Knittel, 1985; Rapparini et al., 1987) durum wheat in its response to some retardants is closer to barley than to common wheat.

The purpose of this investigation was to establish the selectivity and stability of some foliar fertilizers, growth stimulator Amalgerol premium and antitranspirant Pureshade on the durum wheat by influence of different meteorological conditions.

MATERIALS AND METHODS

The research was conducted during 2010 - 2012 on pellic vertisol soil type. It was carried out a two factor experiment as a block method in 4 repetitions, on a 15 m^2 harvesting area, after sunflower pre-crop. Under investigation was Bulgarian durum wheat cultivar Victoria, which belongs to *Triticum durum* var. *valenciae* Desf. Factor A included years of investigation. Factor B included 5 foliar fertilizers – Vertex high-H34 – 3 l/ha, High-phos – 5 l/ha, Potassium thiosulfate (PTS) – 5 l/ha, Foliar extra – 2.5 l/ha and Trace elements for cereals (TEC) – 1 l/ha, a growth stimulator Amalgerol premium – 3 l/ha, an antitranspirant Pureshade - 20 l/ha and a tank mixture Amalgerol premium – 3 l/ha + TEC – 1 l/ha. Foliar fertilizers and growth stimulator Amalgerol premium were treated during tillering stage of the durum wheat EC21-EC29, with quantity of 200 l/ha solution. Anti-transpirant Pureshade was treated during ear emergence EC70 and grain development stages of durum wheat EC80. During early spring was carried out fertilizer with 120 kg N/ha as form of ammonium nitrate. All of variants are treated on the main level: Akurat 60 WG - 10 g/ha (against broadleaved weeds) + Foxtrot 69 EB – 1 l/ha (against graminaceous weeds) + Impact 25 SC - 500 ml/ha (against diseases) which applied as tank mixture in tillering stage of durum wheat.

The efficacy of foliar fertilizers and growth regulators has been established with their influence on grain yield. The statistically processing of the data was done according to the method of analyses of variance (Shanin 1977; Barov, 1982; Lidanski 1988). The stability of foliar fertilizers and growth regulators for grain yield with relation to years was estimated using the stability variances σ_i^2 and S_i^2 of Shukla (1972), the ecovalence W_i of Wricke (1962) and the stability criterion YS_i of Kang (1993).

RESULTS AND DISCUSSIONS

The data for the influence on grain yield of preparations included in experience (Table 1) show that all investigated fertilizers have proven mathematically increase on grain yield. Compared to untreated control this increase varies from 254 kg/ha or 5.0 % by Potassium thiosulfate (PTS) to 420 kg/ha or 8.3 % by Vertex-high-H34.

Table 1. Grain yields, kg/ha

Variants	2010		2011		2012	
	kg/ha	%	kg/ha	%	kg/ha	%
Control – no treated	5360	100	5073	100	4539	100
Amalgerol premium – 3 l/ha	5597	104.4	5455	107.5	4950	109.1
Vertex high-H34 – 3 l/ha	5657	105.5	5493	108.3	4998	110.1
High-phos – 5 l/ha	5567	103.9	5417	106.8	4839	106.7
PTS – 5 l/ha	5573	104.0	5327	105.0	4800	105.7
Foliar extra – 2.5 l/ha	5563	103.8	5377	106.0	4804	105.8
TEC – 1 l/ha	5587	104.2	5397	106.4	4829	106.4
Amalgerol premium – 3 l/ha + TEC – 1 l/ha	5760	107.4	5667	111.7	5103	112.4
Pureshade - 20 l/ha – ear emergence	5573	104.0	5487	107.8	4566	100.6
Pureshade - 20 l/ha – grain development	5657	105.5	5407	106.6	4506	99.3

LSD, kg/ha:

F.A	p≤5%=67	p≤1%=90	p≤0.1%=117
F.B	p≤5%=123	p≤1%=164	p≤0.1%=213
AxB	p≤5%=213	p≤1%=284	p≤0.1%=370

The nitrogen fertilization of durum wheat gives the highest results especially in wet years. The highest yield Vertex-high-H34 is due to the fact that this foliar fertilizer is characterized by a high content of nitrogen (34 %) and contains a combination of different forms of nitrogen - amide, ammonium and nitrate. It contains also magnesium, which is a basic building element for chlorophyll, and minor amounts of copper, which is important for the processes of flowering. Not high rate of soil fertilization with ammonium nitrate during the tillering stage (120 kg N/ha) is the reason for this high effect of this foliar fertilizer. Other fertilizers included in the study contain less nitrogen. High-phos is a foliar fertilizer with phosphorus, potassium and magnesium plus trace elements. Potassium thiosulfate (PTS) is potassium fertilizer containing sulfur. Foliar extra is a combination of nitrogen, phosphorus, potassium, magnesium and trace elements. Trace elements for cereals (TEC) contain the most necessary for cereals trace elements.

Growth stimulator Amalgerol premium contains an extract of seaweed, distilled paraffin oil, vegetable oils, distilled herbal extracts. This stimulator is rich in hydrocarbons and natural plant growth hormones and increasing microbial soil activity. The use of Amalgerol premium increases grain yield of durum wheat average for period with 382 kg/ha or 7.5 %.

Combined application of trace elements for cereals (TEC) with stimulator Amalgerol premium in tillering stage of durum wheat leads to the highest increase in grain yield - with 594 kg/ha, or 11.%. Combination of trace elements cereals (TEC) with Amalgerol premium not only leads to increased quality and quantity of yield but also increases and resistance to durum wheat to adverse weather conditions.

Antitranspirantat Pureshade protects plants from harmful ultraviolet and infrared radiation, while allowing for flow of photosynthesis. The product forms a protective film on the durum wheat leaves, which acts as a reflective barrier against harmful effects of sunlight. Reducing harmful solar influence, Pureshade limits transpiration from the stomata of the plant and improve the use of water quantities available in soil. This antitranspirant enhances the plants growth during hot and dry weather.

During 2011, the treatment of durum wheat with antitranspirant Pureshade during ear emergence stage give a better effect on grain yield in comparison to treatment during grain development stage. The increase in yield was respectively 414 kg/ha or 7.8 % during ear emergence stage and 334 kg/ha or 6.6 % during grain development stage. During to ear emergence stage of durum wheat weather was hot and dry and there were days with strong winds - dry winds. The preparation limited the adverse effects of drought and lead to better pollination of spikelets.

During 2010 Pureshade gave better results in the treatment during grain development stage, though the differences in yields between two stages of application are not big. It is in the range of 1.5 % or only 84 kg/ha. The reason for the small difference is less spring drought during this harvest year.

During 2012, as a result of wet weather during May, with rainfall of 142 l/m^2, use of antitranspirant not had an influence on grain yield. These results indicate that the introduction of Pureshade should not be linked with the development stage of crop and should be linked with weather conditions. This antitranspirant must be applied during drought when Pureshade limits transpiration from the plants leaves and assists to more economical use of limited water quantities in soil.

Analysis of variance for grain yield (Table 2) shows that investigated variants have proven influence on grain yield – 86.6 %. The years have the highest influence on grain yield – 72.5 % on the variants. The reason is the large differences in the meteorological conditions during the three years of investigation.

The strength of influence of investigated preparations is 10.0 %. The influence of variants, years and preparations is very well proven at $p \leq 0.01$. There is an interaction between preparations and meteorological conditions of years (AxB) – 4.1 %. They are proven at $p \leq 0.5$. That means that weather conditions over the three years of experience have influenced the degree of influence of foliar fertilizers and growth regulators. The largest differences are accounted for in antitranspirant Pureshade. Its effectiveness is changed the most depending on temperate and rainfalls during the years.

Based on proven preparation x year interaction, it was evaluated stability parameters for each variant for grain yield of durum wheat with relation to years (Table 3). It was calculated the stability variances σ_i^2 and S_i^2 of Shukla, the ecovalence W_i of Wricke and the stability criterion YS_i of Kang.

Table 2. Analysis of variance for grain yield

Source of variation	Degrees of freedom	Sum of squares	Influence of factor, %	Mean squares
Total	89	142964	100	-
Tract of land	2	9198	6.5	4599.0***
Variants	29	123878	86.6	4271.7***
Factor A - Years	2	103620	72.5	51810.0***
Factor B – Preparations	9	14356	10.0	1595.1***
AxB	18	5902	4.1	327.9*
Pooled error	58	9888	6.9	170.5

*p≤5% **p≤1% ***p≤0.1%

Table 3. Stability parameters for the variants for grain yield with relation to years

Variants	$\bar{x}$	σ_i^2	S_i^2	W_i	YS_i
Control – no treated	4991	186.4	336.0*	198.5	-6
Amalgerol premium – 3 l/ha	5334	191.2	-9.8	366.2	9+
Vertex high-H34 – 3 l/ha	5383	220.5	-9.8	413.2	11+
High-phos – 5 l/ha	5274	6.8	-6.6	71.3	8+
PTS – 5 l/ha	5233	48.1	113.7	137.4	3
Foliar extra – 2.5 l/ha	5248	-15.2	-3.4	36.1	4
TEC – 1 l/ha	5270	-11.1	0.3	42.5	7+
Amalgerol premium – 3 l/ha + TEC – 1 l/ha	5510	147.4	54.6	2962	13+
Pureshade - 20 l/ha – ear emergence	5208	861.1**	423.7	1438.1	-6
Pureshade - 20 l/ha – grain development	5186	1484.0**	-6.7	2434.8	-7

Stability variances (σ_i^2 и S_i^2) of Shukla, which recorded respectively linear and nonlinear interactions, unidirectional evaluate the stability of the variants. These variants which showed lower values are considered to be more stable because they interact less with the environmental conditions. Negative values of the indicators σ_i^2 and S_i^2 are considered 0. At high values of either of the two parameters - σ_i^2 and S_i^2, the variant are regarded as unstable. At the ecovalence W_i of Wricke, the higher are the values of the index, the more unstable is the variant.

On this basis, using the first three parameters of stability, it is found that the most unstable are variants of antitranspirant Pureshade which is treated during ear emergence and grain development stages of durum wheat, followed by no treated control. In these variants values of stability variance σ_i^2 and S_i^2 of Shukla and ecovalence W_i of Wricke are the highest and mathematically proven. At Pureshade instability is a linear type - proven values of σ_i^2, the values of S_i^2 are not proven. The reason for this high instability is greater variation in grain yields during years of experience as weather conditions affect those most. At no treated control instability is a nonlinear type - proven values of S_i^2, the values of σ_i^2 are not proven. Other variants exhibit high stability because they interact poorly with the conditions of years.

To evaluate the complete efficacy of each foliar fertilizer and growth regulator should be considered as its effect on grain yield of durum wheat and its stability - the reaction of wheat to this variant during the years. Valuable information about the technologic value of the variant give the stability criterion YS_i of Kang for simultaneous assessment of yield and stability, based on the reliability of the differences in yield and variance of interaction with the environment. The value of this criterion is experienced that using nonparametric methods and warranted statistical differences we get a summary assessment aligning variants in descending order according to their economic value.

Generalized stability criterion YS_i of Kang, taking into accounts both the stability and value of yields gives a negative assessment only of untreated control and antitranspirant Pureshade, characterizing them as the most unstable and low yields. According to this criterion, the most valuable technology appears tank mixtures Amalgerol premium + TEC, followed by alone application of foliar fertilizers Vertex high-H34, High-phos, Trace elements for cereals (TEC) and stimulator Amalgerol premium. These variants combine high levels of grain yield and high stability of this index during the years. Variants with alone application of foliar fertilizers Foliar extra and Potassium thiosulfate (PTS) get low ratings and them to be avoided.

CONCLUSIONS

The grain yields are increase by foliar fertilizers Vertex high-H34, High-phos, Potassium thiosulfate (PTS), Foliar extra and Trace elements for cereals (TEC) and the growth stimulator Amalgerol premium were treated during tillering stage of the durum wheat and the antitranspirant Pureshade was treated during ear emergence and grain development stages of the durum wheat.

Antitranspirant Pureshade is the most unstable for grain yield by treatment in both stages - ear emergence and grain development. Pureshade must be treated during the occurrence of drought, not during special stage of the durum wheat development.

Tank mixture Amalgerol premium + TEC, followed by foliar fertilizers Vertex high-H34, High-phos, TEC and stimulator Amalgerol premium are technological the most valuable. They combine high grain yield with high stability with relation to different years.

Using of these preparations is being proposed as an element of the technology for growing of durum wheat.

REFERENCES

Barov V., 1982. Analysis and schemes of the field experience. NAPO, Sofia, p. 668.

Barraclough P., Haynes J., 1996. Effect of foliar supplements of potassium nitrate and urea on the yield of winter wheat. Fertilizer Research, 44 (3) 217-223.

Delchev Gr., 2003. Use of growth regulators and complex fertilizers of different fertilization rates of durum wheat. PhD Dissertation.

El-Naga S., 1995. Influence of micronutrients (Co, Mo, Fe, Mn and Zn) on growth and nitrogen fixation in clover and wheat plants in calcareous soil. Journal of Agricultural Research, 20 (2) 803-826.

Jürgens G., Knittel H., 1985. Durum-Weizen: die Produktionstechnik ansfeilen. DLG - Mitteilunger. BRD, 100 (4), 184-186.

Kang M., 1993. Simultaneous selection for yield and stability: Consequences for growers. Agronomy Journal, 85: 754-757.

Lidanski T., 1988. Statistical methods in biology and agriculture, Sofia, p. 376.

Panayotova G., Stoyanova A., 2014. Influence of universal liquid fertilizer MaxGrow on yield and quality of durum wheat (*Triticum durum* Desf.) cultivar Progress. Science and Technology, Vol. 6, No 1, pp. 50 – 56.

Phillips S., Chen J., Raun W., Johnson G., Cossey D., Murray D., Westerman R., 1999. Winter wheat and seed response to foliar nitrogen applications. Journal of Plant Nutrition, 22 (10) 1541-1549.

Rapparini G., Benussi D., Bassi F., 1987. Verifica dell'utilita d'impiego di fitoregulatori di crescida sui cereali vernini. Informatore Agrario, 43 (5), 29-35.

Shanin Yo., 1977. Methodology of the field experience. BAS, p. 384.

Shukla G., 1972. Some statistical aspects of partitioning genotype - environmental components of variability. Heredity, 29: 237-245.

Shuqing J., Shuzhang Zh, Fengrong L., 1998. Effect of nitrogen application under different conditions at late growth stage of wheat. Acta Agronomica Sinica, 24 (6) 884-888.

Taniguchi Y., Fujita M. Sasaki A., Ujihara K., Ohnushi M., 1999. Effect of top dressing at booting stage on crude protein content of wheat in Kyushu district. Japanese Journal of Crop Science, 68 (1) 48-53.

Vildflush I.R. and Gurban K.A., 1999. Yield and quality of spring wheat in an integrated application of mineral fertilizers, trace elements and new growth regulators. In: International scientific conference. Minsk, Belarus, 16-19. 02; 84-85.

Wricke G., 1962. Über eine Methode zur Erfassung der ekologischen Strekbreitein Feldersuchen. Pflanzenzuecht, 47: 92-96.

Yuande Q., Peichang Y., Weimin Y., 1994. Yield increasin efficacy of multiple elements micronutrient liquid fertilizers on wheat. Agricultural Science, №6 268-270.

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COMPARATIVE TESTING OF OIL SUNFLOWER HYBRIDS IN THE REGION OF NORTH – EAST BULGARIA

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Abstract

The field experiment was corried out in the experimental selected area in Dropla village (North-East Bulgaria) in the period 2012 - 2014. The test was performed by means of a block method with four repetitions; experimental field area - 25 m^2 after winter wheat predecessor. The following sunflower hybrids were tested; Kondi, Neoma, Adajhio, Alego and PR64F50. The aim of the investigation was to determine the potential of yield of the tested sunflower hybrids in the region of North-East Bulgaria. The analysis of the results showed that the highest values of elements of productivity were reported with the hybrid Neoma and the lowest – with the PR64F50 hybrid. Hybrid Neoma was most suitable for growing under the conditions of North-East Bulgaria; it gave maximum mean seed yield (3523 kg/ha) and oil yield (1742 kg/ha) during the three years of testing. This was the hybrid with highest mean crude fat content – 49.3%. Lowest seed and crude fat seed yields were obtained from the Alego hybrid (3160 and 1456 kg/ha).

Key words*: sunflower, hybrids, seed yield, crude fat seed yield.*

INTRODUCTION

Important role in realizing the potential of a variety or hybrid have as genetic traits and region with the specific soil and climatic conditions in which are cultivated (Georgiev et al., 2009; Iliev, 2004; Safahani et al., 2014; Krizmanic et al., 2003; Ribeiro and Raiher., 2013). In our country constantly test new hybrids with high productive potential and valuable economic qualities, that's why this study in various areas of the country is of great interest. Therefore, to use the full productive potential of the hybrid as a factor for obtaining high yield important is the right choice of the most suitable for each agro-ecological area (Nenova et al., 2005; Penchev et al., 2006; Saldjiev., 2004). This raises the need for systematic studies of hybrid sunflower in different regions of the country (Nenova et al., 2007; Tahsin and Yankov, 2006; Tahsin, 2012; Yankov et al., 2009).

The aim of this study is to determine the yield potential of some sunflower hybrids in Northeastern Bulgaria.

MATERIALS AND METHODS

In the period 2012-2014 was carried out field experience in the village Dropla municipality Balchik - Northeastern Bulgaria. For comparative testing included oil sunflower hybrids - 'Kondi', 'Neoma', 'Adazhio', 'Alego' and 'PR64F50'.

The experiment was set in block method in four repetitions, size of the crop area of 25m^2/plant with precrop wheat. The sunflower was grown without irrigation conditions adopted for region technology. For realizing the aim of the study account was taken following parameters: plant height, diameter of the disk, number seed of one disk, seed weight on the disk, mass of 1000 seeds, seed yield, crude fat content and yield of raw fat. The experimental data were processed by way of the analysis of variance (ANOVA), and the differences between the versions - by Duncan-test (1995).

The testing period (2012-2014) covers the years whose daily average temperatures during the growing season of sunflower are very close to each other and slightly higher than those reported in multiannual period but different in terms of rainfall collateral which have an impact on growth and development plant. The amount of precipitation during the growing season of sunflowers are as follows; 2012 - 171,2 mm, 2013 - 190.0 mm and 2014 - 532,4 mm in multi-standard - 304 mm.

The amount of rainfall during critical phases plants, has a significant impact on the productivity of investigational hybrids. In this respect, the most favourable was 2014, when during budding, flowering and seed filling, the amount of precipitation was 297 mm and the resulting yields of all hybrids are highest compared to previous years. In the year 2012, the amount of rainfall during critical development stages of the sunflower was 43,6 mm i.e. insufficient to realize the productive potential of investigational hybrids and receive lower yields.

RESULTS AND DISCUSSIONS

The resulting averages for the height of plants and the structural elements of the yield is presented in Table 1.

Table 1. Height of plants and structural elements of the yield, average during the period 2012-2014

Hibrids	Height of plants (cm)	Head diameter (cm)	Number of seed per head	Weight of seed per head (g)	1000 seed weght (g)
Kondi	196.7 d	17.5 b	1108 b	68.7 b	62.0 b
Neoma	190.3 c	19.0 c	1257 d	77.0 d	68.0 c
Adazhio	180.3 a	16.0 a	1134 c	69.2 b	61.0 b
Alego	186.0 b	16.3 a	1158 c	72.5 c	58.0 a
PR64F50	184.0 b	16.5 a	1085 a	61.8 a	57.0 a

Data show that the tested sunflower hybrid differ materially signs height of the plants. Statistically proven with the lowest altitude plants are of hybrid Adazhio (180.3 cm), while the highest - those of hybrid Kondi – 196.7 cm. This indicator hybrids Alego and PR64F50 are inferior to Neoma average of 2.9%.

Analysis of the disk shows that hybrid Neoma mathematically proven by all the values of the structural elements of yield exceeds hybrids Kondi, Adazhio, Alego and PR64F50.

Hybrid Neoma has a diameter of disk - 19.0 cm and surpasses by 8.6% - Kondi. Hybrids PR64F50, Alego and Adazhio have the lowest values of this parameter that are too close and the differences between them are unproven. The index number of seeds in a head when tested hybrids ranged from 1085 in number - PR64F50 to 1257 in number - Neoma. Hybrids Adazhio and Alegho outperform - Kondi respectively with 26 and 50 pieces. Statistically proven hybrid Neoma superior hybrids Alego; Adazhio; Kondi and PR64F50 8.5; 10.8; 13.4 and 15.8%. The lowest values of the indicator mass of seeds in one disk were reported in hybrid PR64F50 - 61,8 g. and inferior to Kondi, Adazhio, Alego 11.2; 13.1 and 17.3 and Neoma with 24.6 % respectively. The mass of 1000 seeds in sunflower hybrids tested ranged from 57.0 to 68.0 g.

Neoma hybrid outperforms Kondi and Adazhio average of 6.5 g, and Alego and PR64F50 - with 10.5 g.

The favourable combination of weather in 2014, are a prerequisite for obtaining high yields of seed compared to 2012 and 2013 (Table 2).

Table 2. Seed yield - kg/ha

Hibrids	Years of study			Average for the period
	2012 (kg/ha)	2013 (kg/ha)	2014 (kg/ha)	(kg/ha)
Kondi	2940 b	3100 b	3800 b	3280
Neoma	3210 e	3380 e	3980 c	3523
Adajhio	3000 c	3150 c	3790 b	3313
Alego	2800 a	3020 a	3660 a	3160
PR64F50	3160 d	3180 d	3610 a	3317

The values obtained ranged from 3610 kg/ha for hybrid PR64F50 to 3980 kg/ha at - Neoma. This hybrid proven exceeded seed yield hybrids Kondi and Adazhio respectively 180 and 190 kg/ha, and Alego and PR64F50 - 320 and 370 kg/ha.

In the second experimental year (2013) obtained yields of the tested hybrids from 13.5 to 17.7% lower than 2014 year statistically processing of the data shows that the differences between all studied hybrids are significant. Alego is inferior hybrid seed yield of PR64F50 by 5.3% and Neoma 11.9%.

The lowest yields of sunflower seeds were recorded in the first experimental year (2012) and range from 2800 kg/ha in hybrid Alego to 3210 kg/ha at - Neoma. Hybrid Adazhio excels at mining Kondi by 2.0%, but inferior to PR64F50 5.3%. Average for the period of study (2012-2014 g) hybrid Neoma yield of 3523 kg / ha superior of 6.2 to 11.5% in all studied hybrids.

The lowest yield was recorded in hybrid Alego - 3160 kg/ha, which gives way to the other - with 120 to 363 kg/ha. The results of the analysis of variance (Table 3) show that the variation of the yield of sunflower seeds is determined as the weather conditions during the years (97,0%) and of hybrids (82.0%).

Table 3. Analysis of variance for seed yield

Source of Variation	Sum of Square	DF	Mean Square	Sig of F	% η 2
Hibrids	819899,77	4	204974,94	,000	82
Years	6292471,03	2	3146235,5	,000	97
2- Way Interactions	224007,63	8	28000,95	,000	55
Residual	186581,50	45	4146,26		

There is a well proven interaction between test factors (hybrid x year) - 55.0%.

The yield of crude fat in tested sunflowers hybrids varies, as over the years and the average cultivation period and follows the trend emerging in the yield seeds (Table 4).

Table 4. Crude fat seed yield - kg/ha

Hibrids	Content of crude fat - % (2012-2014)	Years of stady			Average for the 3 years kg/ha
		2012 (kg/ha)	2013 (kg/ha)	2014 (kg/ha)	
Kondi	47,3	1396 b	1457 b	1824 c	1559
Neoma	49,4	1541 e	1656 e	2030 d	1742
Adajhio	47,2	1410 c	1496 d	1781 b	1562
Alego	46,1	1296 a	1389 a	1684 a	1456
PR64F50	46,4	1454 d	1469 c	1698 a	1540

The highest values of this indicator is obtained in 2014, followed by 2013 and the lowest - in 2012.

In the most favourable for sunflower i.e. the third testing year, the values of this indicator in the study are hybrids the range of 1684 in Alego to 2030 kg/ha with Neoma. Differences between the variants are statistically significant.

In 2012 and 2013 years, the yield of crude fat in sunflower hybrids tested on average 30.9 and 22.0% lower compared to 2014

Average for the three years of study with the highest yield crude fat stands hybrid Neoma - 1742 kg/ha, follows Adazhio - 1562 kg/ha, while the lowest - hybrid Alego - 1456 kg/ha.

The results of ANOVA showed significant influence of both factors (hybrid and year) on the obtained crude fat yield per hectare (Table 5).

Table 5. Analysis of variance for crude fat seed yield

Source of Variation	Sum of Square	DF	Mean Square	Sig of F	% η 2
Hybrids	1618629,59	4	809314,79	,000	99
Years	524768,34	2	131192,08	,000	99
2- Way Interactions	76709,87	8	9588,73	,000	98
Residual	1562,17	45	33,50		

CONCLUSIONS

Structural elements of the yield of investigational sunflower hybrids with the highest value in hybrid Neoma.

Best suited to the conditions of northeastern Bulgaria's was hybrid Neoma which gives maximum average yield seeds (3523 kg/ha) and crude fat yield (1742 kg/ha) in the three years years of study.

He is also a hybrid with the highest crude fat content - 49.3%. The lowest seed yield and oil were obtained from hybrid Alego (3160 and 1456 kg/ha).

REFERENCES

Georgiev G., Hristov M., Piskov A., 2009. Sravnitelno izpitvane na chujdi hibridi slynchogled v rajona na Severoiztochna Bulgaria.Izsledvane vyrhu polskite kulturi, Tom 5-2,307-314.

Iliev I., 2004. Vliqnie na parametrite na pokritieto pri listno torene na slynchogled. Sb. Izsledvaniq vyrhu polski kulturi, General Toshevo, tom I, str. 448-453.

Nenova N., Penchev E., Hristov M., Petykov D., Drumeva M.., 2005. Strukturen analiz na vajni pokazateli pri perspektivni hibridi slynchogled. Agraren universitet - Plovdiv, Nauchni trudove t. L. kH. 5, 79- 84.

Nenova N., Drumeva M., Ivanova I., Hristov M.., 2007. Prouchvane vyrhu sydyrjanieto na proteinen i aminokiselinniq systav v semenata na linii slynchogled. Nauch. syobsht. na SUB kl. Dobrich, t. 9.

Penchev P., Hristov M., Petrov P., 2006. Sravnitelno izpitvane na hibridi slynchogled v rajona na Iugoiztochna Bylgariq. Izsledvane vyrhu polskite kulturi, Tom 3-4,585-590.

Saldjiev I., 2004. Vliqnie na osnovnite agrotehnicheski faktori vyrhu dobiva na slynchogled. Rastenievydni nauki, 41, 536- 540.

Tahsin N., 2012. Produktivnost na maslodajni hibridi slynchogled v zavisimost ot pochveniq tip. Agrarni nauki, 11, 27-32.

Tahsin N., Yankov B., 2006. Sravnitelno izpitvane na hibridi slynchogled pri pochveno-klimatichnite usloviq na Plovdivski rajon. Izsledvane vyrhu polskite kulturi, Tom 3-4, 591-596.

Yankov P., Venkova I., Tonev T., 2009. Vliqnie na gystotata na poseva vyrhu razvitieto i produktivnostta na hibridi slynchogled otglejdani v razlichni agroekologichni rajoni. Izsledvane vyrhu polskite kulturi, Tom 5-1,191-199.

Krizmanic M., Liovic I., Mijic A., Bilandzic M., Krizmanic G., 2003. Genetic potential of OS sunflower hybrids in different agroecological conditions. Genetski potencijal OS hibrida suncokreta u različitim agroekološkim uvjetima. Sjemenarstvo, 20(5/6), 237-245.

Ribeiro M.S., Raiher A.P., 2013. Economic performance of sunflower in family farming systems of southeastern Paraná, southern Brazil. Desempenho econômico da cultura do girassol em sistemas de agricultura familiar do sudeste paranaense. Ciência Rural, 43(5), 786-791.

Safahani A.R., Kamkar B., Teixeira da Silva J.A., Ataei M., 2014. Response of Sunflower Cultivars to Deficit Irrigation. Helia, 37 (60), 37

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RESULTS ON SOYBEAN TIME OF SOWING AND DISTANCE BETWEEN ROWS IN ROMANIA IN THE EXPERIMENTAL YEARS 2015 AND 2016

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Abstract

From 2013 to 2015 soybean planted area in Europe - including Ukraine and the European part of Russia - increased 160% respectively, from 2,653 thousand ha to 4,206 thousand ha. The most favorable area for soybean, Danube region recorded 170% increase of the soybean area from 2013 to 2015, from 441 thousand ha to 758 thousand ha. The new CAP measures - entering into force in 2015 - allows EU member states to grant subsidies under Voluntary Coupled Support (VCS) for protein crops, soybean being included. VCS amounts are on top of the Single Area Payment System (SAPS). Therefore, the soybean crop is more and more reconsidered by the farmers all over Europe in general, mostly in the Danube region due to the agronomic and commercial benefits. In some countries from the Danube region, such as Romania and Bulgaria, soybean cultivation was disrupted for many years. Under present growing interest in cropping soybean, the development of farmers' technological skills and the transfer of know-now became more and more important for obtaining high and good quality yields. The experimental plots have been created with the purpose to provide farmers with field observations and solutions for various factors of soybean technology such as soybean genotypes, time of sowing, distance between rows, seeding density, weed control, bacterization, fertilization and micro-elements.

The research was focused on two technological factors: time of sowing and distance between rows. The information and data were collected cover two consecutive years, 2015 and 2016.

Key words: *soybean, technology, time of sowing, distance between rows.*

INTRODUCTION

From 2013 to 2015 soybean planted area in Europe - including Ukraine and the European part of Russia - increased 160% respectively, from 2,653 thousand ha to 4,206 thousand ha (Figure 1).

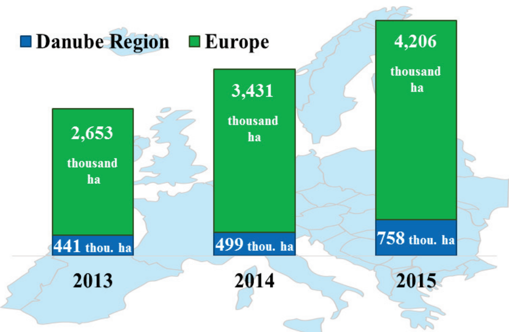

Figure 1. Soybean planted area in Europe and Danube region (2013-2015)

The most favorable area for soybean, Danube region recorded 170% increase of the soybean area from 2013 to 2015, from 441 thousand ha to 750 thousand ha. All Danube region countries increased the planted area with soybean (Kruppa, 2016). Out of these countries an increase over the average of 170% was registered in Germany (360%, from 5 thousand ha to 18 thousand ha), Romania (246%, from 67 thousand ha to 165 thousand ha), Croatia (189%, from 47 thousand ha to 89 thousand ha), Hungary (174%, from 42 thousand ha to 73 thousand ha) and Czech Republic (171%, from 7 thousand ha to 12 thousand ha). A significant increase was recorded in Bulgaria where the soybean area increased from below one thousand ha to 30 thousand ha. The new CAP measures - entering into force in 2015 - allows EU member states to grant subsidies under Voluntary Coupled Support (VCS) for protein crops, soybean being included. VCS amounts are on top of the Single Area Payment System (SAPS). The countries introducing VCS are Bulgaria, Croatia, Czech Republic, France, Greece, Hungary, Italy, Poland, Romania, Spain and Slovenia (Kruppa, 2017).

Therefore, the soybean crop is more and more reconsidered by the farmers' all over Europe in

general, mostly in the Danube region due to the agronomic and commercial benefits.
In some countries from the Danube region, such as Romania and Bulgaria, soybean cultivation was disrupted for many years. Under present growing interest in cropping soybean, the development of farmers' technological skills and the transfer of know-now became more and more important for obtaining high and good quality yields (Dima, 2016).
Among the factors influencing the yield, time of sowing and distance between rows have an important impact. Time of sowing is influencing the production potential of a specific soybean variety (Roman et al., 2011) and should be closely observed under present climate change. The distance between rows has impact on the yield, mainly from the weed control point of view. The seeding can be done either with row crop planter or with small grains drill (Ion, 2010).

MATERIALS AND METHODS

This paper was completed based on the observations and gathering of field experimental data in demonstration platforms organized in three soybean cultivation areas with different climate conditions namely, Turda - Central Romania, Secuieni - East Romania and Caracal - South Romania (Figure 2).

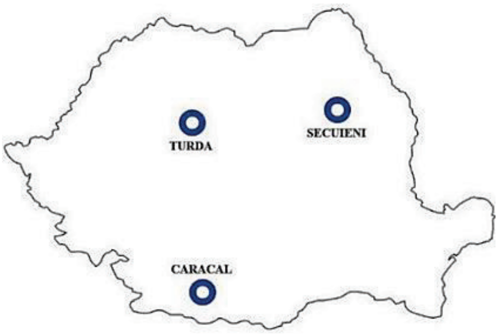

Figure 2. Demo platform locations: Turda, Secuieni and Caracal

Turda experimental fields are located at 46°35' latitude North and 23°47' longitude East and an altitude of 345 - 493 m above sea level. The experimental fields in Secuieni are located at 46°5' latitude North and 26°5' longitude East, altitude of 205.7 m. Caracal experimental fields are located at 44°06' latitude North and 24°21' longitude East, altitude of 98 m.
The rainfall monthly sum for 2015 in Turda, Secuieni and Caracal is presented in Figure 3.
The rainfall data for 2016 in same three locations is presented in Figure 4.

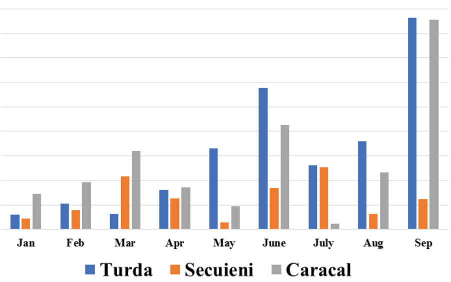

Figure 3. Rainfall in Turda, Secuieni and Caracal in 2015

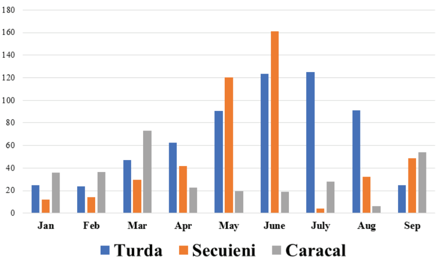

Figure 4. Rainfall in Turda, Secuieni and Caracal in 2016

The air temperature average sum for 2015 in Turda, Secuieni and Caracal is presented in Figure 5.

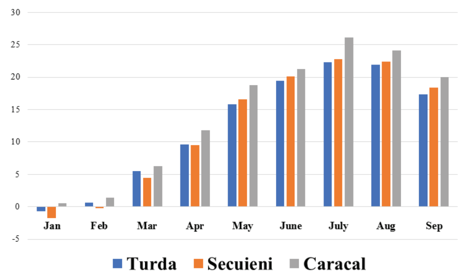

Figure 5. Air temperature in Turda, Secuieni and Caracal in 2015

The air temperature data for 2016 in same three locations is presented in Figure 6.
The information and data collected cover two consecutive years, 2015 and 2016.

The research was focused on two technological factors: time of sowing and distance between rows.

The scope of this paper is to provide farmers and other interested stakeholders with information on soybean technology factors researched in different experiences established in demonstration platforms.

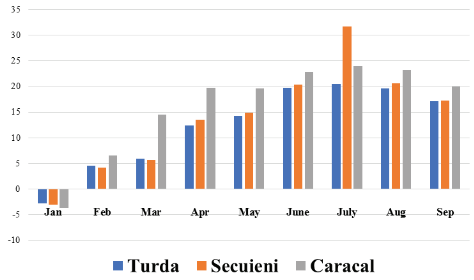

Figure 6. Air temperature in Turda, Secuieni and Caracal in 2016

RESULTS AND DISCUSSIONS

The genetic material used in the research is of Romanian and French origin. The soybean genotypes are presented in Table 1.

Table 1. The soybean genotypes used in 2015 and 2016

Year	Experience	Genotype	Turda	Secuieni	Caracal
2015	Time of sowing	Variety	Felix	Onix	ES Mentor
		Maturity group	00	00	00
		Breeder	ARDS Turda	ARDS Turda	Euralis
	Distance between rows	Variety	Felix	Onix	Sponsor
		Maturity group	00	00	I
		Breeder	ARDS Turda	ARDS Turda	Euralis
2016	Time of sowing	Variety	Caro TD	Onix	ES Mentor
		Maturity group	00	00	00
		Breeder	ARDS Turda	ARDS Turda	Euralis
	Distance between rows	Variety	Caro TD	Onix	Sponsor
		Maturity group	00	00	I
		Breeder	ARDS Turda	ARDS Turda	Euralis

The experimental plots in Turda in 2015 and 2016 displayed three time of sowing: early, normal and late.

In 2015 (Table 2) the highest yield of 1794 kg/ha was obtained when sowing was executed on April 28th. For the other two sowing dates, the yields were nearly the same, respectively 1443 kg/ha for sowing date April 1st and 1419 kg/ha for sowing on April 15th.

The highest plant height was recorded when sown on April 1st, respectively 114 cm. The lowest plant height of 105 cm was obtained when sowing was done on April 28th. For sowing on April 15th, the plant height had an intermediate value of 109 cm. The insertion height of the first basal pods registered very close values for all three sowing times (13-15 cm). The highest TGW value of 178 g was registered for sowing on April 15th followed by 175 g on April 1st and 168 g on April 28th.

In 2016 (Table 2), in Turda the highest yield of 3934 kg/ha was obtained when sowing was done on April 18th, followed by 3878 kg/ha for sowing on April 4th and 3483 kg/ha for the sowing date of May 5th.

The plant height ranged between 117 cm for sowing date April 18th, 119 cm in case of sowing on April 4th and 133 cm for sowing on May 5th. The insertion height of the first basal pods presented similar values for all three sowing experiences (13 - 14 cm). In this year, the highest TGW value of 202 g was registered for sowing on April 18th, followed by 188 g on April 4th and 178 g on May 5th.

Table 2. The influence of time of sowing on soybean crop (Turda, 2015-2016)

Year	Sowing Date	Date of Emerging	Plant Height (cm)	Insertion Height (cm)	Yield (Kg/ha)	TGW (g)
2015	01-Apr	27-Apr	114	14	1443	175
	15-Apr	4-May	109	13	1419	178
	28-Apr	7-May	105	15	1794	168
2016	04-Apr	18-Apr	119	13	3878	188
	18-Apr	4-May	133	14	3934	202
	5-May	14-May	117	14	3483	178

The experimental plots in Secuieni in 2015 displayed three time of sowing: early, normal and late.

In 2016, time of sowing was done normal and late. In 2015 (Table 3), the highest yield of 3244 kg/ha was obtained when sowing was done on April 30th, followed by 3065 kg/ha for sowing on April 20th and 2934 kg/ha for the sowing date of April 9th.

The highest plant height of 103.4 cm was recorded for sowing on April 30th; the next was the plant height of 102.4 cm for sowing date of April 20th. The lowest plant height (92.5 cm) was recorded for sowing on April 9th. The highest insertion of the first basal pods of 10.5 cm was registered for the soybean sown on April 30th, followed by 9 cm on April 20th and 7 cm for the sowing date of April 9th. The highest TGW value of 145 g was registered for sowing on April 30th, followed by 130 g on April 20th and 128 g on April 9th.

In 2016 (Table 3), in Secuieni the highest yield of 1548 kg/ha was obtained when sowing was done on April 27th, the next yield was of 1433 kg/ha for sowing on May 9th.

The plant height ranged from 93.3 cm for sowing date April 27th to 84.3 cm for sowing on May 9th. The highest insertion of the first basal pods of 23.4 cm was registered for the soybean sown on April 27th, followed by 18.1 cm for the sowing date of May 9th. The highest TGW value of 154 g was registered for sowing on April 27th, followed by 151 g on May 9th.

Table 3. The influence of time of sowing on soybean crop (Secuieni, 2015-2016)

Year	Sowing date	Date of Emerging	Plant Height (cm)	Insertion Height (cm)	Yield (Kg/ha)	TGW (g)
2015	9-Apr	24-Apr	92.5	9.0	2934	128
	20-Apr	7-May	102.4	7.0	3065	130
	30-Apr	18-May	103.4	10.5	3244	145
2016	27-Apr	5-May	93.3	23.4	1548	154
	9-May	23-May	84.3	18.1	1433	151

The experimental plots in Caracal in 2015 and 2016 displayed three time of sowing: early, normal and late.

In 2015 (Table 4) the highest yield of 3524 kg/ha was obtained when sowing was completed on May 8th, 2015. For the other two sowing dates, the yields were 3374 kg/ha for sowing date April 27th, respectively 3122 kg/ha for sowing on April 16th.

The plant height ranged between 50 cm for sowing date April 27th, 56 cm in case of sowing on April 16th and 65 cm for sowing on May 8th. The insertion height of the first basal pods was between 5 cm to 7 cm. The highest TGW value of 184 g was registered for sowing on April 16th, followed by 176 g on April 27th and 172 g for sowing date of May 8th.

Table 4. The influence of time of sowing on soybean crop (Caracal, 2015-2016)

Year	Sowing Date	Date of Emerging	Plant Height (cm)	Insertion Height (cm)	Yield (Kg/ha)	TGW (g)
2015	16-Apr	4-May	56	5	3122	184
	27-Apr	8-May	50	6	3374	176
	8-May	12-May	65	7	3524	172
2016	15-Apr	8-May	38	7	3120	210
	26-Apr	15-May	40	6	3300	208
	10-May	22-May	50	8	3220	220

In 2016 (Table 4), in Caracal the highest yield of 3300 kg/ha was obtained when sowing was completed on April 26th, followed by 3220 kg/ha for sowing on May 10th and 3120 kg/ha for the sowing date of April 15th.

The highest plant height of 50 cm was recorded for sowing on May 10th; the next was the plant height of 40 cm for sowing on April 26th, followed by 38 cm for sowing date of April 15th. The insertion height of the first basal pods presented similar values for all three sowing times. The highest TGW value of 220 g was registered for sowing on May 10th, followed by 210 g on April 15th and 208 g for sowing date of April 26th.

The experimental plots in Turda in 2015 and 2016 displayed three distances between rows: 12.5 cm, 25 cm and 50 cm.

In 2015 (Table 5) the highest yield of 1977 kg/ha was obtained for 25 cm between rows, followed by 1710 kg/ha for 50 cm and 1696 for 12.5 cm.

Table 5. The influence of distance between rows on soybean crop (Turda, 2015-2016)

Year	Distance Between Rows (cm)	Sowing date	Plant Height (cm)	Insertion Height (cm)	Yield (Kg/ha)	TGW (g)
2015	12.5	05-May	106	16	1696	184
	25		106	17	1977	182
	50		108	17	1710	184
2016	12.5	22-Apr	119	16	4277	182
	25		122	15	4607	174
	50		126	15	4721	173

For all three distances between rows the plant height presented very close values: 106 cm for 12.5 and 25 cm, respectively 108 cm for 50 cm between rows. The insertion height of the first basal pods was 16-17 cm. In the same year, TGW recorded very close values for all three experiences, 184 g for 12.5 and 50 cm and 182 g for 25 cm.

In 2016 (Table 5), in Turda, the highest yield of 4721 kg/ha was obtained for 50 cm between rows, followed by 4607 kg/ha for 25 cm and 4277 kg/ha for 12.5 cm.

The highest plant height of 126 cm was recorded for 50 cm distance between rows; the next was 122 cm for 25 cm and 119 cm for 12.5 cm. The insertion height of the first basal pods ranged from 15 to 16 cm. The highest TGW value of 182 g was registered for 12.5 cm between rows; the next was 174 g for 25 cm and the lowest was 173 g for 50 cm.

The experimental plots in Secuieni in 2015 and 2016 displayed three distances between rows: 12.5 cm, 25 cm and 50 cm.

In 2015 (Table 6), the highest yield of 2530 kg/ha was obtained for 50 cm between rows, followed by 1961 kg/ha for 25 cm and 1490 kg/ha for 12.5 cm.
The highest plant height of 98 cm was recorded for 50 cm distance between rows, followed by 97 cm for 25 cm and 77 cm for 12.5 cm. The insertion height of the first basal pods varied from 7.1 cm for 12.5 cm between rows, 6.6 cm for 25 cm to 5.3 cm for 50 cm. TGW registered the following values: 156 g for 50 cm between rows, 134 g for 25 cm and 121 g for 12.5 cm.

Table 6. The influence of distance between rows on soybean crop (Secuieni, 2015-2016)

Year	Distance Between Rows (cm)	Sowing date	Plant Height (cm)	Insertion Height (cm)	Yield (Kg/ha)	TGW (g)
2015	12.5	24-Apr	77.0	7.1	1490	121
	25		97.0	6.6	1961	134
	50		98.0	5.3	2530	156
2016	12.5	27-Apr	113.6	35.0	1510	138
	25		97.4	26.2	1849	163
	50		94.4	26.8	2206	187

In 2016 (Table 6), in Secuieni, the highest yield of 2206 kg/ha was obtained for 50 cm between rows, followed by 1849 kg/ha for 25 cm and 1510 kg/ha for 12.5 cm.
The highest plant height of 113.6 cm was recorded for 12.5 cm distance between rows, followed by 97.4 cm for 25 cm and 94.4 cm for 50 cm. The highest insertion of the first basal pods of 35 cm was registered for 12.5 cm distance between rows, followed by 26.8 cm for 50 cm and 26.2 cm for 25 cm. The highest TGW value of 187 g was registered for 50 cm between rows; the next was 163 g for 25 cm and the lowest was 138 g for 12.5 cm.
The experimental plots in Caracal in 2015 and 2016 displayed two distances between rows: 25 cm and 50 cm.
In 2015 (Table 7) the highest yield of 2215 kg/ha was obtained for 50 cm between rows, followed by 1503 kg/ha for 25 cm.
The highest plant height of 95 cm was recorded for 50 cm distance between rows, followed by 89 cm for 25 cm. The insertion height of the first basal pods varied from 9 cm for 50 cm between rows to 7 cm for 25 cm. TGW registered the following values: 155 g for 50 cm between rows and 144 g for 25 cm.
In 2016 (Table 7), in Caracal, the highest yield of 4710 kg/ha was obtained for 50 cm between rows, followed by 3300 kg/ha for 25 cm.
The highest plant height of 78 cm was recorded for 50 cm distance between rows, followed by 73 cm for 25 cm.
The insertion height of the first basal pods was 9-10 cm. TGW registered the following values: 153 g for 50 cm between rows and 148 g for 25 cm.

Table 7. The influence of distance between rows on soybean crop (Caracal, 2015-2016)

Year	Distance Between Rows (cm)	Sowing date	Plant Height (cm)	Insertion Height (cm)	Yield (Kg/ha)	TGW (g)
2015	25	8-May	89	7	1503	144
	50		95	9	2215	155
2016	25	8-May	73	9	3300	148
	50		78	10	4710	153

CONCLUSIONS

In 2015, in Turda, sowing on April 1st, the plants emergence occurred on April 27th (26 days since the date of sowing) due to low air temperatures. In case of sowing on April 15th, the emergence occurred on May 4th (19 days). Sowing on April 28th, the emergence was normal and uniform within 9 days (May 7th). The highest yield of 1794 kg/ha was obtained when soybean was sown on April 28th. For this time of sowing, the plant height registered 105 cm, the insertion height of the first basal pods was 15 cm and TGW was 168 g. In 2016, in Turda all three experiences with time of sowing indicated a uniform emergence of the plants (11-16 days). The highest yield of 3934 kg/ha was obtained sowing the soybean on April 18th. For this sowing time, the plant height registered 133 cm, the insertion height of the first basal pods was 14 cm and TGW was 202 g.
In 2015, in Secuieni, for the soybean sown on April 9th, the emergence was observed on April 24th, 15 days from the date of sowing. In case of sowing on April 20th, the emergence occurred within 17 days (May 7th). Sowing on April 30th, the emergence occurred on May 18th (18 days). The highest yield of 3244 kg/ha was obtained sowing the soybean on April 30th. For this time of sowing, the plant height registered 103.4 cm, the insertion height of the first basal pods was 10.5 cm and TGW was 145 g.
In 2016, in Secuieni, for the sowing date of April 27th, the soybean uniformly emerged within 9 days, on May 5th. For sowing on May

9th, the emergence occurred within 14 days (May 23rd). The highest yield of 1548 kg/ha was obtained when sowing the soybean on April 18th. For this time of sowing, the plant height registered 93.3 cm, the insertion height of the first basal pods was 23.4 cm and TGW was 154 g.

In 2015, in Caracal, when sowing on April 16th, the emergence occurred within 18 days, on May 4th. In case of time of sowing on April 27th, the plant emergence occurred within 11 days (May 8th). The soybean sown on May 8th emerged rapidly and uniform on May 12th (4 days). The highest yield of 3524 kg/ha was obtained for sowing the soybean on May 8th.

In 2016, in Caracal, for sowing date of April 15th, the plant emergence occurred within 23 days (May 8th). For sowing on April 26th, the emergence was observed on May 15th (19 days). For sowing on May 10th, the emergence occurred within 12 days (May 22nd).

The highest yield of 3300 kg/ha was obtained sowing the soybean on April 26th.

In 2015, in Turda the highest yield of 1977 kg/ha was obtained for 25 cm between rows, closely followed by 1710 kg/ha for 50 cm.

For both 25 and 50 cm distances between rows, identical or very close values had been recorded for plant height (106/108 cm), insertion height of the first basal pods (17 cm) and TGW (182/184 g).

In 2016, in Turda the highest yield of 4721 kg/ha was obtained for 50 cm between rows, closely followed by 4607 kg/ha for 25 cm.

For both 25 and 50 cm distances between rows, identical or very close values had been recorded for plant height (122/126 cm), insertion height of the first basal pods (15 cm) and TGW (174/173 g). Both distances of 25 and 50 cm between rows can be used with good results subject to weed infestation and available equipment and methods for weed control.

In 2015, in Secuieni the highest yield of 2530 kg/ha was obtained for 50 cm between rows. For this distance between rows, the plant height registered 98 cm, the insertion height of the first basal pods was 5.3 cm and TGW was 156 g.

In 2016, in Secuieni the highest yield of 2206 kg/ha was obtained for 50 cm between rows. For this distance between rows, the plant height registered 94.4 cm, the insertion height of the first basal pods was 26.8 cm and TGW was 187 g.

In 2015, in Caracal the highest yield of 2215 kg/ha was obtained for 50 cm between rows. For this distance between rows, the plant height registered 95 cm, the insertion height of the first basal pods was 9 cm and TGW was 155 g.

In 2016, in Caracal the highest yield of 4710 kg/ha was obtained for 50 cm between rows. For this distance between rows, the plant height registered 78 cm, the insertion height of the first basal pods was 10 cm and TGW was 153 g.

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REFERENCES

Roman Gh.V., Tabără V., Pîrşan P., Axinte M., Ştefan M., Robu T., 2011. Field Crops - Cereals and Grain Legumes, Vol. I. “Universitară” Publishing House, Bucharest.

Ion V., 2010. Phytotechnics, Faculty of Horticulture, Bucharest.

Kruppa B., 2016., Danube Soya - Market Report, Danube Soya Association, Wien.

Kruppa B., 2017. Donau Soja Statistics, Danube Soya Association, Wien.

Dima D.C., 2016. Soybean Demonstration Platforms: The Bond Between Breeding, Technology and Farming in Central and Eastern Europe, Agriculture and Agricultural Science Procedia, Elsevier.

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AN ASSESSMENT OF THE WATER USE EFFICIENCY IN ALFALFA CANOPY UNDER THE CLIMATE REGIME OF TARGOVISTE PIEDMONT PLAIN

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Abstract

The rationale of the overall experiment was to emphasize the ecophysiological behavior of alfalfa in the eco-climatic conditions of Targoviste Piedmont Plain, from the south of Romania, during three contrasting years of cropping (2012-2014) from the rainfall point of view. Potential evapotranspiration (PET) is a complex index that describes the conceptual processes of soil water losses in atmosphere through evaporation and transpiration from the canopies depending on the plant species, land cover, climatic conditions, and soil type. Reference ET from a defined vegetated surface is a function of local weather serving as an evaporative index by which specialists can predict ET for a wide range of vegetation and surface conditions using the application of "crop" coefficients for agricultural or landscaped areas. The objectives of the study were to establish the water use (ETc) and water use efficiency (WUE) of alfalfa for the specific conditions of Targoviste Piedmont Plain, Romania, and to quantify the effects of limiting water on the growth and development of alfalfa tested cultivars. Roxana and Mihaela cultivars of alfalfa (Medicago sativa L.) developed by NARDI Fundulea were sown in a Latin rectangle design with four replicates. Both cultivars showed valuable biological characteristics regarding the WUE in non-irrigated conditions i.e., annual average of WUE of 13.4 kg DM mm^{-1} ha^{-1} (1st year of cropping), 14.7 (2nd year) and 18.4 (3rd year) in Roxana cultivar, and 13.6 kg DM mm^{-1} ha^{-1} (1st year of cropping), 16.1 (2nd year) and 19.1 (3rd year) in Mihaela cultivar, respectively. The significant increasing of WUE in the last year of cropping was correlated with a well-distributed rainfall regime during the vegetation season and increased annual quantity (>1000 mm). No significant differences ($p<0.05$) were found in yield and WUE among varieties and between cropping years. The results can be used to estimate the economic impact of irrigation use, water consumption and optimal scheduling in alfalfa cropping systems.

Key words: *evapotranspiration, reference evapotranspiration, ASCE modified Penman-Monteith algorithm, dry matter.*

INTRODUCTION

Ecological factors play an important role in the growth and development of alfalfa (*Medicago sativa* L.) plants. Alfalfa has a wide ecological plasticity, but its productive potential can be reached only under certain soil and climatic conditions. It is a C3 perennial legume with a high water use.

Because of its deep and well-developed root system, alfalfa has an increased resistance to drought, despite the fact that consumes significant quantities of water to accumulate dry matter. In Romania, the highest yields are recorded in areas with annual rainfall of 500-650 mm, which are well distributed during the growing season (Motcă, 2005). Alfalfa does not support the water puddles on the surface and any excess of water in the soil. The stagnation of water, for 3-9 days, immediately after mowing, has determined the mass reduction of the root system by 30-80%, respectively the production by 20-60% (Moga et al., 1996). On the lands where the ground water table is at a depth of less than 1.2 to 1.5 m, the root growth and the activity of nitrogen-fixing bacteria are intensively hindered reducing the vitality and production of alfalfa.

Requirements for heat and light are large in alfalfa. The amount of temperature for alfalfa plants required to reach the start of flowering in the 2nd and 3rd year of vegetation is around

900°C for the first cutting cycle and about 800-850°C for the next two cuttings (Motcă, 2005). Brown et al. (2006) found that the estimated radiation use efficiency (RUE) in alfalfa showed a clear seasonal pattern, increasing from 0.80 g DM MJ^{-1} in early spring to 1.60 g DM MJ^{-1} in late summer before decreasing to 0.80 g DM MJ^{-1} in late autumn.

The rationale of the study was to emphasize the ecophysiological behavior of alfalfa in the eco-climatic conditions of Targoviste Piedmont plain, from the south of Romania, during three contrasting years of cropping. The concept of reference evapotranspiration (ET) was developed in the 1970's as a practical and definable replacement for the concept of potential evapotranspiration (PET) (Allen et al., 2004). PET is a complex index that describes the conceptual processes of soil water losses in atmosphere through evaporation and transpiration from the canopies depending on the plant species, land cover, climatic conditions, and soil characteristics (Dunea and Dincă, 2015).

Reference ET, which is a function of local weather, represents the ET from a defined vegetated surface, and serves as an evaporative index by which specialists can predict ET for a range of vegetation and surface conditions using the application of "crop" coefficients for agricultural or landscaped areas (Allen et al., 2004).

The Penman-Monteith equation identifies the key abiotic and biotic factors that control canopy evaporation (Jarvis and McNaughton, 1986).

In this context, the objectives of the study were to establish the water use (ETc) and water use efficiency (WUE) of alfalfa for the specific conditions of Targoviste Piedmont Plain, Romania, and to quantify the effects of limiting water on the growth and development of alfalfa tested cultivars. The results can be used to estimate the economic impact of irrigation use and optimal scheduling in intensive alfalfa cropping systems.

MATERIALS AND METHODS

Experiments were carried out between 2012 and 2014 in Targoviste Piedmont Plain, Romania at Dobra village (N44°46¹.905, E25°43¹.045, 179-m altitude) on pseudogleic brown alluvial soil. Roxana and Mihaela cultivars of alfalfa (*Medicago sativa* L.) were sown in a Latin rectangle design with four replicates. Both cultivars having valuable biological characteristics were developed by NARDI Fundulea (Schitea, 2010). The synthetic cultivars were obtained from the recombination of foreign and Romanian germplasm, presenting rapid spring growth, faster regrowth after cutting, good resistance to common diseases occurring in Romania, and improved winter hardiness.

The plots were sown in pure stand in March 22, 2012. The plants were given nitrogen fertilizer in all experimental variants at one rate (25 kg N ha^{-1}) to avoid nutrient limiting growth. Irrigation was not applied to comply with the common cropping practices used by farmers. Three cutting cycles were performed each year according to the recommended phenophases for alfalfa harvesting (Moga et al., 1996) i.e., 1st cutting cycle: at the beginning of flowering stage; 2nd: +7 weeks from the 1st cut; 3rd cutting: +6 weeks after 2nd cutting.

Samples were collected before each cutting cycle using a quadrate of 50×50 cm in two points of each variant and each repetition to determine dry matter accumulation (g m^{-2}). Samples were dried in an oven at 70°C for 24 hours. The dry matter was determined using a Sartorius precision balance, and the results were extrapolated to a full hectare.

Evapotranspiration (ET) represents the sum of evaporative losses of water from the soil surface – evaporation process, and from the canopy – transpiration process (Allen et al., 1998; Dunea et al., 2014).

A series of equations were used to establish alfalfa's water use (ETc) and water use efficiency (WUE) for conditions of the Targoviste Piedmont Plain, Romania. The reference evapotranspiration for short canopies (ETo) using required weather data was calculated based on the standardized Penman-Monteith algorithm modified by the Environmental Water Resources Institute (EWRI) of the American Society of Civil Engineers – ASCE (see Allen et al., 2004).

The outputs of the model were the daily mean of ETo for each month. The input variables in the algorithm required a series of weather measurements that comply with the complexity of the equations, the estimation period, and the accuracy of results e.g., solar radiation, temperature regime, relative humidity and wind speed.

Table 1 summarizes the statistics of meteorological time series recorded between 2012 and 2014.

Table 1. The meteorological variables recorded in Targoviste Piedmont Plain between 2012 and 2014 – annual data

Variable	2012	2013	2014
Temperature (°C)	-	-	-
Average	10.9	8.1	10.8
Min.	-23.7	-14.9	-17.5
Max.	39.3	32.7	33.1
St.dev.	11.6	8.9	9.0
Coeff. of Var. (%)	105.7	108.9	83.2
Atmospheric pressure (mm Hg)	-	-	-
Average	735.5	735.4	735.8
Min.	717.7	712.2	722.8
Max.	749.6	752.3	752.2
St.dev.	5.5	20.1	4.6
Coeff. of Var. (%)	0.8	2.7	0.6
Relative humidity (mm)	-	-	-
Average	71.4	78.3	79.8
Min.	15.0	22.0	14.0
Max.	100.0	100.0	100.0
St.dev.	22.3	19.4	19.4
Coeff. of Var. (%)	31.3	24.8	24.3
Dew Point (°C)	-	-	-
Average	4.9	3.9	6.8
Min.	-25.8	-16.6	-19.0
Max.	20.3	22.2	21.7
St.dev.	9.1	7.3	7.2
Coeff. of Var. (%)	187.6	184.4	106.6
Precipitations (mm)	-	-	-
Average (mm/day)	2.0	2.0	2.1
Min. (mm/day)	0.1	0.1	0.1
Max. (mm/day)	27.0	29.0	29.0
St.dev.	3.4	3.3	3.4
Coeff. of Var. (%)	174.5	162.3	159.5
Sum of precipitations (mm)	612	553	1039
Days without precipitations	308	235	300
Mean Wind Speed (m/s)	-	-	-
Average	2.5	2.3	2.4
Min.	0.0	0.0	0.0
Max.	12.0	9.0	10.0
St.dev.	1.9	1.7	1.3
Coeff. of Var. (%)	75.4	73.1	56.2

During experiment, the year 2013 recorded the lowest annual average temperature (8.1°C) compared to 2012 and 2014 with more than 2.5°C lower.

The year 2012 showed the highest amplitude of temperature regime, while year 2014 was characterized by the highest amount of annual precipitations.

Crop evapotranspiration (ETc), which is an indicator of the crop water use, provides the evapotranspiration quantum from well-watered fields that achieve full production under the specific climatic conditions (eq. 1).

$$ET_c = K_c \times ET_o \qquad (1)$$

where K_c is a crop coefficient; value of 0.85 was selected for calculating ETc in alfalfa (Allen and Wright, 2002) for each cutting cycle.

The results were used to compute Water Use Efficiency (WUE). WUE is the Ratio between the net yield and the amount of water used to produce that yield (eq. 2).

$$WUE = DM/ET_c \qquad (2)$$

Descriptive, associative, and comparative statistics of the data set was analyzed using SPSS software (SPSS Inc., Chicago, IL, 2011). The computation of multiple range tests (LSD test) provided the statistical significance of comparisons between years, cutting cycles, and cultivars.

RESULTS AND DISCUSSIONS

The accumulation of aboveground dry matter was constant between the two tested cultivars without significant differences ($p > 0.05$).

Table 2. Dry matter yields (t ha^{-1}) of alfalfa cultivars grown in Targoviste Piedmont Plain between 2012 and 2014 (three cutting cycles/year)

Variety	2012	2013	2014
Roxana	-	-	-
1st cuting	3.1	3.2	3.8
2nd cuting	1.8	1.9	3.3
3rd cuting	2.9	2.5	3.1
Annual yield	**7.8**	**7.6**	**10.2**
Mihaela	-	-	-
1st cuting	3.3	3.5	4.0
2nd cuting	2.0	2.1	3.4
3rd cuting	2.7	2.7	3.2
Annual yield	**8.0**	**8.3**	**10.6**
LSD 95%	±1.5	±1.5	±0.8

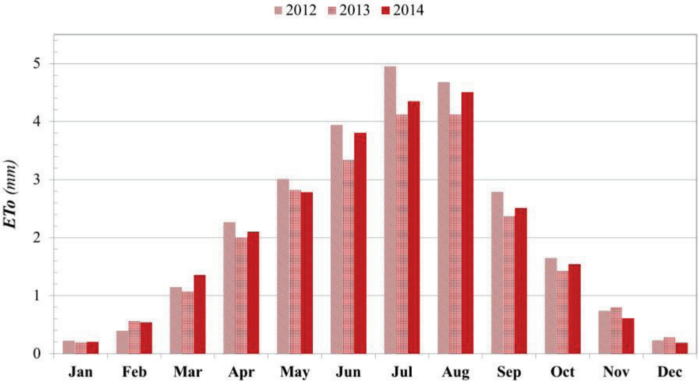

Figure 1. Estimated daily potential evapotranspiration for short canopies (*ETo*) in *mm* under the given climatic conditions of Targoviste Piedmont Plain between 2012 and 2014

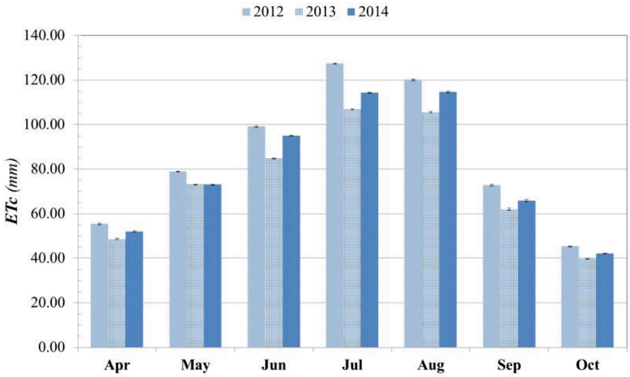

Figure 2. Crop evapotranspiration (*ETc*) in *mm* showing the crop water use under the given climatic conditions of vegetation seasons in Targoviste Piedmont Plain between 2012 and 2014; data were obtained using for alfalfa a crop coefficient (*Kc*) of 0.85 suitable for non-irrigated conditions; error bars represent the standard deviation

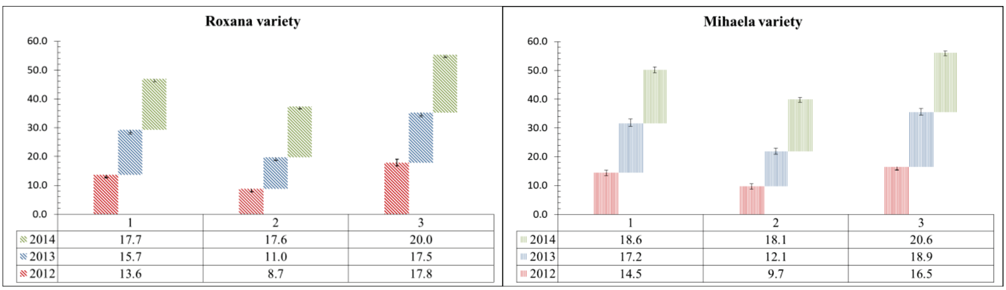

Figure 3. Water use efficiency (*WUE*) of alfalfa cultivars in $kg \cdot mm^{-1} \cdot ha^{-1}$ for each cutting cycle (1-3) in Targoviste Piedmont Plain between 2012 and 2014; data were obtained by dividing the accumulated dry matter by water used during the cropping cycle (*ETc*) ; error bars represent the difference determined between cultivars (no statistical significance $p > 0.05$)

Table 2 presents the dry matter yields (t ha^{-1}) of alfalfa cultivars grown in Targoviste Piedmont Plain between 2012 and 2014, for each cutting cycle. The results are in agreement to the yields reported by Motcă (2005) obtained at Moara Domneasca in Romanian Plain between 2002 and 2004 in non-irrigated and non-fertilized conditions (i.e., average of three cropping years ranging between 8 and 9 t DM ha^{-1}).

Schitea (2010) reported for Romanian alfalfa cultivars an average production of more than 17 t DM ha^{-1} of the three cropping years in irrigated conditions and application of optimal fertilization. Alfalfa yields were found to be responsive to irrigation level, decreasing with reductions in irrigation amount.

Hansen (2008) reported average yields of 8.4, 7.2, 6.8, and 5.3 t ac^{-1} for 4 treatments i.e., "Full Irrigation", "Stop irrigation after 2nd cutting", "Spring and fall irrigation", and "Stop irrigation after 1st cutting", respectively, over two years of the study (with 2006 being a dry year and 2007 being a normal year in terms of precipitation).

Conversion of the reported values from acres to hectares provides the following yields: 20.7, 17.7, 16.8 and 13.8 t ha^{-1} respectively. However, in 2006, a dry year, the reported production for the "Stop irrigation after 1st cutting" treatment was 8.8 t ha^{-1}, which is close to our findings in rainfed conditions.

In dry land regions, alfalfa yields in non-irrigated conditions varied between 2.3 and 4.7 t ha^{-1} (Chedjerat et al., 2016). Karagic et al. (2005) pointed out that the climatic conditions of the cultivation region have a significant effect on the alfalfa yield, which ranged from 5.4 to 8.9 t ha^{-1}.

In this context, optimization of water consumption in forage farms has important implycations for the economic and environmental sustainability of agricultural sector. In our experiment, we followed the common cropping practices used in the region, i.e., an extensive system without major inputs of fertilizers and no irrigation. Such system provides an eco-friendly approach by excluding increased water consumption and associated required energy. However, the obtained yields are almost half compared to full irrigated crops. In the last period, there is a growing interest regarding the application of limited irrigation in cropping systems as a means of addressing changing water supply and demand issues while maintaining profitable irrigated agricultural systems (Hansen, 2008). The quest is on to find the "weak" points in the vegetation season in which to control the crop water stress for avoiding economic losses and a reliable balance between input costs and water consumption especially in areas with high water demands and few water sources. The new cropping practices should consider also the intercropping and mixed cropping as means to increase land utilization e.g., the use of intensive grass-legume mixtures in forage production systems (Dunea and Dincă, 2014). The sowing of two or more species in mixtures would provide benefits regarding the complementary requirements for water, light and nutrients (Dunea and Dincă, 2015; Stanciu et al., 2016). The ecophysiological processes occurring in the forage systems can be assessed using adapted crop growth models (Dunea et al., 2016) or complex hydrological models (Neitsch et al., 2011). WUE is an important variable required to build such models and it can be established in field experiments.

In our experiment, we found that the multiannual climatic variability influencing the estimated daily potential evapo-transpiration and crop evapotranspiration (*ETc*) has a significant correlation with the WUE of both alfalfa varieties (Figures 1 and 2).

Both Romanian cultivars showed valuable biological characteristics in rainfed conditions regarding the WUE i.e., annual average of WUE of 13.4 kg DM mm^{-1} ha^{-1} (1st year of cropping), 14.7 (2nd year) and 18.4 (3rd year) in Roxana cultivar, and 13.6 kg DM mm^{-1} ha^{-1} (1st year of cropping), 16.1 (2nd year) and 19.1 (3rd year) in Mihaela cultivar, respectively (Figure 3).

The increasing of WUE in the last year of cropping was correlated with a well-distributed rainfall regime during the vegetation season and increased annual quantity (>1000 mm). No significant differences ($p < 0.05$) were found in yield and WUE among varieties and between cropping years. The second cropping cycle located during the summer, presented the lowest WUE values in each year. Undersander (1987) reported that the first and fourth cuttings had higher WUE than the middle two cuttings, alfalfa loosing efficiency during the hotter summer cuttings. In 2014, the highest WUE values were recorded because of the rainfall regime.

The lowest values were occurring in 2013, which was the driest year. Hansen (2008) reported values of 0.185 tons ac^{-1} in^{-1} for both years, which converted represents approximately 17.9 kg DM mm^{-1} ha^{-1}, which matches positively with the values found in the literature and in our study.

CONCLUSIONS

The resulted elements characterizing the water use efficiency in alfalfa, which were determined during three vegetation seasons in two Romanian cultivars, are useful for the parameterization of alfalfa growth and development in suitable crop growth models.

Furthermore, the results can be used for defining experiments and future strategies to reduce consumptive water use of alfalfa and to facilitate the estimation of the economic impact of irrigation use and optimal scheduling in alfalfa cropping systems by knowing the moments of crop water stress and the biological potential of the tested cultivars in non-irrigated conditions.

REFERENCES

Allen R.G., Pereira L.S., Raes D., Smith M., 1998. Crop evapotranspiration: Guidelines for computing crop water requirements. FAO Irrigation and drainage paper 56. Irrigation and Drainage 300(56): 1–15.

Allen R.G., Wright J.L., 2002. Conversion of Wright (1981) and Wright (1982) alfalfa-based crop coefficients for use with the ASCE Standardized Penman-Monteith Reference Evapotranspiration Equation,https://www.kimberly.uidaho.edu/water/asceewri/Conversion_of_Wright_Kcs_2c.pdf

Allen R.G., Walter I.A., Elliott R., Howell T. et al., 2004. The ASCE standardized reference evapotranspiration equation, Report of Task Committee on Standardization of Reference Evapotranspiration of the Environmental and Water Resources Institute of the American Society of Civil Engineers.

Brown H.E., Moot D.J., Teixeira E.I., 2006. Radiation use efficiency and biomass partitioning of lucerne (*Medicago sativa*) in a temperate climate. Europ. J. Agronomy 25: 319–327.

Chedjerat A., Bouzina M.M., Gacemi A., Abdelguerfi A., 2016. Forage yield components of various alfalfa (*Medicago sativa* L.) cultivars grown on salt-affected soil under rainfed and irrigated conditions in a Mediterranean environment. African Journal of Agricultural Research 11(34): 3246-3253.

Dunea D., Iordache S., Dinca N., Casadei S., Petrescu N., Nitu I., 2016. Considerations Regarding the Agronomical Variables Associated to the Performances of SWAT Model Simulations in the Romanian eco-climatic Conditions. Agriculture and Agricultural Science Procedia 10: 83-93.

Dunea D., Iordache Ş., Pohoaţă A., Frăsin L.B.N., 2014. Investigation and Selection of Remediation Technologies for Petroleum-Contaminated Soils Using a Decision Support System, Water, Air, & Soil Pollution 225(7): 1-18.

Dunea D., Dincă N., 2015. Contributions to the Development of a Crop Growth Model for Assessing Grass-Legumes Interactions, Bulletin USAMV CN series Agriculture, 72(2), 388-396.

Dunea D., Dincă N., 2014. Improving land utilization using intensive grass-clover mixtures in forage production systems, Romanian Agricultural Research, 31, 147-158.

Hansen N., 2008. Strategies for Reducing Consumptive Use of Alfalfa. http://ucanr.edu/sites/adi/files/204436.pdf

Jarvis P.G., McNaughton K.G., 1986. Stomatal control of transpiration. Advances in Ecological Research. 15: 1-49.

Karagic D.J., Katiç S., Miliç D.J., 2005. Cutting schedule in combined alfalfa forage and seed production. EGF, Grassland science in Europe, 10: 467-471.

Moga I., Schitea M., Mateiaş M., 1996. Plante Furajere. Ed. CERES, Bucureşti.

Motcă Gh., 2005. Îmbunătăţirea valorii de utilizare a gramineelor şi leguminoaselor perene, în contextul dezvoltării durabile a agriculturii în Câmpia Română – Raport de cercetare. Revista de Politica Ştiinţei şi Scientometrie, Număr Special 2005 – ISSN - 1582-1218.

Neitsch S.L., Arnold J.G., Kiniry J.R., Williams J.R., 2011. Soil and Water Assessment Tool Theoretical Documentation, Version 2009. Temple, Texas Water Resources Institute: USDA-ARS Grassland, Soil and Water Research Laboratory, Available at: http://swat.tamu.edu/media/99192/swat2009-theory.pdf

Schitea M., 2010. Results in alfalfa breeding at NARDI Fundulea during 2000-2009. AN. I.N.C.D.A. Fundulea, vol. LXXVIII (2).

Stanciu A.M., Dinca N., Dunea D., 2016. Researches regarding the solar radiation bioconversion in *Dactylis glomerata* L. pure stands and in mixture with *Medicago sativa* L. Romanian Agricultural Research 33: 153-160.

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BEHAVIOR OF SOME WINTER WHEAT CULTIVARS UNDER DOBROGEA CONDITIONS

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Abstract

The paper analyzes the behavior of 10 winter wheat genotypes, under 2012-2016 specific conditions, on south-east part of Romania at ARDS Valu lui Traian, Constanta. The cultivars under study had a good behaviour and a different reaction to environmental conditions during 2012-2016. The rainfalls and temperatures from testing period were characterized by large fluctuations, so that, the yield ranged from one year to another. *The yields registered by the cultivars under test, generally was affected by the climatic conditions: the highest yields being obtained in 2016 an year with good rainfall and temperatures level, while the lowest ones in the driest year, 2014. Yield stability has been estimated using the relationship between yield of each variety and average of trial, analysis of variance coefficient. In average, on five years, the genotypes Ostrov, Miranda and Faur had the better results. Ostrov genotyp manifested a higher yield stability, Miranda, Faur and Litera had a better stability under contrasting environmental conditions. The purpose of the study was to evaluate the yield performance and stabilities to make the better recommendations about adapted winter wheat cultivars under contrasting environmental conditions, for area farms.*

Key words: *winter wheat, contrasting environmental conditions*.

INTRODUCTION

Climate change from the last time emphasized the extreme variations that cause serious consequences for agricultural production. Therefore this paper aims to analyze the behavior of ten genotypes of Romanian winter wheat in the Dobrogea region of Romania based on multiannual comparative crops tests, to make recommend the culture of the wheat varieties better adapted to the area (Săulescu et al., 2006).

As a result of very different environmental factors, and the varieties of characters and traits, interactions between genotype and environment occurred as determined in improvement process to create new varieties with specific adaptability to adverse and favorable climatic conditions (Negru, 2009).

Plant responses to water stress depends on several factors, such as the stage of development of the plant, duration and severity of stress period and wheat genetic variety (Beltrano and Marta, 2008).

A strategy selection should take into account early flowering, grain filling period, a late maturity period, a large number of grains per ear, the great ear weight to increase yields in drought conditions (Kiliç and Yağbasanlar, 2010).

New varieties of winter wheat must combine a high production potential and a good resistance to biotic and abiotic stress conditions, to achieve and get a stable production from year to year (Săulescu et al., 2006).

Growing in every area of more varieties distinguishable from one another, varieties with wide adaptability to environmental conditions can diminish to obtain low yields in unfavorable years (Mustăţea et al., 2008).

The diversity of the wheat varieties range created in our country report an improved resistance to adverse environmental conditions and increased resistance to biotic and abiotic culture, thus contributing to the stability and increased crop production potential (Săulescu et al., 2007).

These genotypes of winter wheat study was done in order to highlight the most suitable in terms of production capacity, but also constant production from year to year as well as resistance to unfavorable environmental factors (Săulescu et al., 1980).

In the last period the creation process of new genotypes has been substantially shortened using modern biotechnological methods

through the rapid homozygosity by Zea system, varieties Faur and Glosa being obtained by this method (Giura and Mihailescu, 2000).
This paper aims to analyze the behavior of a ten genotypes of Romanian winter wheat, in Dobrogea area, based on comparative multi-annual crops tests, in order to recommend the better wheat varieties culture suited for expansion in south-east of Romania.
In the wheat variety cultivation technology, wheat genotype is the essence, therefore choosing varieties that will grow but not adapted to drought conditions can, like all other investments in the wheat crop to be recovered only partially (Mustăţea et al., 2003).

MATERIALS AND METHODS

Research has been made in ARDS Valu lui Traian conditions, Constanţa, on a vermic chernozem soil, with clay texture, humus content 3.53%, Phosphorus content 0.165%, water field capacity 261.8 mm, wilting coefficient 0-80: 99.0 mm, low moisture ceiling 178.0 mm, pH (water): 7.4.
Comparative culture was placed after the subdivided parcels method in three repetitions without repeating basic scheme with 6.72 m^2 plot harvest conditions without irrigation. Previous plant was rape and seeding density was 550 germinating grains/m^2.
The varieties studied were characterized, each of the five years, both from the point of view of production capacity, as well as the morphological characters.
The data presented in this paper refers to the behavior of 10 genotypes of winter wheat (Dropia, Boema, Delabrad, Faur, Glosa, Izvor, Litera, Miranda, Ostrov, Alex) under optimal fertilization with nitrogen and phosphorus in five years (2012-2016) with very different climatic conditions in terms of temperature and rainfall.
Using regression analysis it was determined the reaction of each genotype to the environment and the average production of all varieties in the same environmental conditions (Brukner şi Frohberg, 1987).
Production stability was appreciated using regression coefficient and the average production (Finlay şi Wilkinson, 1963).
The effects of different climatic conditions from one year to another from the experimentation period determined the specific reaction of wheat genotypes submitted most significantly by the yields achieved and by morphology.

RESULTS AND DISCUSSIONS

From recorded data at Valu Traian ARDS during 2012-2016 was observed that year 2012 was the driest, when was recorded a total rainfall of 394.9 mm with 43.7 mm below the annual average in 75 years. As shown in Figure 1 with the exception of May, mostly months were recorded below the annual average rainfall in all the years of experimentation period. 2014 was the best year in that which concerns the rainfall recorded when it recorded 755.3 mm, 316.7 mm more than the annual average. On Figure 1 can be seen recorded rainfall, which have been very fluctuating, patchy distributed monthly and from year to year throughout the test duration, but the annual averages recorded were above the multiannual average recorded in 75 years.

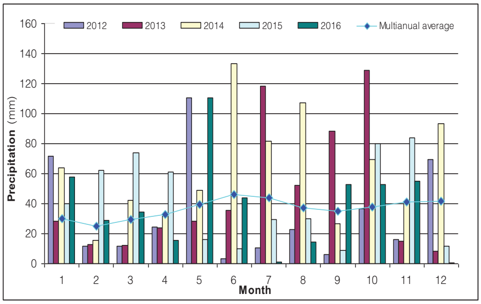

Figure 1. Rainfall registered in SCDA Valu lui Traian in 2012-2016

Temperatures recorded in the five-year period of the experience confirms global warming and also aridity trend of Dobrogea area when they recorded values of annual average temperatures over the survey period (Figure 2).
From Table 1 it is observed that the lowest productions were obtained in the years 2014 (4920 kg/ha) and 2015 (4935 kg/ha) and in 2016 the highest yields 7128 kg ha.

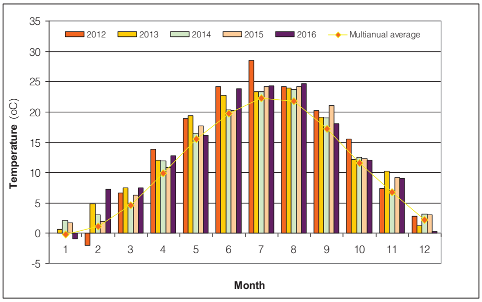

Figure 2. Temperatures registered in Dobrogea in 2012-2016

Watching the average yields of each genotype in the studied period is seen that the Miranda variety with 6155 kg/ha achieved the highest production followed by Faur variety with 6035 kg/ha, Dropia and Alex variety achieving the lowest production (5407-5408 kg/ha). Boema variety achieved the lowest yield of all studied varieties during testing performance with a significant negative difference from the average yields.

Boema variety (8025 kg/ha) and Faur (7908 kg/ha) have made the biggest productions significant distinct and Litera varieties, Miranda and Ostrov was highlighted by significant production.

This five years of experimentation although, from the point of view of weather conditions shows the tendency of developments in the last decade, we believe that is enough to interpret all possible outcomes we performed testing both the error experimentation and testing to interactions with the years (Table 2).

Table 1. Wheat yields obtained at ARDS Valu lui Traian in 2012-2016

No.crt	Genotip	2012	2013	2014	2015	2016	Average
1	DROPIA	5576	6202	4599	4406	6254	5407
2	BOEMA	5381	6217	5308	41630	8025**	5819
3	DELABRAD	5455	5882	4631	4830	7640*	5688
4	FAUR	5722	5849	4777	5917	7908**	6035
5	GLOSA	5993	5980	5036	4767	7021	5759
6	IZVOR	5421	6023	5234	5071	7212	5792
7	LITERA	5764	5995	5019	4979	7749*	5901
8	MIRANDA	6999	7469	4958	5189	6161*	6155
9	OSTROV	6379	5928	5240	5073	7280*	5980
10	ALEX	5733	5928	4396	4953	6028	5408
	Average	5842	6147	4920	4935	7128	5794
	P 5%						437.17
	P 1%						577.77
	P 0.1%						746.92

From Table 2 is distinguish Boema variety with the biggest difference between high and low production of the same variety, during experimentation period (3862 kg/ha).

The smallest differences production in different environmental conditions recorded varieties Alex, Dropia and Glosa.

Lower average production than average experience besides Alex, Dropia and Glosa made also Delabrad and Izvor varieties.

The reaction of genotypes to contrasting environmental conditions can be observed in Table 2 after regression coefficient, where genotypes can differentiate into two categories:

1 - genotypes adapted to adverse environmental conditions ($b < 1$): Dropia, Glosa, Izvor, Miranda, Ostrov, Alex.

2 - genotypes adapted to favorable environmental conditions ($b>1$): Boema, Delabrad, Faur, Litera.

For better wheat varieties identification with good adaptability to different environmental conditions, beside the regression coefficient was pursued the regression constant. The two regression parameters determined varieties dividing into two categories:

1 - genotypes adapted to adverse environmental conditions ($b<1$ when "a" is positive), Dropia, Glosa, Izvor, Miranda, Ostrov and Alex.

2 -genotypes adapted to favorable environmental conditions (b>1 when "a" has negative values): Boema, Delabrad, Faur, Litera.

Analysis of variance for grain yield of winter wheat varieties in the 2012-2016 period highlighted the very significant effects, also for varieties, environmental conditions, and for genotype x environment interactions (Table 3). This shows that the varieties had a different behavior from one year to another.

Table 2. Average yields, minimum, maximum and amplitude of 10 wheat varieties production and their response of parameters to variation in environmental conditions

No. crt	Genotyp	Production (kg/ha)				Parameters		
		Average	Maximum	Minimum	Amplitude	a	b	r^2
1	DROPIA	5407	6254	4406	1848	0.87	323	0.84
2	BOEMA	5819	8025	4163	**3862**	1.44	-2564	0.86
3	DELABRAD	5688	7640	4631	3009	1.26	-1654	0.94
4	FAUR	6035	7908	4777	3131	1.06	-116	0.72
5	GLOSA	5759	7021	5036	1985	0.95	222	0.96
6	IZVOR	5792	7212	5071	2141	0.89	581	0.9
7	LITERA	5901	7749	4979	2770	1.18	-991	0.94
8	MIRANDA	6155	7469	5189	2280	0.7	2093	0.34
9	OSTROV	5980	7280	5073	2207	0.92	606	0.9
10	ALEX	5408	6028	4396	1632	0.68	1496	0.44
	Average	5794	7128	4920	2208			

Table 3. Analysis of variance for the production of wheat genotypes

Variation source	***SP***	***GL***	***PM***	F Factor
A Factor:years of experimentation	102271800	4	25567940	7.225***
Erorr A	28307090	8	3538386	
B Factor:genotypes	8194287	9	910476	2.51*
Interplay A*B	28476240	36	791006	2.18*
Erorr B	32576540	90	361961	

Table 4. Production of wheat obtained at ARDS Valu lui Traian in 2012-2016

No. crt	Genotip	Production kg/ha	% to:		Variation coefficient (s%)
		Years Average	Wt	Genotypes Average	
1	DROPIA (Wt)	5407	100	94	8.71
2	BOEMA	5819	110	104	14.34
3	DELABRAD	5688	107	101	12.00
4	FAUR	6035	114	107	11.44
5	GLOSA	5759	109	102	8.95
6	IZVOR	5792	109	103	8.72
7	LITERA	5901	111	105	11.26
8	MIRANDA	6155	116	110	10.96
9	OSTROV	5980	113	106	8.98
10	ALEX	5408	102	96	7.06
	Average	5794	109	100	9.23

Following yields obtained at ARDS Valu lui Traian during test and making a classification it is noted that in the first place is Miranda varieties (6155 kg/ha), followed by Faur (6035 kg/ha) and Ostrov (5980 kg/ha) (Table 4). Boema and Delabrad varieties recorded the highest values of the variation coefficient (14.34-12.00%) so they have a stable production, lower than other varieties studied. From table 4 which showing differences between media productions and wheat variety witness Dropia, we can say that it has not been exceeded by Alex varieties, the remaining varieties studied surpassing wheat variety witness.

CONCLUSIONS

On average during the studied period the biggest productions have achieved by varieties: Miranda, Faur, Ostrov şi Litera.

They were identified varieties adapted to adverse environmental conditions (b<1): Dropia, Glosa, Izvor, Miranda, Ostrov, Alex but also varieties adapted to favorable environmental conditions (b>1): Boema, Delabrad, Faur, Litera.

The new varieties have a better adaptability to contrasting environmental conditions and potential for higher production than Dropia wheat variety witness.

Among the varieties studied evidenced variety Miranda with the best production potential, variety well adapted to adverse environmental conditions.

Growing varieties with wide adaptability to environmental contrasting conditions can minimize risks production decrease in unfavourable years.

The diversity of the range of wheat varieties created in Romania, confirm an improved resistance to adverse environmental conditions and increasing resistance to biotic and abiotic on the new varieties, thus contributing to the stability and increased crop production potential.

REFERENCES

Beltrano J., Marta G.R., 2008. Improved tolerance of wheat plants (*Triticum aestivum* L.) to drought stress and rewatering by the arbuscular mycorrhizal fungus *Glomus claroideum*: effect on growth and cell membrane stability. Brazilian Journal of Plant Physiology 2008, vol.20, n.1, p. 29-37.

Brukner Pl., Frohberg R.C., 1987. Stress tolerance and adaptation in spring wheat. Crop Science, 27:31-37.

Finlay K.W., Wilkinson G.N., 1963. The analysis of adaptation in a plant breeding program. Aust. J. Agr. Ress, 14, 6: 742-754.

Giura A., Mihăilescu Al., 2000. Metode moderne de reducere a duratei programelor de ameliorare la grâu şi orz. În: „Metode de cercetare în cultura plantelor” Edit. Agris, Bucureşti: 17-36.

Kiliç H., Yağbasanlar T., 2010. The Effect of Drought Stress on Grain Yield, Yield Components and some Quality Traits of Durum Wheat (*Triticum turgidum* ssp. *durum*) Cultivars. Bot. Hort. Agrobot. Cluj 38 (1): 164-170.

Mustăţea P., Săulescu N.N., Ittu Gh., G., Păunescu Gabriela, Stere Ioana, Tanislav N. Zamfir, M.C. Voinea I., 2003. Diferenţe genotipice în rezistenţa grâului la secetă, evidenţiate în condiţiile anului 2002. An. I.N.C.D.A. Fundulea, LXX: 8-15.

Mustăţea P., Săulescu N.N., Ittu Gh., Tican C., Lobonţiu I., Bunta Gh., 2006. Pre-harvest amylase activity and sprouting in Romanian wheat cultivars. Romanian Agricultural Research, 23: 1-6.

Negru Silvia, 2009. Comportarea unor soiuri de grâu de toamnă la S.C.D.A. Secuieni. Anale INCDA Fundulea, LXXVII: 25-30.

Săulescu N.N., Popa Stela, Păcurar I., 1980. Noi soiuri romîneşti de grâu comun de toamnă şi extinderea lor în producţie. Producţia vegetală. Cereale şi plante tehnice, XXXII:3-8.

Săulescu N.N., Ittu Gh., Mustăţea P., Păunescu G., Stere I., Nistor Gh., Rînchiţă L., Voinea I., 2006. Comportarea unor soiuri de grâu de toamnă româneşti în condiţii contrastante de aprovizionare cu apă. Probleme de genetică teoretică şi aplicată, 38 (1-2): 21-29.

Săulescu N.N., Ittu Gh., Ittu M., Mustăţea P., 2007. Cinci decenii de ameliorare a grâului la Fundulea, AN. I.N.C.D.A. Fundulea, VOL. LXXV, 2007, Volum Jubiliar, Genetica şi Ameliorarea Plantelor.

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YIELD COMPONENTS AT DIFFERENT MAIZE HYBRIDS UNDER THE SPECIFIC CONDITIONS FROM SOUTH ROMANIA

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Abstract

Maize is the most important crop in Romania, covering an area that varied between 2.0 and 3.2 million hectares in the years after 2000. The large surfaces grown with maize in Romania are due to favourable climatic conditions for this crop, but also to high-performance crop technologies which makes the crop to be performant. Taking into consideration the total maize production, Romania ranges the second position in EU, after France. In this context, selecting the most suitable maize hybrids for each agricultural area is essential in view to obtain high yields in an efficient way.
The aim of this paper is to present the results related to yield components and grain yields at an assortment of maize hybrids cultivate with a high-performance crop technology and under favourable soil and climatic conditions from South Romania. Our study was performed under conditions of the cambic chernozem in Baneasa area, Giurgiu County from South Romania, and in the context of the favourable climate conditions of the year 2013. The studied maize hybrids in our field experiment were the following: DKC 4964 (FAO group 390), PR36R10 (FAO group 400), PR37K67 (FAO group 400), Olt (FAO group 400), Fundulea 376 (FAO group 450), PR35F38 (FAO group 450), PR35P12 (FAO group 470), Florencia (FAO group 490), PR35T06 (FAO group 500), Rapsodia (FAO group 500), and Generos (FAO group 540).
From the climate point of view, the year 2013 was favourable for maize crop in the experimental area. At harvesting time, determinations and analyses were performed regarding: the above-ground biomass, the cob weight, the number of grains per cob, the grain weight per cob, the grain ratio on cob, the thousand grain weight, and the grain yield.

***Key words**: maize hybrids, growing conditions, yield, yield components.*

INTRODUCTION

At present, Romanian farmers growing maize benefit of a divers assortment of maize hybrids with a high yield potential, but they also have to pay attention to the climatic conditions and the crop technology which have a considerable influence on the yield components and the average yield of these hybrids.
According to their precocity, the maize hybrids react considerably function of: cultivation area, climatic conditions and rainfall distribution during plant growth, fertilization strategy, weed control, and the correct establishment of the plant density according to the growing conditions in the field. These hypotheses are confirmed by several experimental results cited in the specialised literature.
The yield components are influenced considerably by the hybrid selected for a certain cultivation area and the fertiliser doses used (Aadeyemi, 2011).
Even in the case of the high-performance crop technologies used for growing maize, aggressive temperatures in the context of rainfall shortages during the growth stages with maximum water requirements have a considerable influence on the yield components, regardless of the selected hybrid (Ion et al., 2013). Thus, it can be stipulated that an understanding of the environmental and agronomic responses of maize hybrids is fundamental to improving efficiency of maize production (Grada and Ciulca, 2012). In this respect, for a better understanding of climatic and technological effects on maize yield and grain quality, intensive research that evaluates different geographic locations, sowing dates and genotype selection are needed (Koca and Canavar, 2014).

Establishing the plant density correctly has a considerable influence on the competition among the plant population, allows the use of the natural resources and determines the yield components and the yield obtained for each hybrid (Sharifi et al., 2009).
Plant spacing has significant effects on growth, yield and yield components of maize hybrids (Mukhtar et al., 2012). Varying row spacing and distance between plants on the same line can contribute to the decreasing of the competition among plants, respectively it can ensure a better use of growth resources.
Farmers growing maize must use the appropriate crop technology in view to diminish the effects of the limitative factors on yield components and for a maximum use of soil and climatic resources (Dumbrava et al., 2016). However, identifying maize hybrids with genetically improved characteristics and high level of adaptability in order to have low yielding losses is indeed relevant (Schitea and Motca, 2013).
The aim of this paper is to present the results related to yield components and grain yields at an assortment of maize hybrids cultivate with a high-performance crop technology and under favourable soil and climatic conditions from South Romania.

MATERIALS AND METHODS

Our study was performed under conditions of the cambic chernozem in Baneasa area, Giurgiu County, and in the context of the favourable climate conditions of the year 2013.
The climatic conditions were considered as being favourable for maize crop, as the annual amount of rainfall was of 625.7 mm, with a good distribution along the growing period, and the average annual temperature was of 11.7^{o}C.
The studied maize hybrids were the following: DKC 4964 (FAO group 390), PR36R10 (FAO group 400), PR37K67 (FAO group 400), Olt (FAO group 400), Fundulea 376 known also as F376 (FAO group 450), PR35F38 (FAO group 450), PR35P12 (FAO group 470), Florencia (FAO group 490), PR35T06 (FAO group 500), Rapsodia (FAO group 500), and Generos (FAO group 540).
The field experiment was designed with four replications, the number of variants was 44 (11 hybrids x 4 replications), each variant having four lines with a length of 10 m. Sowing was performed on 15th of April, with a plant density of 55,000 plants per hectare.
The main elements of crop technology were the following: the preceding crop was wheat, fertilisation was performed with 100 kg/ha of complex fertilizer 16:48:0 applied before bed preparation and 150 kg/ha of ammonium nitrate applied at the growing stage of seven leaves. For weed control, during the growing period of maize plants, the following herbicide was used at the growing stage of five leaves: Equip, which is based on active substance foramsulfuron - 22.5 g.l^{-1} and isoxadifen-etil 22.5 g.l^{-1} as safener, and which was applied in a rate of 2 l.ha^{-1}.
At harvesting, determinations and analyses were performed regarding: the above-ground biomass, the cob weight, the number of grains per cob, the grain weight per cob, the grain ratio on cob, the thousand grain weight, and the grain yield. The obtained data were processed by analyses of variance.

RESULTS AND DISCUSSIONS

Above-ground biomass

The above-ground biomass was calculated by weighing the plants which were cut at soil surface at harvesting time, when the plants were completely dried. The grain humidity upon harvesting varied between 15.5% for the hybrid DKC 4964 and 18.5% in the case of the hybrid Fundulea 376. Under these conditions, the average yield of above-ground biomass at plant humidity from harvesting time was of 24.72 t.ha^{-1} (Figure 1).
The highest above-ground biomass yields were recorded for the hybrids Fundulea 376 (27.58 t.ha^{-1}) and PR35P12 (27.14 t.ha^{-1}). The lowest above-ground biomass yield was recorded in the case of hybrid DKC 4964, with 17.43 t.ha^{-1}. Of the eleven maize hybrids studied in the field experiment, seven hybrids achieved above-ground biomass yields higher than the average per experiment (Figure 1).
It is noteworthy that the above-ground biomass yield was boosted by the very favourable growth conditions until the second decade of July (last rainfall of 25 mm.m^{-2} was recorded on 19th of July) the hybrids being at the stage of

silk emergence – the beginning of grain development. Starting with the last decade of July, there were registered temperatures above 35°C, in the context of a rainfall shortage, which had different influences on the yield potential of the testes hybrids.

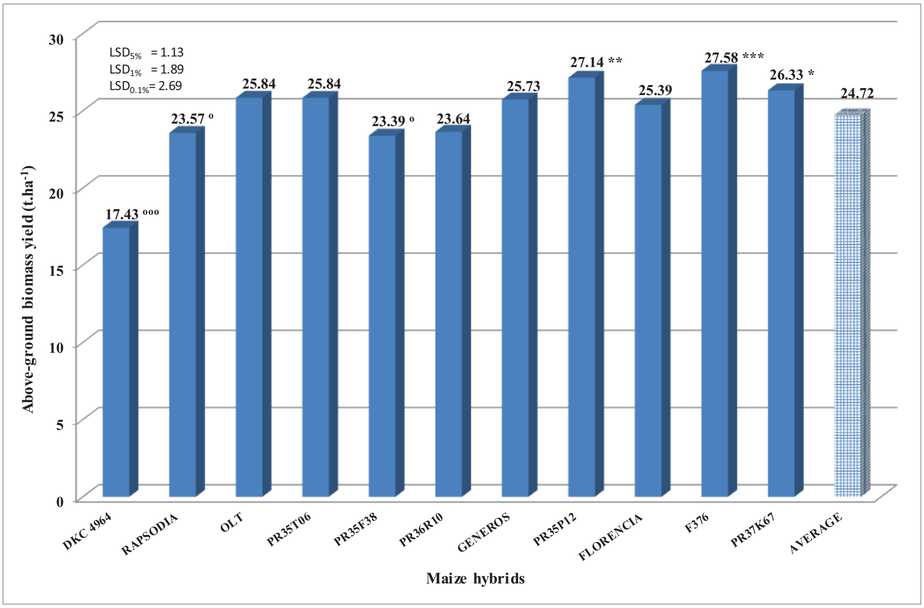

Figure 1. Above-ground biomass yields at the studied maize hybrids

Cob weight

The cob weight is variable and correlated to the number of grains per cob and grain weight per cob.

The average weight of cob at the studied maize hybrids was of 293.42 g (Figure 2). Based on this indicator, we point out the hybrids with more than 300 g the weight of cob, respectively: Fundulea 376 with 344.86 g, PR35P12 with 319.2 g, PR36R10 with 319.20 g, Generos with 318.35 g, Florencia with 306.8 g, and PR35T06 with 303.56 g. On the opposite side, there is the hybrid DKC 4964, with less than 200 g the weight of cob, respectively 184.14 g.

Number of grains per cob

The number of grains per cob is correlated with the size and mass of the grains per cob. The average number of grains per cob at the studied maize hybrids was of 674 (Figure 3).

We point out the hybrids PR35P12 with 848 grains per cob, PR35T06 with 768 grains per cob, Florencia with 720 grains per cob, which significantly exceed the average of the eleven studied maize hybrids. On the opposite side there are the hybrids Rapsodia with 552 grains per cob and PR37K67 with 565 grains per cob.

Grain weight per cob

The grain weight per cob was influenced by the cob weight, grain weight, grain size and grain humidity. In the case of the eleven tested maize hybrids, we noticed a variation of the grain weight per cob from 161.46 g for the hybrid DKC 4964 to 280.75 g for the hybrid PR35P12 (Figure 4). Higher values of the grain weight per cob, statistically ensured, were recorded also in the case of hybrids Fundulea 376 (270.1 g), PR36R10 (255.15 g) and Florencia (251.2 g). Lower values of the grain weight per cob were recorded also for the hybrids Rapsodia and Olt.

The grain weight per cob and the plant density influenced directly the grain yield.

Grain ratio on cob

This indicator is influenced but the cob weight, the grain weight per cob, the thousand grain weight, and the grain humidity.

For the maize hybrids with grain humidity higher than 18% at harvesting time (Figure 5), the grain ratio on cob had low values, respectively: 77.1% for the hybrid Generos, 77.3% for the hybrid Olt, and 78.3% for the hybrid Fundulea 376. For the maize hybrids with grain humidity less than 17% at harvesting time (Figure 5), this being because they have higher rates of humidity loss at plant maturity, the grain ratio on cob registered higher values, respectively: 87.4% for the hybrid DKC 4964, 82.5% for the hybrid PR35P12, and 81.8% for the hybrid Florencia.

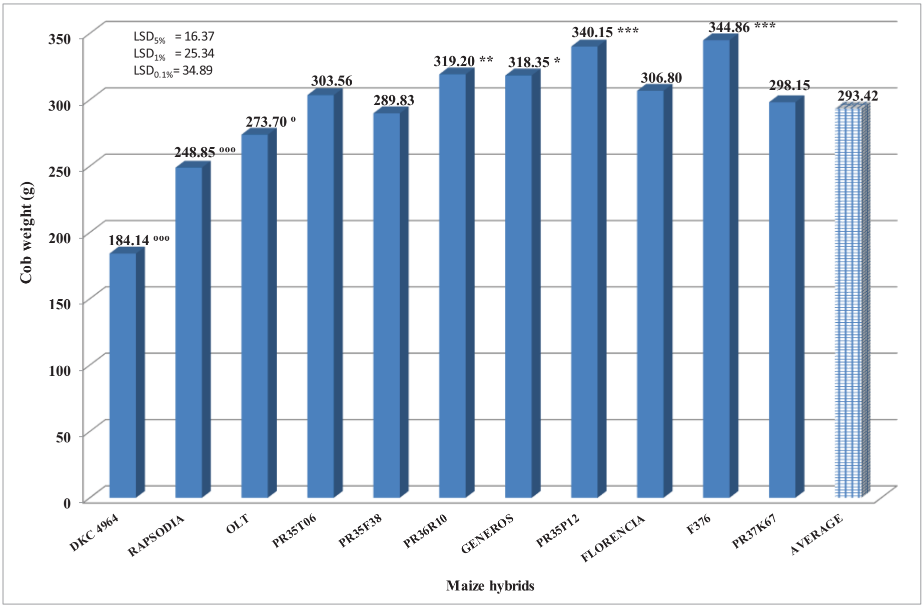

Figure 2. Cob weight at the studied maize hybrids

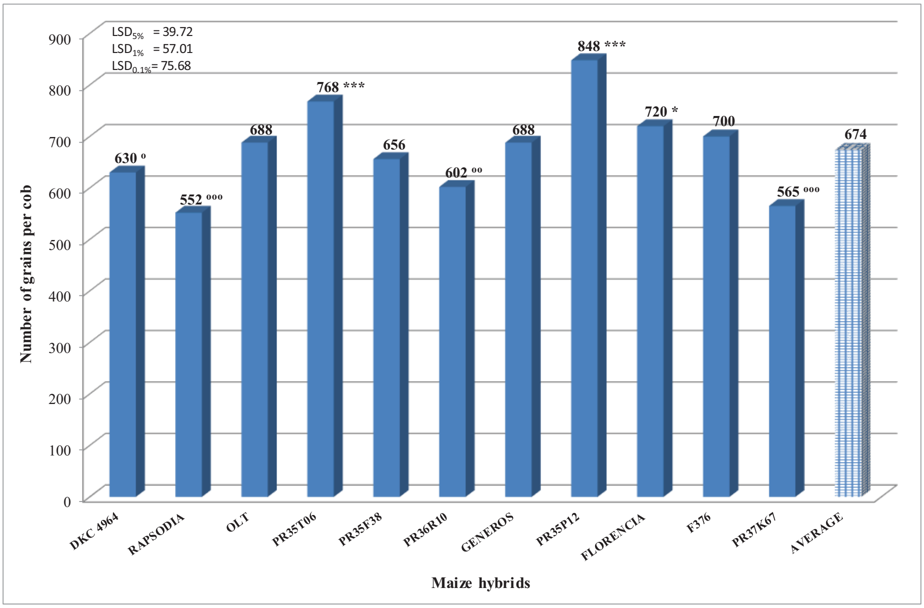

Figure 3. Number of grains per cob at the studied maize hybrids

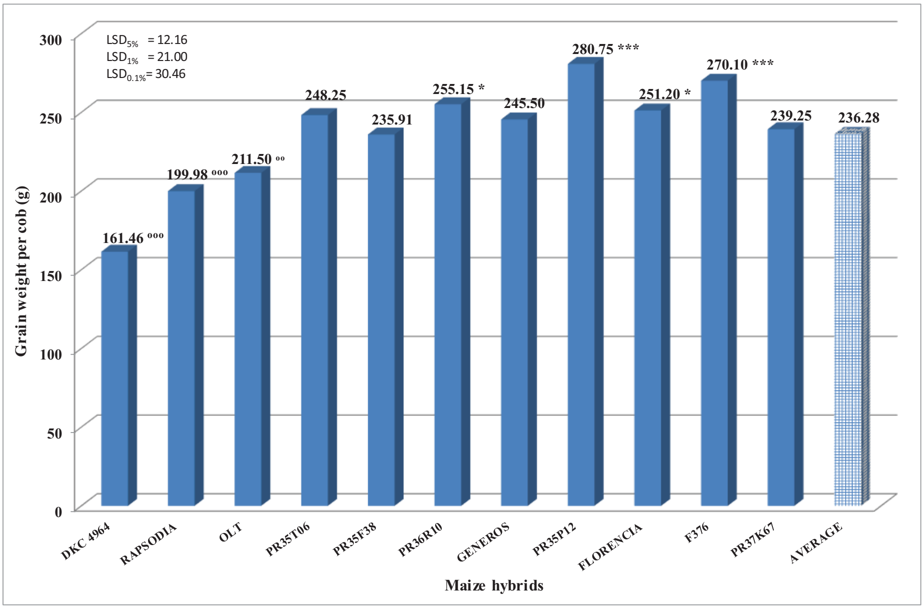

Figure 4. Grain weight per cob at the studied maize hybrids

Thousand grain weight (TGW)

TGW is determined by the hybrid characteristics, growing conditions, presence of limitative factors and grain humidity.

The average TGW for the studied maize hybrids was of 354.7 g, with values ranging from 250.5 g for the hybrid DKC 4964 to 444.1 g for the hybrid Generos.

Significantly higher values of the TGW were also recorded for the hybrids PR36R10 (423.8 g) and Fundulea 376 (400.1 g). Significantly lower values of the TGW were also recorded for the hybrids Olt (307.4 g) and PR35T06 (323.2 g).

Grain yield

The average grain yield for the studied maize hybrids was of 10.14 $t.ha^{-1}$, with important significant variations among hybrids (Figure 5). The highest yield was of 11.48 $t.ha^{-1}$ for the hybrid PR35P12 and 11.37 $t.ha^{-1}$ for the hybrid Fundulea 376. High yields which significantly exceeded the average yield per experiment were also recorded for the hybrids Florencia (11.29 $t.ha^{-1}$), PR35T06 (11.19 $t.ha^{-1}$), and PR35R10 (10.68 $t.ha^{-1}$). Lower yields, significantly distinct from the average yield per experiment, were recorded for the hybrids DKC 4964 (7.27 $t.ha^{-1}$), Rapsodia (8.99 $t.ha^{-1}$), Generos (9.27 $t.ha^{-1}$), and Olt (9.52 $t.ha^{-1}$).

Grain humidity

We noticed that the average grain humidity of the studied maize hybrids was of 17% (Figure 5).

Some of the hybrids registered grain humidity valued above 18%, such as Fundulea 376 (18.5%), Generos (18.1%), and Olt (18.1%). Except the hybrid Rapsodia with grain humidity of 17.7%, all the other hybrids registered values of the grain humidity less than 17%, more precisely values between 15.5 and 16.9%. These maize hybrids with grain humidity less than 17% had the ability to lose grain humidity fast at plant maturity, which represents an advantage for the mechanical harvesting.

Standard yield at the humidity 15.5%

The average standard yield for the studied maize hybrids was of 9.96 $t.ha^{-1}$ (Figure 5).

Significantly higher standard yields were recorded for the following hybrids: PR35P12 (11.39 $t.ha^{-1}$), PR35T06 (11.11 $t.ha^{-1}$), Florencia (11.11 $t.ha^{-1}$), and Fundulea 376 (10.96 $t.ha^{-1}$).

Significantly lower standard yields were recorded for the following hybrids: DKC 4964 (7.27 $t.ha^{-1}$), Rapsodia (8.76 $t.ha^{-1}$), and Generos (8.99 $t.ha^{-1}$).

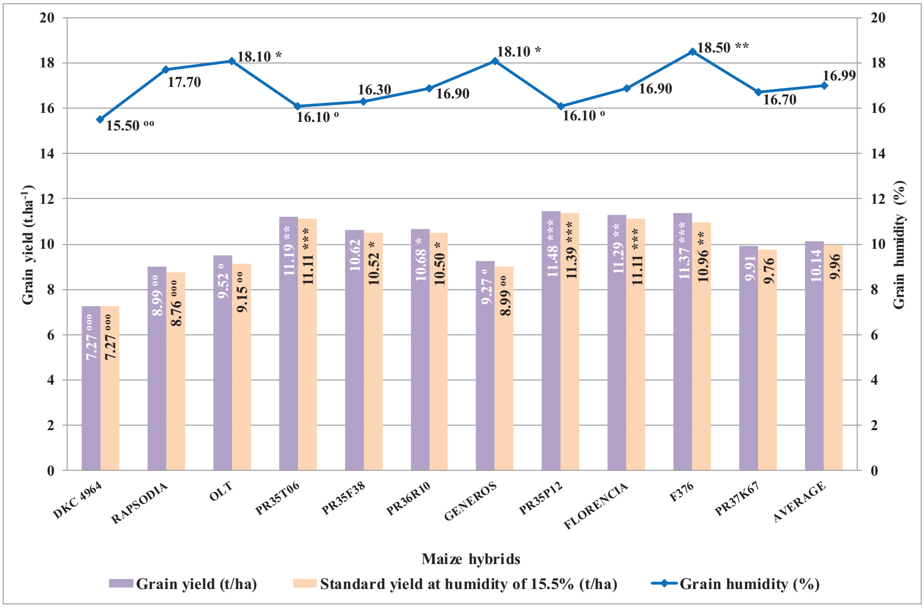

Figure 5. Grain yield, standard yield at 15.5% humidity, and grain humidity at the studied maize hybrids

CONCLUSIONS

The yield components are elaborated along the growing period of the maize plants. They are determined by the cultivated hybrid, being influenced by the growing conditions (soil and climatic conditions), as well as by the crop technology (as for example the correct establishment of plant density according to the precocity of the hybrid and the supply of water and nutrients). Through the crop technology, it is envisaged the decreasing of the effect of limitative factors which have a considerable impact on the yielding capacity of the plants.

The studied maize hybrids reacted differently to growing conditions, despite the year 2013 was favourable to maize crop on the area the field experiment was performed. Therefore, the correct choice of the maize hybrid according to the specific growing and technological conditions is essential for maize grower in order to achieve high and profitable yields.

REFERENCES

Adeyemi A.A., 2011. Yield and yield components of maize as influenced by cultivars and fertilizer rates. International Journal of Applied Agricultural and Agricultural Research, 1 and 2, p. 72-78.

Dumbravă M., Ion V., Băşa A.Gh., Duşa E.M., 2016. The behaviour of some maize hybrids under the specific conditions from South Romanian Plain. 16th International Multidisciplinary Scientific GeoConference (SGEM 2016), Energy and Clean Technologies Conference Proceedings, Book 4 - Renewable Energy Sources and Clean Technologies, Vol. I, p. 691-696.

Grada F., Ciulca S., 2012. Evaluation of grain yield stability for some maize hybrids using regression analysis. Journal of Horticulture, Forestry and Biotechnology, Vol. 16(1): 123-126.

Ion V., Dicu G., State D., Fântâneru G., Epure L.I., Băşa A.G., Toader M., 2013. Yield components of different hybrids of maize cultivated in South Romania under drought conditions. Scientific Papers. Series A. Agronomy, Vol. LVI, p. 276-283.

Koca Y.O., Canavar Ö., 2014. The effect of sowing date on yield and yield components and seed quality of corn (*Zea mays* L.). Scientific Papers. Series A. Agronomy, Vol. LVII, p. 227-231.

Mukhtar T., Arif M., Hussain S., Atif M., Rehman S., Hussain K., 2012. Yield and yield components of maize as influenced by plant spacing. J. Agric. Res., 50(1): 59-69.

Schitea L.F., Motca Gh., 2013. Results regarding drought resistance of same maize hybrids in South part of Romania conditions. Scientific Papers. Series A. Agronomy, Vol. LVI, p. 347-352.

Sharifi R.S., Sedghi M., Gholiopuri A., 2009. Effect on population density on yield and yield attributes of maize hybrids. Res. J. of Biological Sc., 4:375-379.

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NICOSULPHURON EFFICACY IN ANNUAL AND PERENNIAL WEED CONTROL IN MAIZE

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Abstract

High fertilization of soils in Romania, groundwater and intake correlated with biological reserve in the soil creates favorable conditions for growth and development both for plants and for weeds, especially Sorghum halepense. Due to the high degree of weed infestation it can reach to partially or even total crop calamity. The present work is based on studies that were carried out in maize at a farm in Afumati, Ilfov County. Sulfonylurea-based herbicide nicosulphuron was applied post-emergence at doses of 0.8, 1.0 and 1.5 l/ha, when the maize crop had minimum 2 leaves, BBCH 12. The experiments were placed in randomized blocks and observations aimed at degree of effectiveness in controlling weeds and crop selectivity. From observations made in recent years result in a change in the ratio between monocotyledonous and dicotyledonous species in favor of monocotyledonous especially for the perennial weeds. In these studies the observations were made before the treatment (0 days), 14, 28 and at 42 days after treatment. The predominant species identified were: Sorghum halepense, Echinochloa crus-galli, Setaria spp.
The herbicide based on nicosulphuron had a good efficacy in controlling annual and perennial weeds in maize crops. At the dose of 0.8 l/ha monocotyledonous weeds were not fully controlled. For Sorghum halepense species the best results were obtained at the dose of 1.5 l/ha. No phytotoxicity symptoms have been shown in the study.

***Key words**: control, herbicide, nicosulphuron, weeds.*

INTRODUCTION

Regardless of the historical stage and maize cultivation system, the highest costs in the production process are with weeds control. By its biology nature, corn plants are characterized as lacking the ability to compete with weeds, especially in the early stages of vegetation. Slow growth of corn plants in the first 4-6 weeks after emergence, associated with a low density (4-6 plant/m^2), creates a major advantage in the competition since the beginning in favor of weeds. Weeds by their number, by rapacity for space, water and food, are causing great damage to maize crops. Depending on the degree of weed infestation, the damage varies between 30-80% of the production obtained, and in case of infestation with species *Sorghum halepense* from rhizomes sometimes can reach to total compromise of the crop (Sarpe et al., 1976, Chirila et al., 2001, Berca, 1996, 2004). In this context, the paper presents data on the efficacy of nicosulphuron, sulfonylurea-base herbicides, in control of annual and perennial monocotyledonous weeds in maize, aiming to improve agricultural technology and obtaining stable crops.

MATERIALS AND METHODS

The experiments were placed at SC Agricola Afumati, Ilfov, Romania, in randomized blocks, in 4 repetitions with plot area of 30 m² on loamy clay soil with a pH of 6.5 and an organic matter content of 2.5%. Each experimental block included an untreated and a standard reference.
Weed density was assessed in ground % and in coupla/m². Weed control (efficacy) was assessed at 14, 28, 42 days after application in coupla/m^2 and % control comparative with untreated. Also, were performed observations on the weeds present in the experimental plots before treatment, and selectivity - at each date of the efficacy assessments.
Determination of segetal flora was performed on a square meter using a metric frame. Statistical preparation of the results was based on the analysis of ARM-9 (P=.05, Student-Newman-Keuls).

RESULTS AND DISCUSSIONS

Maize, the main cultivated plant in romanian agriculture, shows a strong and diversified infestation with monocotyledonous and dicotyledonous annual and perennial weeds. The agriculture practiced in recent years has led to changes in the structure and frequency of weeds in maize both quantitatively and especially qualitatively.

Grass weed species have become more damaging than dicotyledonous, with an increasing frequency of *Echinochloa crus-galli*, *Setaria* spp., *Sorghum halepense* and *Elymus repens*. Romania has one of the highest degrees of infestation with *Sorghum halepense*. The large number of seeds (2000-5000/plant) and extensive rhizome system makes this weed difficult to control (Chirila, 2001).

Maximum sensitivity toward infestation with *Sorghum halepense* manifests itself in the early stages of vegetation.

The predominant species identified in the studied locations were: *Sorghum halepense, Echinochloa crus-galli and Setaria* spp. (Table 1).

In the experimental field were present also other weed species: *Amaranthus retroflexus*, *Convolvulus arvensis*, *Xanthium italicum*, *Solanum nigrum*, but with a low density.

Table 1. Growth stage of dominant weeds

Weeds	BBCH	Description
SORHA *Sorghum halepense*	1st assessment 14	4 true leaves unfolded
	2nd assessment 17	7 true leaves unfolded
	3rd assessment 22	G=4 tillers visible
	4th assessment 48	V= Constant new development of young plants-vegetative reproductive organs reach final size
ECHCG *Echinochloa crus-galli*	1st assessment 13	3 true leaves unfolded
	2nd assessment 16	6 true leaves unfolded
	3rd assessment 22	2 side shoots visible; 2 tillers visible
	4th assessment 43	Harvestable vegetative plant parts or vegetatively propagated organs have reached 30% of final size;
SETSS *Setaria* spp.	1st assessment 12	2 true leaves unfolded
	2nd assessment 15	5 true leaves unfolded
	3rd assessment 21	First side shoots visible
	4th assessment 34	Stem (rosette) 30% of final length (diameter);4 nodes detectable

Coverage with species *Sorghum halepense* in the experimental field was high: 57.7% before treatment application, 66.8% at 14 days, 67.5% at 28 days and 71.0% at 42 days after treatment application. In these conditions of weed infestation, the nicosulphuron, sulfonylurea-based herbicide had a good efficacy in control of annual and perennial monocotyledonous weeds in maize. At 14 days after treatment the herbicide had a very good efficacy in control of *Sorghum halepense* (98.0%), *Echinochloa crus-galli* (100%) and *Setaria* spp. (100%), at a dose of 1.5 l/ha, the results being similar to those of the standard reference (Table 2). Good results were recorded at the dose of 0.8 l/ha respectively: 90.0% for *Sorghum halepense*, 92.8% for *Echinochloa crus-galli* and 100% for *Setaria* spp.

Table 2. The efficacy of herbicides in maize crop after 14 days of treatment

Treatment name	Dose l/ha	Weeds					
		Sorghum halepense		*Setaria* spp.		*Echinochloa crus-galli*	
		Dens. (%) [1]	E. (%)[2]	Dens. (%)	E. (%)	Dens. (%)	E. (%)
Untreated		66.8	0.0	15.5	0.0	6.0	0.0
Nicosulphuron	0.8	9.0 a	90.0 b	0.0 a	100 a	0.8 a	92.8 ab
	1.0	5.5 ab	94.8 ab	0.0 a	100 a	0.3 a	93.8 ab
	1.5	3.0 b	97.3 a	0.0 a	100 a	0.0 a	100 a
Standard reference	1.5	0.5 b	99.5 a	0.0 a	100 a	0.0 a	100 a
LSD (P=.05)		2.91	3.74	0.22	0.00	0.81	16.21
Standard Deviation		2.01	2.59	0.15	0.00	0.56	11.22

[1]Dens. = density (ground %)
[2]E.= efficacy (control %)

Nicosulphuron applied in postemergence is quickly absorbed by weeds mainly through the leaves and roots, is then translocated into the sap stream to the apical meristems, where they cause irreversible disturbances in cell division. The total control of weeds is carried out in a longer period of up to three weeks. The weed ceases to grow immediately after treatment. Observations shows that the action of the herbicide is influenced by climatic conditions and vegetation at the time of application, absorption and translocation are more intense and faster when weeds have optimal growth conditions (light, heat, water, food) and thus the inhibitory effect is more complete. In order to fully penetrate into the plant, it is necessary that after treatment, precipitations does not fall for a period of 4-5 hours. Subsequent observations (28 and 42 days after treatment) confirmed the good results of the nicosulphuron herbicide in control of annual and perennial monocotyledonous weeds in maize (Tables 3 and 4). At the dose of 1.5 l/ha, the effect of the herbicide was maintained throughout the growing season of maize: *Sorghum halepense* (91.5%), *Echinochloa crus-galli* (100%) and *Setaria* spp. (98.0%) at 42 days after treatment. At the dose of 0.8 l/ha species *Sorghum halepense* is not entirely controlled such as control rate decreased from 85.5% at 28 days to 61.3% at 42 days after treatment application.

Table 3. Efficacy of herbicides in maize crop after 28 days of treatment

Treatment name	Dose l/ha	Weeds					
		Sorghum halepense		*Setaria* spp.		*Echinochloa crus-galli*	
		Dens. (%)	E. (%)	Dens. (%)	E. (%)	Dens. (%)	E. (%)
Untreated		67.5	0.0	9.5	0.0	10.5	0.0
Nicosulphuron	0.8	12.3 b	85.5 c	1.0 b	90.0 a	0.0 a	96.2
	1.0	7.3 cd	91.0 abc	0.0 b	100 a	0.0 a	100 a
	1.5	5.8 de	94.3 abc	0.0 b	100 a	0.0 a	100 a
Standard reference	1.5	3.0 ef	97.0 ab	0.0 b	100 a	0.0 a	100 a
LSD (P=.05)		3.04	7.15	1.09	9.47	0.44	10.89
Standard Deviation		2.11	4.95	0.76	6.42	0.30	7.54

Table 4. Efficacy of herbicides in maize crop after 42 days of treatment

Treatment name	Dose l/ha	Weeds					
		Sorghum halepense		*Setaria* spp.		*Echinochloa crus-galli*	
		Dens. (%)	E. (%)	Dens. (%)	E. (%)	Dens. (%)	E. (%)
Untreated	-	71.0	0.0	18.0	0.0	14.5	0.0
Nicosulphuron	0.8	29.8 a	61.3 d	2.5 b	87.5 a	1.0 a	85.5 a
	1.0	9.5 cd	88.8 b	1.0 bc	96.3 a	0.8 a	91.8 a
	1.5	7.5	91.5 b	0.5 bc	98.0 a	0.0 a	100 a
Standard reference	1.5	7.5	91.5 b	0.0 c	100 a	0.3 a	93.8 a
LSD (P=.05)		2.90	3.21	1.49	7.60	0.87	11.91
Standard Deviation		2.01	2.22	1.03	5.27	0.60	8.24

No phytotoxicity symptoms have been shown in the experimental plot. No symptoms of chlorosis, necrosis, leaf deformation, height reduction, distortion and delay at flowering in plots treated with herbicides nicosulphuron. Maize plants managed by its own mechanism to metabolize the active substance and convert it to biologically inactive compounds, so the majority of maize hybrids show no phytotoxicity symptoms. In treated plots, maize plants were more vigorous and taller and culture density was much higher compared to control (Figure 1).

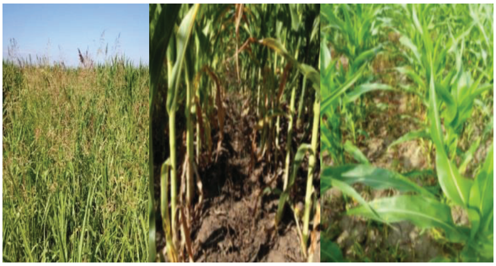

Figure 1. Aspects regarding nicosulphuron efficacy at 28 days after treatment.

CONCLUSIONS

The degree of weeds in maize was high, the predominant weed species was a perennial weed, *Sorghum halepense*, with a coverage rate of over 70% at 42 days after treatment application.

Also annual monocotyledonous weed species *Echinochloa crus-galli* and S*etaria* spp. were present with low density percentage, 14.5% and 18%.

The herbicide based on nicosulphuron had a good efficacy in controlling annual and perennial weeds in maize crops.

At the dose of 0.8 l/ha *Sorghum halepense* is not entirely controlled.

For *Sorghum halepense* species the best results were obtained at the dose of 1.5 l/ha. No phytotoxicity symptoms have been shown in experimental plots.

No symptoms of chlorosis, necrosis, leaf deformation, height reduction, distortion and delay at flowering in plots treated with nicosulphuron.

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REFERENCES

Berca M., 1996. Weed control in crops. Fermierul Roman Publishing House, Bucharest.

Berca M., 2004. Integrated weed management. Ceres Publishing House, Bucharest.

Chirila C., 2001. Weed biology. Ceres Publishing House, Bucharest.

Sarpe N., Ciorlaus A., Ghinea L., Vladutu I., 1976. Herbicides. Principles and Practice in weed control. Ceres Publishing House, Bucharest.

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ACTUAL PROBLEMS CONCERNING PROTECTION OF THE WHEAT CROPS AGAINST CEREAL GROUND BEETLE (*Zabrus tenebrioides* Goeze) ATTACK IN SOUTH-EAST OF THE ROMANIA

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Abstract

Cereal ground beetle (Zabrus tenebrioides Goeze) represents one of the most important pests of wheat crop, in south-east of the Romania. Larva lives in soil and represents the most damaging stage of this pest. Higher attacks can occur in case of wheat monoculture or plants emerged from untreated seeds. High soil moisture and moderate temperatures are favorable conditions for Zabrus tenebrioides larva development and attack. In this paper, authors collective present results concerning testing effectiveness of the seed treatment with both, low and high doses of imidacloprid and mixture (imidacloprid+tebuconazole), in climatic conditions from south-east of the Romania, at NARDI Fundulea. Favorable conditions for pest attack it has registered in period October 2014-March 2015, when attacked plants percent at wheat emerged from untreated seeds was 46.16% and October 2015-March 2016, when attacked plants percent at wheat emerged from untreated seeds was 32.89%. In last years, during autumn, periods with higher rainfall amount occurred when wheat plants were in first vegetation stages, the most critical period of this crop for cereal ground beetle attack. In all of the years from this study, highest effectiveness in protection of wheat plants against attack of Zabrus tenebrioides larva were provided by imidacloprid active ingredient, in dose of 0.88 and 1.66 l/t. Also, imidacloprid+tebuconazole active ingredients provide good protection for wheat crops against this pest. In case of different climatic conditions, registered in last years, seed treatment assign stable protection of wheat crop and represent an effective method for control of Zabrus tenebrioides.

***Key words**: wheat, ground beetle, damage, control.*

INTRODUCTION

With a surface higher then 2 million hectares, each year, wheat is the second crop cultivated in Romania, after maize (MADR data, 2016). Cereal ground beetle (*Zabrus tenebrioides* Goeze) represents one of the most important pests of wheat crop, in south and south-east of the country (Knechtel and Knechtel, 1909; Manolache et al., 1959, 1960; Paulian et al., 1959; 1965; Hulea et al., 1975; Barbulescu et al., 1985, 1988, 1995, 2001; Popov, 1975, 1985; Popov et al., 1996, 2004a). Also, this pest occurs in West Plane, Tarnava or Mures rivers valley (Rosca and Rada, 2009). Same authors mentioned that highest populations of this pest in Romania occur in Baragan Plane. In Europe this pest produce damage at wheat and barley crops, especially in countries around Black Sea (Romania, Bulgaria, Ukraine, South of Russia, Turkey) and Greece (Chenikalova et al., 2009). Also, *Zabrus tenebrioides* is spread in several countries from Western Europe such as: England, France, Germany, Italy (Bassett, 1978; Kreuz et Engelhardt, 1991, Nicosia et al., 1996; Jullien, 1999) or Central Europe such as Austria, Czech Republic or Slovakia (Cate, 1980; Martinez and Pillon, 1993; Oezder and Kivan, 1998). Larva lives in soil and represents the most damaging stage of this pest, for wheat crops (Manolache et al., 1963; Hulea et al., 1975; Kryazheva et al., 1989; Walczak, 2007). In the climatic conditions of Romania, the attack of *Zabrus tenebrioides* larva is very dangerous in autumn, when plants are in first vegetation stages (Manolache et al., 1963;

Popov, 2002). In case of higher attack occurred in autumn, wheat crops can be destroyed and farmers must sowing again (Popov, 1999 cited by Rosca and Rada, 2009). Attack occurred in spring, after tillering stage of wheat, are less harmful, generally one or two tillers are destroyed by larva, but plants survive (Hulea et al., 1975; Popov et al., 1996). According Popov et al. (2006), the late attack in spring, is less visible, because the plants have a high biomass, fact that camouflages the damage and ensures a better survival of the attacked plants. Same author mentioned that high soil moisture and moderate temperatures are favorable conditions for *Zabrus tenebrioides* larva development, as result attack of this pest at wheat crops can be high. Contrarily, in years with dry autumns, low humidity from soil represent unfavorable conditions for larva development, as result the attack occurs later, after the first rains, with no obvious damages. Popov et Barbulescu (2007) mentioned that in period 1950-1960, in south and south-east of the Romania it was recorded high pest density, ranged from 75000 to 100000 larva/ha. In first half of XX century, in some favorable years it has recorded more the 250000 ha with wheat destroyed by cereal corn beetle larva attack (Popov et al., 2010). Wheat monoculture favors *Zabrus tenebrioides* attack and the increasing of pest density from one year to another (Popov et al., 1983, 2004b). However, only crop rotation is not enough for wheat crop protection against cereal ground beetle (Popov et al., 2008). Along the time, at NARDI Fundulea (former ICCPT Fundulea) it has made several researches concerning chemical protection of the wheat crops against *Zabrus tenebrioides* attack (Popov et Barbulescu, 2007, Popov et al., 2010). First product synthesized in Romania for seed treatment was FB 7 (Paulian et al., 1965). This product has two active ingredients, linden for pest control and ethyl mercuric chloride for seed borne diseases. Popov (1985) mentioned that seed treatment with FB7 was generalized in Romania, in 8th decade of 20th century, when more then 1 million hectares were sowing with treated seeds. After ban of ethyl mercuric chloride active ingredient, product FB7 was replaced with Tirametox 90 PTS (Popov et al., 2007). After 2006, linden active ingredient was banned, because of higher toxicity for environment. As result, neonicothinoids insecticides remain available for seed treatment, with effectiveness higher then 90 % (Popov et al., 2010; Trotus et al., 2011). In a previous study, made in south of the Romania, Popov et al. (2010) mentioned that, between 2003 and 2007, the attack of *Zabrus tenebrioides* larva at wheat plants emerged from untreated seeds ranged from 9,8 to 17,0 % at NARDI Fundulea. Also, in same period, at ARDS Marculesti the attack ranged between 6,2 and 17,2 % while at ARDS Caracal the attack of larva, was 7,3 % in 2003 and 23 % in 2004. Unpublished reports and some articles published in journals for farmers make in evidence higher attack of *Zabrus tenebrioides* at wheat crops in last years (Georgescu, 2014; Georgescu et Risnoveanu, 2015). Possible reasons for increasing of the cereal ground beetle attack is lack of seed treatment, because of higher price of pesticides, wheat monoculture and climate changes (Kocmánková et al, 2010; Olesen et al., 2011; Lup et al., 2013). After EU directive 485/2013, from 1 December 2013, the use of three active ingredients for seed treatments of the spring crops and oilseed rape (imidacloprid, clothianidin and thiamethoxam) were restricted (Official Journal of the European Union, 2013). However, seed treatment for cereals sowed in autumn is not affected by this directive.

The aim of this study is testing effectiveness of the seed treatment with both, low and high doses of imidacloprid and mixture imidacloprid+tebuconazole, to control *Zabrus tenebrioides* attack in conditions of wheat monoculture, in south-east of the Romania.

MATERIALS AND METHODS

The researches were carried out at experimental field of the Plant Protection Collective, from National Agricultural Research Development Institute, Fundulea, Calarasi County, Romania (44° 30′ N, 24° 1′ E), starting from autumn of the year 2013 until spring of the year 2016. The experiments were arranged after randomised blocks designs. Each experimental variant have four repetitions. Experimental plots have 10 m length, 2 m width, as result plot surface was of 20 m^2. In all years of study, wheat was sowed in monoculture system, at the middle of the

October. It has tested four doses of imidacloprid (600 g/l) active ingredient and two doses of imidacloprid (233 g/l)+tebuconazole (13 g/l) mixture (Table 1).
The assessments concerning the attack of *Zabrus tenebrioides* it was made at the end of autumn (November) and beginning of spring (March). At each plot, on 10 row meter chosen randomly or in "stair" system, in central area of plot, it has assessed the number of emerged plants and the number of damaged plants. The attack of *Zabrus tenebrioides* is easy to recognize in the field, larva drag the plants in soil and chewed them, finally from attacked wheat plants remains at the soil surface, main nervures like a hemp flock (Figure 1). At each experimental variant it has calculated the effectiveness of seed treatment, comparative with control (untreated) variant.

Table 1. Active ingredients used in the field experiments concerning wheat seed treatment effectiveness against *Zabrus tenebrioides* Goeze

Variant	Active ingredient	Dose (kg/t)
1	control (untreated)	—
2	imidacloprid (600 g/l)	0.58
3	imidacloprid (600 g/l)	0.70
4	imidacloprid (600 g/l)	0.88
5	imidacloprid (600 g/l)	1.66
6	Imidacloprid (233 g/l)+tebunconazole (13 g/l)	2.00
7	Imidacloprid (233 g/l)+tebunconazole (13 g/l)	2.25

Meteorological data (average air temperatures and daily rainfalls) were provided by meteorological station of NARDI Fundulea, each year. From this study it has taken in considerations data from the beginning of October until end of March, that represent the most critical period for attack of cereal ground beetle larva at wheat crop.
The data were **statistical analyzed** through the analysis of variance method by using of the Microsoft Excel 2003 and ARM 8.5 software.

RESULTS AND DISCUSSIONS

Climatic conditions during this experiment were variable. Concerning rainfall amount, registered in October and November, period that coincide with first vegetation stages of wheat plants, data from the meteorological station of NARDI Fundulea show that highest amount of rainfalls were registered in November 2015 (Figure 2).

Figure 1. Typically symptoms of *Zabrus tenebrioides* larva attack, at wheat plants (ARDS Braila, 2015)

In 2014, both in October and November, rainfalls amount were higher then multiyear average, while in October 2013, rainfalls amount were with 20,8 mm over multiyear average. Contrarily, in November 2013 it has registered low rainfall amount, below multiyear average. However, analyzing daily distributions of the rainfalls at NARDI Fundulea, it has ascertained that more then 80 % of the rainfalls from October 2013 it has registered only in one day, at the first day of this month. After 1 October 2013, until the end of autumn, it has registered low rainfalls amount. However sol moisture was high.

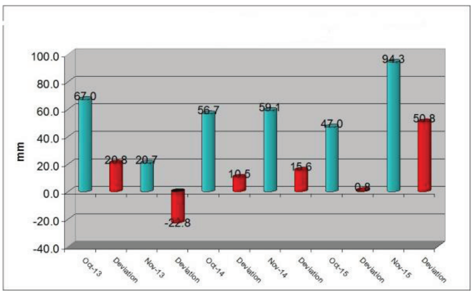

Figure 2. Rainfalls amount registered in October and November, at NARDI Fundulea, period 2013-2015

Average air temperature was highest then multiyear average in November 2013 and November 2015 (Figure 3). In rest of the period from autumn (years 2013-2015), deviations from multiyear average was low.
Data from table 2 show highest attack of *Zabrus tenebrioides* larva at wheat untreated

plants in season 2014-2015 (I=43.16 %) and season 2015-2016 (I= 32.89%). Also, in season 2013-2014 (autumn of 2013-spring of 2014) it has ascertained that more then 20 % of the plants from experimental variant without treated seeds were attacked. In last years, the attack of cereal ground beetle larva at untreated wheat plants, registered at NARDI Fundulea, was highest then 10 years ago.

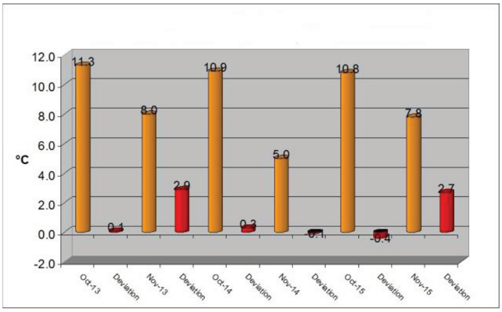

Figure 3. Temperatures registered in October and November, at NARDI Fundulea, period 2013-2015

A possible explication for this is because in last years, during autumn, periods with higher rainfall amount occurred when wheat plants are in first vegetation stages, the most critical period of this crop for *Zabrus tenebrioides* attack. Data from literature demonstrate that attack of larva can continue during winter season too, if temperature at soil surface is higher then +3 °C, without snow (Manolache et al., 1963; Hulea et al., 1975; Bassett, 1978; Popov, 2002; Rosca et Rada, 2009). At low temperatures and snowfall, the attack stops.

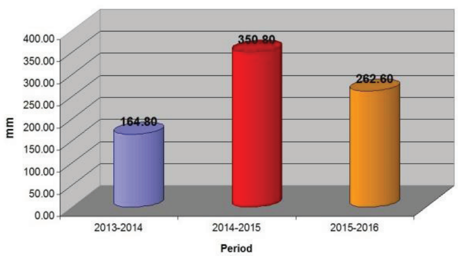

Figure 4. Rainfalls amount registered in October and March, at NARDI Fundulea, period 2013-2016

Total rainfall amount registered from October until March was highest in season 2014-2015 (Figure 4). Also, in season 2015-2016, between October and March it has registered 262,6 mm of rains. Deeper analyze of meteorological data from NARDI Fundulea, make in evidence that rainfalls amount from December 2014 was 119.4 mm comparative with multiyear average for this month, of 44.1 mm. Highest amount of rainfalls amount registered in October, November and December, 2014, determined high soil moisture, that represent favorable conditions for larva development. This is a possible explication for high value of *Zabrus tenebrioides* attack at wheat untreated plants, sowed in monoculture system. In last years, at NARDI Fundulea there was positive correlation between rainfalls amount, registered from autumn (October) until beginning of the spring (March) and attack of cereal ground beetle larva at wheat untreated plants (Figure 5).

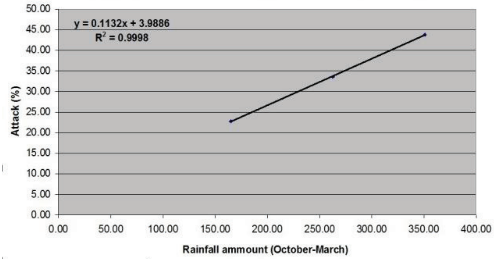

Figure 5. Relations between rainfalls amount and attack of *Zabrus tenebrioides* larva at untreated wheat plants (2013- 2016)

Long term studies on precipitations evolution show a decreasing trend, in countries from Central and South-East Europe, including Romania (Bozo, 2011). Same author mentioned that, sometime, increasing precipitations is visible as a shorter term tendency. This situation occurred in last years, in autumn period, at NARDI Fundulea. According Gregory et al. (2009), many pests and diseases can be favoured by climate changes. Same author mentioned that the interactions between crops and pests are complex and poorly understood in the context of new climatic conditions. Further study are necessary to determinate influence of the climate changes from both, autumn and winter period, concerning attack of *Zabrus tenebrioides* at wheat plants, in south and south-east of the Romania.

Analyzing data from Table 2, it can be ascertained that the attack of the *Zabrus tenebrioides* at treated variants was higher in case of lower dose of imidacloprid (0.58 l/t) in all studied years. Lowest percentage of attacked wheat plants, it has registered in case of higher dose of imidacloprid used in this experiment (1.66 l/t), and mixture between imidacloprid and tebuconazole. In all of these cases, the attack was below 1 %.

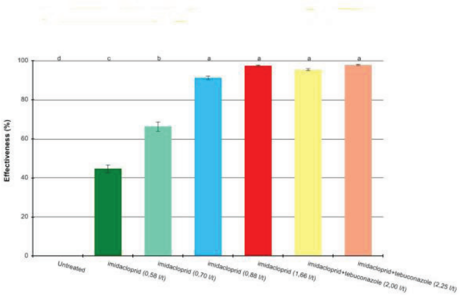

Figure 6. Effectiveness of seed treatment against *Zabrus tenebrioides* (2013-2014)

In autumn of 2013 and beginning of the spring, 2014, highest effectiveness in protection of wheat plants, against cereal ground beetle larva attack was provided in case of both, highest dose of imidacloprid and mixture between imidacloprid and tebunconazole (E = 97.48 % respectively 97.88 %).

The differences between these variants and control (untreated) variant were significant (P<0.05). Also, high effectiveness it has registered in case of lower dose of mixture (imidacloprid+tebuconazole) used in this experiment, and imidacloprid dose of 0.88 l/t (Figure 6).

In season 2014-2015, at lowest dose of imidacloprid used in this experiment (0.58 l/t) the attacked wheat percent was 22.13 %. Also, at variant treated with imidacloprid in dose of 0.70 l/t, the attack presented high values. Contrary, at highest dose of imidacloprid from this experience (1.66 l/ha), the attack of *Zabrus tenebrioides* was low (Figure 7).

In case of high pest pressure from autumn period of 2014 and beginning of the spring 2015, imidacloprid active ingredient in dose of 1.66 l/t and both doses of mixture between imidacloprid and tebunocazole, provide high effectiveness in protection of wheat plants, in first vegetation stages against *Zabrus tenebrioides* larva attack.

Table 2. Attack frequency (%) of *Zabrus tenebrioides* Goeze, at wheat plants, in experimental field of Plant Protection Collective, NARDI Fundulea (2013-2016)

Active ingredient	**Dose (l/t)**	**Attacked plants percent (%)**		
		2013-2014	**2014-2015**	**2015-2016**
control (untreated)	—	22.51**a**	43.16**a**	32.89**a**
imidacloprid (600 g/l)	0.58	13.29**b**	22.13**b**	17.01**b**
imidacloprid (600 g/l)	0.70	7.44**c**	11.68**c**	9.51**c**
imidacloprid (600 g/l)	0.88	1.91**b**	2.96**d**	2.70**d**
imidacloprid (600 g/l)	1.66	0.57**f**	0.29**f**	0.30**f**
imidacloprid (233 g/l)+tebunconazole (13 g/l)	2.00	0.99**e**	0.91**e**	0.82**e**
imidacloprid (233 g/l)+tebunconazole (13 g/l)	2.25	0.47**f**	0.73**e**	0.40**f**
LSD P=.05		0.083	0.077	0.098t
Standard deviation (SD)		0.056	0.052	0.066t
Coefficient of variation (CV)		8.6	6.82	9.45t
Replicate F		3.308	0.455	3.739
Replicate Prob. (F)		0.0438	0.7171	0.0300
Treatment F		303.379	546.317	299.766
Treatment Prob. (F)		0.0001	0.0001	0.0001

Means followed by same letter do not significantly differ (P=0.05, Student-Newman-Keuls)

Also, effectiveness of the imidacloprid active ingredient, in dose of 0.88 l/t was higher then 93 %. Similar like in previous season, higher pest pressure was registered in season 2015-2016. The attack of *Zabrus tenebrioides* larva at wheat untreated plants was higher then 30 %.

At lowest dose of imidacloprid active ingredient, used in this experiment (0.58 l/t), the attacked wheat plants percent by larva of *Zabrus tenebrioides* was 17.01 % while at higher dose of imidacloprid (1.66 l/t) the attack was 0.3 %. In case of both doses of mixture (imidacloprid+tebuconazole), the attacked plants percent has low values (I = 0.82 % respectively 0.40 %).

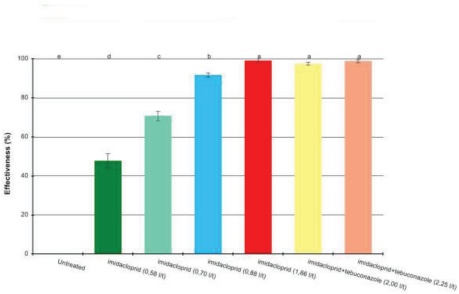

Figure 8. Effectiveness of seed treatment against *Zabrus tenebrioides* (2015-2016)

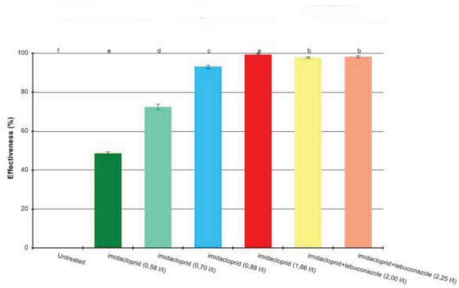

Figure 7. Effectiveness of seed treatment against *Zabrus tenebrioides* (2014-2015)

In autumn of the 2015 and beginning of the spring, 2016, highest effectiveness in protection of wheat plants, in first vegetation stages, was provided by imidacloprid, in dose of 1.66 l/t, and mixture between imidacloprid and tebuconazole, in doses of 2.00 and 2.25 l/t (Figure 8).

The differences between these variants and control (untreated) variant were statistically assigned. Also, in case of variant treated with imidacloprid, in dose of 0.88 l/t, the effectiveness was higher then 93 %.

Contrary, at variant treated with lowest dose of imidacloprid, the effectiveness of the seed treatment was lower.

Data from this experiment demonstrate that seed treatment with imidacloprid active ingredient in dose of 0.88 and 1.66 l/t and mixture between imidacloprid and tebuconazole active ingredients, in dose of 2.00 and 2.25 l/t, provide good protection of wheat plants, from emergence until tillering stage against attack of *Zabrus tenebrioides* larva.

Figure 9. Cereal ground beetle (*Zabrus tenebrioides* Geoze) larva, at wheat crop (NARDI Fundulea, 2015)

Figure 10. Attack of cereal ground beetle (*Zabrus tenebrioides* Geoze) larva, at wheat untreated crop, sowed in monoculture system (ARDS Braila, 2015)

Also, in case of different climatic conditions, registered in last years, seed treatment assign stable protection of wheat crops, even in monoculture system. At same conclusion arrive Popov et al. (2007, 2008, 2010) and Trotus et al. (2011).

In case of favorable climate conditions for *Zabrus tenebrioides* larva, looses at wheat untreated crops can be higher then 40 % (Figures 9 and 10).

CONCLUSIONS

In last years, climatic conditions registered in autumn and beginning of the spring at NARDI Fundule was favorable for *Zabrus tenebrioides* attack. Attacked wheat plants percent by *Zabrus tenebrioides* larva was 43.16 % in season 2014-2015, 32.89% in season 2015-2016 and 22.51% in season 2013-2014.

In all of three years of this study, in different climatic conditions, seed treatment with imidacloprid active ingredient, in dose of 0.88 and 1.66 l/t and mixture between imidacloprid and tebuconazole, provide effective protection of wheat plants, in first vegetation stages, against *Zabrus tenebrioides* attack.

Further studies are necessary to evaluate the impact of climate changes concerning *Zabrus tenebrioides* attack in south-east of the Romania.

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REFERENCES

Barbulescu A., Ciurdarescu G., Mateias M.C., Popov C., Tusa C., Voinescu I., Vonica I., Bratu R., Craiciu M., Gheorghe M., Milim E., Pelmus A., Pelmus V., Marta R., 1985. Evolution of some diseases and pests of grains, industrial and forage crops in our country during 1984. Problems of Plant Protection, 13(1):43-61.

Barbulescu A., Bigiu L., Bratu R., Ciurdarescu G., Craiciu M., Gheorghe M., Mateias M.C., Pelmus A., Pelmus V., Popov C., Rugina M., Tusa C., Voinescu I., Vonica I., 1988. Evolution of some diseases and pests of grains, industrial and forage crops in our country during 1987. Problems of Plant Protection, 16(1) 57-74.

Barbulescu A., Mateias M.C., Popov C., Guran M., Voinescu I., Stanciu M., Raranciuc S., 1995. Evolution of some diseases and pests of grains, industrial and forage crops in our country during 1994. Problems of Plant Protection, 23(1):75-92.

Barbulescu A., Popov C., Mateias M.C., Voinescu I., Guran M., Raranciuc S., Spiridon C., Vasilescu S., Valasn D., 2001. Evolution of some diseases and pests of grains, industrial and forage crops in our country during 2000. Problems of Plant Protection, 29(1):1-16.

Bassett P., 1978. Damage to winter cereals by Zabrus tenebrioides (Goeze)(Coleoptera: Carabidae). Plant Pathology, 27(1):148.

Bozo L., 2011. Climate change in Central Europe: Observations and Model Scenarios. Agrisafe final conference "Climate change: Challenges and Opportunities in Agriculture", pg. 9-11.

Cate P., 1980. The cereal ground-beetle (Zabrus tenebrioides Goeze), an important cereal pest in Austria. Pflanzenarzt, 33(12):115-117.

Chenikalova E., V., Pentyk I., D., Alekseev A., V., 2009. Effectiveness of control of the ground beetle on cereals. Zashchita i Karantin Rasteniĭ, (4):42-43.

Georgescu E., 2014. Why is necessary to treat cereal seeds with an insecticide or a fungicide? Plants Health, (9):18-19.

Georgescu E., Rasnoveanu L., 2015. Zabrus tenebrioides again trouble pest. Farm, (17):50-52.

Gregory P.J., Johnson S.,N., Newton A.,C., Ingram J.,S.,I., 2009. Integrating pests and pathogens into the climate change/food security debate. Journal of Experimental Botany, 60 (10): 2827-2838.

Hulea A., Paulian F., Comes I., Hatmanu M., Peiu M., Popov C., 1975. Cereals diseases and pests. Ceres Publishing House, Bucharest, 234 pp.

Jullien J., 1999. Le Zabre des céréales: Il fait surface dans les Pays de la Loire et en Bretagne: Sol, Environnement et Santé des plantes. Phytoma-La Défense des végétaux, 520:31-32.

Kocmánková E., Trnka M., Eitzinger J., Formayer H., Dubrovsky M., Semerádová D., Zalud Z., Juroch J., Mozny M., 2010. Estimating the impact of climate change on the occurrence of selected pests in the Central European region. Climate Research, 44:95-105.

Kreuz E., Engelhardt K., 1991. Studies on the occurrence of the corn ground beetle (Zabrus tenebrioides Goeze) in winter wheat and winter barley as influenced by crop rotation, tillage and manuring. Archiv für Phytopathologie und Pflanzenschutz, 27(6):487-493.

Kryazheva L., Ovsyannikova E., Pisarenko V., Sorokina M., Shokh G., Shokh N., Dubrovin N., 1989. Characteristics of damage by the corn ground beetle Zabrus tenebrioides Gz.(Coleoptera, Carabidae) in the south of the USSR. Entomologicheskoe Obozrenie, 68(4):689-699.

Knechtel W., Knechtel W.C.K., 1909. Damaging pest from Romania and tools for control. Albert Baer publishing house, Bucharest, 29-30.

Lup A., Miron L., Roman B., 2013. Influence of market economy concerning crops structure. Annals of N.A.R.D.I. Fundulea, 81:185-191.

Manolache C., Manolache F., Hrisafi C., Catuneanu I., Boguleani G., 1959. Situation of the crop pest in years 1955-1956 and 1956-1957. Met. Rap. Mem., I.C.A.R., Bucharest, Academy Publishing house:28.

Manolache F., Nica F., Sapunaru T., 1960. New progress in cereal ground beetle (Zabrus tenebrioides) control. Agricultural Problems, 12(8):44-52.

Manolache C., Nica F., Sapunaru T., 1963. Researches concerning biology, ecology and control of the cereal ground beetle (Zabrus tenebrioides). Study Biological Researches, Series Animal Biology, 15(1):95-122.

Martinez M., Pillon O., 1993. The cereal ground beetle: a pest still little known. Phytoma, 446:26-34.

Oezder N., Kivan M., 1998. Some biological investigations on Zabrus tenebrioides damaged on wheat in Thrace region. The 6th European Congress of Entomology, Ceske Budejovice (Czech Republic), 23-29 Aug 1998.

Olesen J.E., Tmka M., Kersebaumc K.C., Skjelvågd A.O., Seguine B., Peltonen-Sainiof P., Rossig F., Kozyrah J., Micalei F., 2011. Impacts and adaptation of European crop production systems to climate change. European Journal of Agronomy, 34 (2):96-112.

Nicosia O.L.D., Troccoli A., Codianni P., 1996. Zabrus tenebrioides: a focus of infestation in the province of Foggia. Informatore Agrario, 52(8):127-128.

Paulian F., Alexandri A.V., Constantinescu G., Ceianu V., Danet G., Motoi E., Severin V., Snagoveanu C., Tarcomnicu-Neagu M., 1959. Plant protection, Agricultural-Forestry Publishing house, Bucharest, 834 pp.

Paulian F., Barbulescu A., Tarcomnicu-Neagu M., Hatman M., Peiu M., 1965. A new product with insecticide-fungicide action for wheat seed treatment. Agricultural problems, 17 (5):19-23.

Popov C., 1975. Observations on the ecology of Viviania cinerea Fall. (Diptera, Tachinidae). Annals of ICCPT Fundulea, Serie C, 40:113-122.

Popov C., 1985. Chemical seed treatment – an efficient method to control some small grains pests. Problems of Plant Protection, 13(2):115-120.

Popov C., 2002. Researches concerning the protection of the cereals, leguminous for grains, technical and forage plants against pathogen agents and pests, year 2001. Problems of Plant Protection, 30 (2):109-190.

Popov C., Barbulescu A., Vonica I., Banita E., Hondru N., Malschi D., Margarit G., 1983. Influence of some agro technical methods concerning pests population level from cereals crop populations. Vegetal Production, Cereals and Industrial plants, 35(1):17-23.

Popov C., Barbulescu A., Stan O., Udrea A., Petcu L., Stoica V, 1996. Protection of winter wheat and barley crops against cereal ground beetle (*Zabrus tenebrioides* Goeze.) by seed dressing with new insecticide-funcicide mixtures. Problems of Plant Protection, 24(2):143-156.

Popov C., Guran M., Raranciuc S., Rotarescu M., Spiridon C., Vasilescu S., Gogu F., 2004a. Phytosanitary state of cereals, leguminous for grain, industrial and fodder crops in Romania in 2003. Problems of Plant Protection, 32(1):1-23.

Popov C., Rotarescu M., Spiridon C., 2004b. Prevention and control of seed and soil – pest and diseases in small grains in 2004. Problems of Plant Protection, 32(2):163-172.

Popov C., Trotus E., Vasilescu S., Barbulescu A., Rasnoveanu L., 2006. Drought effect on pest attack in field crops. Romanian Agricultural Research, 23: 43-52.

Popov C., Barbulescu A., Raranciuc S., 2007. Seed treatment a modern, efficient and less pollutant method for field crops protection. Annals of N.A.R.D.I. Fundulea, 74:133-139.

Popov C., Barbulescu A., 2007. 50 years of scientific activity in field protection domain against diseases and pests. Annals of N.A.R.D.I. Fundulea, 75:371-404.

Popov C., Barbulescu A., Raranciuc S., 2008. Seed treatment – modern, efficacy and less polluted method, of field crops protection. Annals of N.A.R.D.I. Fundulea, 76:133-139.

Popov C., Cana L., Trotus E., Stoica V., Vilau F., Trasca G., Ciobanu C., 2010. Research regarding the improvement of carabid beetle, Zabrus tenebrioides Goeze., control technology, by wheat and barley seed treatment. Annals of N.A.R.D.I. Fundulea, 78:135-151.

Rosca I., Rada I.., 2009. Entomology (Agriculture, Horticulture, Forest). Alpha Mdn Publishing House, 699 pp (pg. 52-59).

Trotus E., Nae M., Buburuz A.A., Zaharia P., 2011. Wheat crops protection against harmful organisms using chemical treatment of seed. Agronomical Researches in Moldavia, 44(4):19-26.

Walczak F., 2007. Dangerous pests of cereals and methods for their control. Ochrona Roślin, 52(6):22-27.

***MADR data, 2016, http://www.madr.ro/culturi-de-camp/cereale/grau.html

***Official Journal of the European Union, 2013, http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:139:0012:0026:EN:PDF

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IS PLANT GROWTH PROMOTING RHIZOBACTERIA AN ALTERNATIVE TO MINERAL PHOSPHORUS FERTILIZER IN PEA SEED PRODUCTION?

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Abstract

The interest in the usage of biofertilizer as alternative to mineral fertilizer increase continuously due to increasing mineral fertilizer cost and heavy metal accumulation in the soil such as cadmium. The objective of this study was to assess the effects of four biofertilizer (N_2-fixing (NF), P-solibilizing (PS), N_2 fixing-P solubilizing (NF+PS), commercial biofertilizer (CB) with and without mineral phosphorus fertilizer on seed yield forage pea (Pisum sativum spp. arvense L.) The application of biofertilizer did not affect seed yield, biological yield, crude protein content and SPAD value. The use of mineral fertilizer only increased seed crude protein content. The effects of biofertilizer on pea seed yield, biological yield and crude protein content varied significantly depending on year. These results indicated that understanding of factors such as biofertilizer, mineral fertilizer and environment will enable us to use biofertilizer as an alternative to mineral fertilizer to optimize productivity and sustainability of pea production.

***Key words**: biofertilizer, mineral fertilizer, phosphorus, seed yield, pea.*

INTRODUCTION

Peas are cultivated widely as rotation or second crops for forage and pulse production in semi-arid environments. Both seeds and forages of pea are rich in protein and mineral content (Acikgoz et al., 1985). The productivity of peas like in the other legume crops are restricted by phosphorus deficiency. Thus, producers rely on mineral phosphorus fertilizer to achieve sustainable production. However, prices of chemical fertilizer increase continuously due to increasing energy cost which restricted their utilization economically. On the other hand, phosphorus fertilizers are not environmental friendly input in agriculture due to cadmium content (Al-Fayiz et al., 2007). Recently, there has been interest in more environmentally sustainable agricultural practices. A considerable numbers of bacteria species that are associated with the rhizosphere are able to exert a beneficial effect on plant growth (Rodriguez and Fraga, 1999). These microorganisms secrete different type organic acid (Illmer and Schinner, 1992*)* thus lowering the pH in the rhizosphere and consequently dissociate the bound form of phosphate (Rodriguez and Fraga, 1999). Phosphorus biofertilizers also help increase nitrogen fixation and availability of some microelements such as Fe, Zn etc. Generally, only 0.1% of total P in soil is available to plants (Scheffer and Schachtschabel, 1992). The way of increase to P available to plants is enzymatic decomposition or microbial inoculation (Illmer and Schinner, 1992). Hence, bacteria might be partially substitute chemical fertilizer or they are use together.

Plant growth promoting rhizobacteria (PGPR) are a group of bacteria that can actively colonize soils, plant rhizosphere, root or intercellular spaces of plants (Illmer and Schinner, 1992; Sahin et al., 2004; Cakmakci et al., 2007). PGPR promote plant growth either increasing nutrient intake or changes enzymatic or hormone synthesis, even some strains had pathogen control by having antibiotic effect (Xie et al., 1996; Stirk et al., 2002). PGPRs are changes chemical compounds of the applied plants. In general, PGPR application encourages an increase in crude protein content (Peix et al., 2001; Osman et al., 2010; Yolcu et al., 2012)

In general, there are currently no adequate knowledge on the effect of PGPR on the yield and chemical components of forage peas. The objective of this study were to determine the effects of phosphorus (with and without) and bacteria application on seed yield, biological yield, crude protein content and spat value of pea and possibility of phosphorus fertilizer or biofertilizer application in pea cultivation in semi-arid conditions.

MATERIALS AND METHODS

The field experiment was conducted at the experimental station of Faculty of Agriculture, University of Ataturk, Erzurum ($39^0 51^I$N and $41^0 61^I$E, 1850 m above sea level). The soil of experimental area was loamy with organic matter content of 1.92%, with lime 4.65% and pH of 7.24. Corresponding available P_2O_5 and K_2O contents were 27.3 kg ha^{-1} and 120.0 kg ha^{-1} in the first year, respectively. In the second year, it was loamy, with organic matter 1.85%, with lime 4.62%, pH of 7.80, available P_2O_5 88kg ha^{-1} and K_2O 181 kg ha^{-1}. In Erzurum, winters are long and extremely cold and summers are cool, short and arid. Long-term annual mean temperature is 5.0^{o}C, rainfall is 395.6 mm and relative humidity is 66.5% in the study area. Total annual precipitation and mean annual temperature were 437.8 mm and 5.8 ^{0}C in 2009 and 475.9 mm and 7.9 ^{0}C in 2010, respectively in the experiment years.

The experiment was arranged a randomized complete block design with three replications. Treatment consist of 0 or 50 kg P_2O_5 ha^{-1}, which suggested doses of phosphorus fertilizer in annual legumes cultivation in the region. Triple supper phosphate form of the phosphorus fertilizer were used and five different type biofertilizers were (a) control (C), (b) N_2-fixing (NF) (*Bacillus subtilis*), (c) P-solibilizing (PS) (*Bacillus megaterium*), (d) N_2 fixing-P solubilizing (NF+PS) (*Burkholderia cepacia* GC sup.B) and (e) commercial biofertilizer (CB) (Bio-one) was developed by Texas University which contain *Azotobacter vinelandi* living aerobic condition and *Clostridium pasteurianum* living anaerobic condition.

The biofertilizer were applied sterilized seeds before sowing and phosphorus fertilizer were broadcasted plots surface before sowing and it was incorporated the soil using hand harrow. Forage pea (*P. sativum* spp. *arvense* L. cv Taskent) was sown by hand with 100 seeds per m^2 in May 20th 2009 and May 15th 2010. The plot size was 1.5 m by 5 m = 7.5 m^2, consisting of 5 rows spaced 30 cm apart. Weed control was done by hand hoeing in the beginning of June. The plots were irrigated 3 times in 2009 and 2010 with flooding system when plant colour turns dark green due to lack of moisture in the soil during the growing season.

Harvesting was performed after taking out one row from each side of the plots and a 0.5 m area from beginning or end of each row. Seed yield was determined as harvesting the plant at seed maturity stage and samples were dried in the oven at 50^{o}C and then weighted to determine biological yield. Harvested and oven dried material were trashed by hand to separate seed. Seed yield was determined after cleaning the seeds. After weighting, hay and seed samples were grounded to pass through a 2 mm sieve and analysed for chemical characteristics. Total N content of the samples was determined by the Kjeldahl method and multiplied by 6.25 to give the crude protein content. Relative chlorophyll content (SPAD) was determined with a chlorophyll meter (SPAD-502, Minolta cam- era Co., Ltd., Japan) in characteristic development phases that beginning of development of fruits.

All data were subjected to analysis of variance based on General Linear Model for completely randomised design using the Statview package (SAS Institute, 1998). Means were separated using Duncan's multiple range tests.

RESULTS AND DISCUSSIONS

The seed yield was higher in the first year than in the second year (Table 1). Neither phosphorus fertilizer nor biofertilizer application had significant effect on seed yield of pea in the experiment. The plots received biofertilizer plus phosphorus fertilizer had similar or higher seed yield than control. The highest seed yield was obtained from NF+PS application among biofertilizer applications but it was not higher than alone phosphorus fertilizer application. As a result of these different responses, BF x P interaction was significant (Figure 1a). According to first year results, only phosphorus fertilizer application gave the best results with respect to seed production but in the second year PS and

NF+PS application without phosphorus fertilizer gave better result than the other treatments. Thus, BF x P x Y interaction was significant (Figure 1b). An average biological yield was 7.70 t ha^{-1}, it was higher in the first year than the second year. Neither main effects nor interaction effects were significant with respect to biological yield (Table 1).

An average CP content of seed was 27.00% and it changed depending on the years. The seeds had higher CP content in the second year than in the first year. While main effect of phosphorus fertilizer application was significant, biofertilizer applications were not significant. Phosphorus fertilizer application caused a decrease in seed CP content in the experiment. Seed CP content was higher in P_0 doses than P_{50} doses application (Table 1). Whereas, this differences were not recorded when adding biofertilizer to plots. Hence, BF x P interaction for seed CP was significant (Figure 2a). In the first year, there were no significant differences in CP content of seed with respect to phosphorus fertilizer application but higher seed CP content was recorded in P_{50} applications. Hence, P x Y interaction was significant (Figure 2b).

Biofertilizer, phosphorus and year effect was not significant on SPAD value (Table 1). SPAD value application of biofertilizer, phosphorus and year varied from 47.15 to 49.93, from 48.66 to 47.79 and from 47.93 to 48.33, respectively. Biofertilizer, phosphorus application, year and their interactions were not significant (Table 1).

Table 1. Analysis of variance results with main effects and interactions of biofertilizer and phosphorus fertilizer application on seed yield (SY), biological yield (BY) and crude protein content (CP) and SPAD value

Treatments	SY (t ha^{-1})	BY (t ha^{-1})	CP (%)	SPAD
C	1.65	7.56	26.46	47.75
NF	1.76	7.33	26.69	49.93
PS	1.74	7.85	26.67	47.89
NF+PS	1.84	7.86	27.10	47.93
CB	1.49	7.90	28.08	47.15
Average	**1.70**	**7.70**	**27.00**	**48.13**
P_0	1.59	7.51	27.56 A	48.56
P_{50}	1.80	7.89	26.44 B	47.69
Average	**1.70**	**7.70**	**27.00**	**48.13**
2009	1.87 A	8.61 A	25.05 B	47.93
2010	1.52 B	6.79 B	28.95 A	48.33
Average	**1.70**	**7.70**	**27.00**	**48.13**
BF	ns	ns	ns	Ns
P	ns	ns	***	Ns
Y	***	***	***	Ns
BF x P	*	ns	***	Ns
BF x Y	ns	ns	ns	Ns
P x Y	ns	ns	**	Ns
BF x P x Y	*	ns	ns	Ns

ns: non-significant, *: p<0.05, **: p<0.01, ***: p<0.001. Means in the same column with different letters are significant.

The differences in seed yield between years can be attributed to climatic differences because first year weather was cooler than the second year. Pea is a typically cool season plant as the first year prevailed cool weather extent the grain filling period, hence, seed yield was higher than the warmer second year. The yield increase in favourable soil and climate were also reported by various studies (Lambert and Linck, 1958; Egli and Wardlaw, 1980; Claphamet al., 2000). The highest seed yield was obtained by using alone phosphorus fertilizer, phosphorus fertilizer plus PS or NF+PS biofertilizer application (Figure 2a) but phosphorus fertilizer used in the combination of the other biofertilizer causes decreases in seed production. Phosphorus stimulate flowering and seed yield, hence, seed yield must increase with phosphorus fertilizer and PS biofertilizer application. But the decrease in the seed yield phosphorus fertilizer and the other biofertilizer application might be related to changes in rhizosphere microbial activity depending on new bacteria because biofertilizer changes root microbial activity and it can sometimes be harmful effect on plant growth (Rodriguez and Fraga, 1999). The different response related to years to phosphorus fertilizer and biofertilizer caused triple interaction in the experiment. The differences in soil microbial content might have caused this different response. Because, the effects of biofertilizer change depending on soil microbial content (Rodriguez and Fraga, 1999).

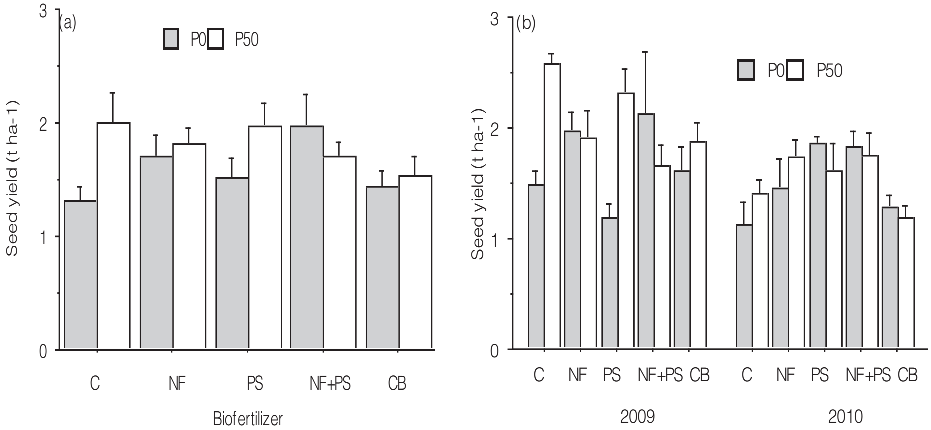

Figure 1. Seed yield of forage pea as affected by: (a) biofertilizer x phosphorus; (b) biofertilizer x phosphorus x year (Bars indicated ± s.e.)

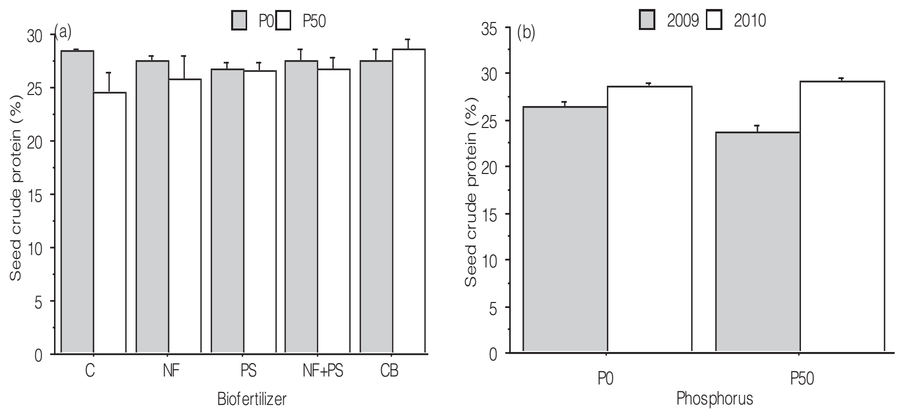

Figure 2. Seed crude protein content of forage pea as affected by: (a) biofertilizer x phosphorus; (b) phosphorus x year (Bars indicated ± s.e.)

As is in seed yield, biological yield showed significant differences between years. Biological yield was higher in the first year than second years because first year weather was cooler than the second year prevailed. Pea is well adapted cool climate (Lambert and Linck, 1958) hence first year biological yield was higher. Neither chemical nor biofertilizer had significant effect on biological yield and there also were not any interaction. These results implied that growing period which determined by climatic condition are more detrimental effect on pea production. Especially warm weather reduced final production in pea cultivation as happened in the second year in the experiment.

Chemical content of pea crops affected significantly by years. Higher crude protein content of both hay and seed were recorded second year in the experiment. The weather was warmer in the second year than in the first year. Since warmer weather restricted photosynthetic period, carbohydrate accumulation in vegetative tissue or grain decrease as a result of this effect crude protein content was higher in the first year. Because initially protein skeleton constituted in the cell thereafter carbohydrate accumulation occurred (Osman et al., 2010).

Phosphorus fertilizer or PS application causes significant changes in chemical content and it generally an increase in crude protein and mineral content (Peix et al.,2001). But crude protein content was not affected by phosphorus fertilizer or also slightly decreases in crude protein content of seeds in the experiment. However, PS bacteria causes significantly increase in crude protein content in both hay and seed. Crude protein content generally increases as phosphorus availability for plant. The decrease in crude protein content of seed might be related to the differences in environmental condition between years. P x Y interaction was significant for crude protein content of seed. Because phosphorus application causes an increases in crude protein content of seed in the first year, it cause a slight decreases in the second year. Environmental factors responsible for very wide changes in crude protein content are not fully understood (Reichert and MacKenzie, 1982). In our studies value of relative chlorophyll content (SPAD) was not differentiated by any treatment, year and their interactions. The value of SPAD ratio depends on the color of leaves, which informs not only of the nutritional status, but also is an inherited trait, as reported by Ambrose (2010). According to this author, genotypes of pea with dark-green bracts are characterized by higher SPAD values, > 60, and those of the bright green bracts have SPAD values < 30.

In conclusions, biofertilizer and inorganic phosphorus application had not positive effect on seed and biological yield in forage pea under Erzurum ecological condition. Conversely the effect of year was significant on seed yield, biological yield and crude protein content. But inorganic phosphorus application decreased crude protein content of seed.

CONCLUSIONS

In these studies, understanding of interaction between microbial fertilizer and soil microbial content will enable us to use microbial fertilizer as an alternative to mineral fertilizer. Because among biofertilizer, mineral fertilizer and year interaction is very common in the microbial fertilizer studies as it is in our study. These results indicated that biofertilizer or mineral fertilizer could be use in pea seed production.

REFERENCES

Acikgoz E., Katkat V., Omeroglu S., Okan B., 1985. Mineral elements and amino acid concentrations in field pea and common vetch herbages and seeds. J. Agron. and Crop Sci, 55: 179-185.

Al-Fayiz Y.S., El-Garawany M.M., Assubaie F.N., Al-Eed M.A., 2007. Impact of phosphate fertilizer on cadmium accumulation in soil and vegetable crops. Bull Environ. Contam. Toxicol, 78: 358-362.

Ambrose M.J., 2010. Field quantification of foliar chlorophyll content in Pisum germplasm. Pisum Genetics, 42: 7-10.

Cakmakci R., Donmez M.F., Erdogan U., 2007. The effect of plant growth promoting rhizobacteria on barley seedling growth, nutrient uptake, some soil properties, and bacterial counts. Turk J. Agric. For, 31: 189-199.

Clapham W.M., Willcott J.B., Fedders J.M., 2000. Effects of seed maturation temperature on seed yield characteristics and subsequent generations of lupin. Crop Sci, 40: 1313-1317.

Egli D.B., Wardlaw I.F., 1980. Temperature response of seed growth characteristics in soybeans. Agron. J, 72: 560-564.

Illmer P., Schinner F., 1992. Solubilization of inorganic phosphates by microorganisms isolated from forest soils. Soil Biol. Biochem., 24: 389-395.

Lambert R.G., Linck A.J., 1958. Effect of high temperature on yield of peas. Plant Physiol, 33: 347-350.

Osman M.E.H., El-Sheekh M., El-Naggar H., Gheda S.F., 2010. Effect of two species of cyanobacteria as biofertilizers on some metabolic activities, and yield of pea plant. Biol. Fertil. Soil, 46: 861-875.

Peix A., Rivas-Boyero A.A., Mateos P.F., Rodriguez-Barrueco C., Martinez-Molina E., Velazquez, E., 2001. Growth promotion of chickpea and barley by a phosphate solubilising strain of Mesorhizobium mediterraneum under growth chamber conditions. Soil Biol. and Biochem, 33: 103-110.

Reichert R.D., MacKenzie S.L., 1982. Composition of peas (Pisum sativum) varying widely in protein content. J. Agric. and Food Chem, 30: 312-317.

Rodriguez H., Fraga R., 1999. Phosphate solubilising bacteria and their role in plant growth promoting. Biotec. Advences, 17: 319-339.

Sahin F., Cakmakci R., Kantar F., 2004. Sugar beet and barley yields in relation to inoculation with N_2-fixing and phosphate solubilising bacteria. Plant and Soil, 265: 123-129.

SAS Institute, 1998. Statistical Analysis System Institute: StatView Reference Manual. SAS Institute, Cary, NC.

Scheffer F., Schachtschabel P., 1992. Lehrbuch der Bodenkunde. Ferdinand Enke Verlag, (Stuttgart).

Stirk W.A., Ordog V., Staden Van J., Jager, K., 2002. Cytokinin and auxin like activity in cyanophyta and microalgae. J. Appl. Phycol, 14: 215-221.

Yolcu H., Gunes A., Gullap M.K., Cakmakci R., 2012. Effects of plant growth-promoting rhizobacteria on some morphologic characteristics, yield and quality contents of Hungarian vetch. Turkish J. Field Crops, 17: 208-214.

Xie H., Pasternak J.J., Glick B.R., 1996. Isolation and characterization of mutants of the plant growth-promoting rhizobacterium Pseudomonas putida GR12-2 that overproduce indolacetic acid. Curr. Microbiol, 32: 67-71.

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MAIZE YIELD EVOLUTION IN ROMANIA AND FARMERS' INVOLVEMENT TO INCREASE IT

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Abstract

Even though pedoclimate conditions in Romania are favourable for maize production (similar with Corn Belt), yield and annual gain yield are quite low. Starting with 1961, national average was only 9 times higher than 4 t/ha. This is also because the use of research results in production is low. Individual farmers from different regions, seed companies and APPR (Romanian Maize Growers Association), have organized field trials to compare hybrids and technology items such as plant density, fertilization and irrigation. This information has a major impact on maize yield at a regional scale because it is used by the APPR members and their neighbours. Maize yield is the combined effect of high-performance genetics (50% to 75% of total gain yield in Romania, according to Sarca et al., 2007) and modern technologies. On the fertile soils (such as in Orezu), hybrid ability to use water and nitrogen efficiently varies significantly among the varieties. One of the highest difference noticed was 5.496 kg/ha. The data obtained on Maize Days in Orezu have shown that high yield could be produced only with particular technologies for every combination of parcel (pedoclimatic conditions) and hybrid (genetic resources). To harvest high yields, farmers must create themselves adapted technologies for each parcel and type of hybrid.

Key words*: maize, hybrids trials, yield, Maize Day, Romania.*

INTRODUCTION

In 2013, Romania ranked the 13th in area terms, with 2.51 million hectares, the 62nd in yield terms (4.497 tons per hectare, one ton below the world average of 5.52 tons per hectare), and the 14th in production terms (11.3 million tons)!
Romanian agronomists, farmers and politicians are always thinking the same when describing the yield potential of the main crops in our country: we could easily double the yield. Is this possible in maize? How can be farmers involved in that demarche?
Maize acreage was always important in Romania: it varied from 978,800 ha (the average for 1862 - 1866 period), up to 4,324,766 ha in 1947. (Ionescu – Șișești, 1955).
Unfortunately, on these large surfaces, we have harvested only small yields: 940 kg/ha up to 1335 kg/ha (averages for 10 years' periods).
Ionescu-Șișești (1955), pointed out two important facts for maize production in Romania.
First, in our country, maize finds very favourable growth conditions, similar with those of Corn Belt (region in USA with ideal conditions for raising corn).
Second, when good agronomic practices were used, satisfactory yield was obtained at county level, with more than 2 t/ha between 1906-1911 and up to 6 t/ha in collective and individual farms after 1950. We should mention that national yield in 5 years (1992, 1993, 2000, 2007 and 2012), was very similar with those obtained one hundred years ago, at county level in Ilfov, Ialomita, Vlasca, Braila and Covurlui (the county that included Galați). This happens because the drought was too severe and irrigation support was too small at country level.
Maize yield is the combined effect of high-performance genetics (50% to 75% of total gain yield in Romania, according to Sarca et al. 2007) and modern technologies. The genetic material must be used by adequate technology.

Sarca et al. 2007 noticed the fact that the research results are being materialized in practice in a proportion no higher than 28-50% (the potential of hybrids is much bigger than the results obtained in production).
We identified a major cause for that situation. It is difficult for farmers to select from the catalogues of seed companies the hybrids to plant, because they propose too many hybrids of different genetics, with a large variation in yield. A wrong choice could reduce the yield up to 4 to/ha. For this reason, individual farmers or associations must find themselves the information they need using field trials.

MATERIALS AND METHODS

In this work, we comment the information obtained from large hybrids trials conducted by farmers in field conditions, called Maize Day, organized by Nicolae Sitaru at Orezu, Ialomita County in 2014 and 2015. Some analysis was made within the project ADER 13.1.2 – Phase 5.5.
Starting with 2010, 50-120 hybrids were planted each year. They belong to the main seed companies present in Romania: KWS, Maisadour, RAGT, Euralis, Syngenta, Limagrain, Procera, Dow Seeds, INCDA Fundulea, Pioneer, Dekalb, IF Porumbeni, and Caussade Semences, in different densities: 60-65,000 and 70-75,000 plants/ha. Nitrogen rate varied from 109 kg N/ha in 2014 to 183 kg N/ha in 2015.
To produce high yields, maize plants need 200-300 mm rainfall from 10 leaves stage to 50% whole plant humidity. Rainfall was 186.7 in 2015 and 275 mm in 2014.

RESULTS AND DISCUSSIONS

All agronomists agree that the most important factors affecting maize yield are hybrid and crop management (especially water and nitrogen). Those factors have different influence on yield, according to large scale economic development of the country. For example, reduced nitrogen rate on the national scale is a weakness of Romanian conventional agriculture, which negatively influences maize yield. But some people consider it as a benefit for those farmers who are interested in conversion to ecological agriculture. In table 1, the data show the slow increase in national yield, measured as an average for 5 years.

Table 1. The evolution of the maize yield (5 years average), from 1961-1965 to 2011- 2015 (data from www.fao.org)

Years	1961-1965	1981-1985	1986-1990	2006-2010	2011-2015
Average yield (to/ha)	1.8	3.4	2.9	3.2	3.9

In the ’50s, Romanian maize growers used local plant populations, local varieties, bred varieties, and two types of hybrids: variety-cross hybrids and – the much more productive – double-cross hybrids, the result of inbred lines of foreign origin. They were followed by Romanian simple and three-way cross hybrids, better adapted to the local conditions (Sarca et al., 2007). Foreign hybrids were also used. Until 1985, maize production recorded annual yield gain of 82 kg/ha/year (Table 2).
Between 1955 and 1985, remarkable increase in technology was noticed, both in mechanical sector (tractors, planters, combines), or crop production (plant density, sowing date, fertilization, plant protection etc.), which had a major contribution to the gain yield.
No significant yield increase was noticed during 1986-2010. In this period, total and annual yield gain have dramatically decreased (Table 2).

Table 2. Total and annual maize yield gain between 1961 and 2015 in Romania (5 years average)

5 years average	Yield gain	kg/ha
(1961-1964) - (1981-1985)	Total yield gain (kg)	1649
	Annual yield gain (kg)	82
(1986-1990) – (2006-2010)	Total yield gain (kg)	341
	Annual yield gain (kg)	17
(2006-2010) - (2011-2015)	Total yield gain (kg)	700
	Annual yield gain (kg)	140

A possible explanation is the significant decrease of the use of nitrogenous fertilizers. The nitrogen is considered a second or a third factor (after weather and hybrid) that influences maize yield. As regards weather, the nitrogen impact on maize yield could be noticed on national scale. For that reason, it makes sense to compare nitrogenous fertilizers used and maize yield evolution. Starting with 1985, in Romania, the rates of NPK fertilizers were significantly reduced, due to political reasons and, after 1990, due to economic (transition) reasons. In the 80's, the total fertilizer rate in Romania was of approx. 150 kg NPK active substances (Popa, 2003).

According to the data from www.fao.org (Table 3, data from 1982 to 2002), the highest amount of nitrogenous fertilizers was used in 1982, 884.000 tons (100%), while the lowest quantity was used in 1999, 182,000 tons (21%). In 2010, the total quantity of fertilizers used in Romania was of 490.8 thousand tons, which means that one hectare of arable land (we assume that 9 million hectares should be fertilized), received 54.5 kg of NPK/ha, 34.6 kg of N/ha, 13.9 kg of P_2O_5/ha, and 5.9 kg of K_2O/ha (NIS).

The significant decrease of nitrogenous fertilizers used, from 100% to 27%, did not affect the yield in the same manner. Only between 1986-1989, nitrogenous fertilizer and the yield had a similar trend, 16% reduction for nitrogenous fertilizer, and 18% for the national yield. During that period, almost all use of inputs was reduced, so maize yield was also probably affected by other inputs that were restricted for homeland use, such as fuel, pesticides etc.

Table 3. Nitrogenous fertilizers and maize yield evolution (data from www.fao.org)

Years	Nitrogenous fertilizers		Maize yield	
	t	%	t/ha	%
1982-1885	874750	100	3.6	100
1986-1989	733500	84	2.9	82
1990-1993	453350	52	2.9	80
1994-1997	236650	27	3.4	93
1099-2002	232205	27	2.8	77

For the period 1994-1997, an unexpected trend was noticed. Nitrogen use decreased from 52% to 27%, while yield increased from 82% to 93%.

There are some possible explanations of the fact that despite permanent and significant decrease of the nitrogenous fertilizer, maize yield was not affected in the same manner:

First, yields per-hectare did not go down too much, because, the supply of hybrids – developed by NARDI Fundulea or multinational companies – went up, offsetting the impact of the lower nitrogen rates. Maize hybrids registered by seed companies during that period were numerous and diverse, in order to best meet growers' requirements. For instance, the Olt and F376 hybrids created in Fundulea, have remained until now among the most planted hybrids in Romania, because of their drought resistance, protein content (10-12.5%) and efficient use of moderate and balanced rates of N and P fertilisers. These traits are very useful to farmers practicing a medium-input agriculture. But the development of the technical equipment is also very likely to have played a significant part, with increase with 35,951 tractors, 41,562 ploughs, and 18,075 planters (NIS). The consumption of inputs has increased too. For instance, the total quantity of herbicides increased during this period by 4,150 tons of active substance. This means that quality mechanical work, carried out on time, and increased volumes of inputs can temporarily compensate for the reduction of the nitrogen fertilizers rate. Moreover, we must not forget the fact that, in areas with (still) fertile soils, yields of 5 t/ha in monoculture or even much more in rotation systems including leguminous plants can be achieved without fertilization. Most of farmers, even the small ones, had for that moment enough knowledge and input accessibility to produce more than 3 t/ha. (Agricultura privată în România, 1997).

Lack of competition between hybrids kept gain yield smaller**.** Till recent, there hasn't been a real competition for high yield between Romanian hybrids and the foreign ones. For commercial reasons, the multinational companies have rarely submitted for registration to the State Institute for Variety Testing and Registration (ISTIS) hybrids that surpass the Romanian "witness hybrids" by more than 20%, although such hybrids have been registered in other countries. For these reasons, the output gap between the hybrids registered in different years is small, as the yearly yield gain. Many of the first Romanian hybrids (until 1970), have been created for a (semi-)extensive agriculture, without access to sufficient material resources, such as mineral fertilizers, plant protection products, agricultural machines or equipment. For this reason, Romanian hybrids are very profitable for a large category of farmers, but are surpassed in favourable years by those foreign hybrids that have been created for "intensive conditions" (good water and nitrogen supply, higher densities than those used with the Romanian hybrids). The most cultivated Romanian hybrids, F376 and Olt, created in 1990-1993, have been evaluated within the Fundulea Institute's network between 1999–2001, the production results being 5.5 – 6 t/ha (Sarca et al., 2007).

Yield gain has increased in the last 5 years, because the farmers used more efficiently the information about yield potential of the hybrids existing on the market.

It is quite difficult to choose the right varieties, because the cultivar market is huge: almost 400 maize hybrids were registered in the 2015 Official Catalogue of the Crop Varieties Cultivated in Romania. There is only one possibility to quickly solve this problem: hybrid trials in the field made within APPR.

Farmers are looking for regional recommended hybrids, not for "universal" ones. All seed companies would like to describe their hybrids as being recommended everywhere in the area where maize is planted in Romania. Such hybrids, if they really exist, would be "rustic", with stable production in rather different pedoclimatic conditions. But the "cost" for such qualities is a medium yield level.

The selection of hybrids for high and stable production each year can be done by APPR`s field trials.

Maize days do not offer very accurate (statistical verified) results, because, usually, the replicates are not used. Instead, general trends are easier to notice. Some of them are described below:

1. In any field trial measuring hybrid potential, among winners, there are always hybrids from Monsanto and Pioneer. In real world, Pioneer hybrids are planted on 30% of the total corn surfaces. Pioneer had best average results for 6 hybrids both in 2014 (10,733 kg/ha) and 2015 (10,511 kg/ha).

2. All seed companies have some very good and competitive hybrids. For this reason, there is no seed monopoly and farmers can buy quality seeds at a good price. In 2014, the average for 6 hybrids was: KWS - 10,422 kg/ha, Dekalb -10,147 kg/ha, Maisadour - 10,064 kg/ha and Euralis - 10,021 kg/ha. In 2015, the differences between the best average yield were higher, the second and the third best average yield being at Euralis 9,191 kg/ha and KWS 9,050 kg/ha.

3. When selecting the hybrids, the farmers must compare their performance in APPR trials in multiple locations and over the years, in order to avoid such situation: in 2015, the difference between the highest yield (10,655 kg/ha) and the smallest (5,159 kg/ha) was 5,496 kg/ha. The small yield hybrid was tested for the first time. The company changed all the hybrids tested one year before.

4. All the companies, even the most important, propose to farmers, for different reasons, cultivars which are not adapted to the local conditions. In 2015, one of the Dekalb hybrids yielded only 5,843 kg/ha. These kinds of situations have to be avoided: very expensive seeds and poor harvest.

5. Many agronomists noticed that same yield could be obtained with different fertilization (Burlacu et al., 2007). Climatic changes strongly affected soil mineralization. Before planting maize for Golden Corn contest organized by APPR in Insula Mare a Brăilei, 150 kg N/ha was found in the soil, due to organic matter mineralization. We must mention that a general recommendation for nitrogen fertilization was a rate of 100-130 kg N/ha. This general recommendation had the effect that average farmers (50-100 ha) do not use more than 70 kg N/ha. This is one of the reasons why national yield is so small, because 70 kg N/ha could provide no more than 4 to/ha when soil mineralisation is not so active and mineral nitrogen before maize planting is only 20-40 kg N/ha.

6. Best results were obtained with 65,000 plants/ha. We must say that this density is the plant population recommended for all FAO groups at Pioneer hybrids.

Yield differences between densities could be quite large, up to 2 t/ha. This means that every hybrid must be planted at its specific density.

In the trial of 2012, the lowest variations among hybrids from the same company due to densities were of 379 kg/ha (from 8,297 kg/ha to 7,918 kg/ha), and the highest were 1,829 kg/ha (from 8,046 kg/ha to 6,217 kg/ha). Specific technologies for every type of hybrid used must be elaborated. Hybrids have to be grouped in 2-3 levels of expected yields.

Plant density varies in Romanian research and production from 30,000 plants/ha to 100,000 plants/ha in irrigated fields.

Plant density must be correlated with fertilization rates. Usually, when densities are tested, the same nitrogen rates are used. For this reason, yield was higher at lower densities, because more nitrogen was available per plant.

Nitrogen timing is also very important. As earlier in the spring is applied, the better the results are. We could ask ourselves if we could go till the autumn application of the nitrogen, because the experimental results in Fundulea have shown that the best results were obtained where most of the nitrogen was applied in the autumn. This method must be accepted by the good agriculture practice code.

7. Yield depends on the water/nitrogen interaction use efficiently by maize plants. In the trials in Orezu, with a fertile soil, water influence on yield is more important than nitrogen influence. In 2014, 109 kg N/ha and 275 mm rainfall from April to August made possible a yield of 9,572 kg/ha. Next year, a significant higher nitrogen rate, 183 kg N/ha, but only 187 mm rainfall, determined only 8,464 kg/ha.

Water stress could be diminished using conservative systems, such as strip-till.

CONCLUSIONS

Maize yield is the combined effect of high-performance genetics (50% to 75% of total gain yield in Romania, according to Sarca et al. 2007) and modern technologies.

On fertile soils (such as in Orezu), hybrid ability to use water and nitrogen efficiently varies significantly among the varieties. One of the highest difference noticed was 5,496 kg/ha.

The data obtained at Maize Days in Orezu have shown that high yield could be produced only with particular technologies for every combination of parcel (pedoclimatic conditions) and hybrid (genetic resources).

To harvest high yields, farmers must create themselves adapted technologies for each parcel and type of hybrid.

Rainfall between April – August had a higher influence on maize yield than nitrogen fertilizer.

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REFERENCES

Burlacu G., Popescu A., Maravela V., 2007. Rezultate ale cercetărilor în domeniul folosirii raţionale a îngrăşămintelor. AN. I.N.C.D.A. Fundulea, VOL. LXXV, 287-307.

Ionescu - Șișești Gh., 1955. Cultura porumbului. Editura Agro-Silvica de Stat, 5-30.

Popa O., 2003. Fertilizer production and market in Romania. IFA Production and International Trade Conference and Regional Conference for Eastern Europe and Central Asia, 22-26 September 2003, St-Petersburg, Russia.

Sarca T., Cosmin O., Antohe I., 2007. Cercetări şi realizări în ameliorarea porumbului la Fundulea. AN. I.N.C.D.A. Fundulea, VOL. LXXV, 99-135.

***Agricultura privată în România. Sondaj în gospodării, 1997. Ministerul Agriculturii şi Alimentației, Comisia Europeană, Banca Mondială. București.

***NIS, National Institute of Statistic

***A793-16 https://www.ag.ndsu.edu/pubs/plantsci/row-crops/a793_16.pdf

***www.ziuaporumbului.ro

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MITIGATE GRAIN YIELD LOSSES OF WHEAT UNDER TERMINAL DROUGHT STRESS BY DIFFERENT NITROGEN APPLICATIONS

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Abstract

Water and nitrogen are both most limiting factors for plant growth and productivity. Effects of different nitrogen applications on grain yield of wheat under terminal drought stress were investigated in the present study. A field experiment was conducted with a bread wheat cultivar Gönen in two experimental sites characterized by loamy-sand (Menemen) and clay-loam (Bornova) soils. Rainout shelters were used to exclude rain from drought imposed plots during grain filling stage. Gradually decrease in soil moisture content caused significant decrease in grain yield in both experimental sites. However, higher yield were recorded in loamy-sand soils (LSs) than clay-loam soils (CLs) in all treatments. Thousand grain yield and grain number per spike were also decreased due to drought conditions. Similar to grain yield, both parameters were also significantly lower in CLs than LSs. Split nitrogen treatment included flowering stage caused a significant decrease in grain yield because of lower biomass production during earlier development stages. Our findings suggested that higher biomass which could be obtained by high earlier nitrogen application may provide an advantage in wheat production for later drought conditions.

Key words: *drought, grain filling, nitrogen, wheat.*

INTRODUCTION

Global warming, the most obvious and harmful consequence of all human activities, affects most seriously the agricultural production. The estimations demonstrated that, globally, climate-induced reduction in agricultural productivity amounts to 16 % by the 2080s (Cline, 2007). However the United Nations of Food and Agricultural Organization estimates that food demand of world population will increase 70 % in next 40 years and the increase will be more pronounced in developing countries (FAO, 2006).

Wheat is the most important stable food for humans (Curtis et al., 2002) and grown on more land area than any other commercial crops (FAO, 2010). Hence, any reduction in grain yield or quality in wheat production leads to considerable economic losses. Drought as a result of progressively increase in global temperature is regarded as a major restricting environmental factor in wheat production (Acevado et al., 1999). The substantial reduction in wheat production due to drought affected lands has already started to be reported in all around the world. Portugal lost around 60% of wheat production as a consequence of drought in 2005 while economic impact of the drought in 2003 was about € 11 billion in Europe overall (Isendal and Schmid, 2006). Turkey was also adversely affected by low rainfall thus water scarcity in 2008 and wheat production significantly decreased (Ayranci et al., 2010). In consideration of increasing effects of global warming, wheat production is expected to decrease more frequently because of increasing drought-prone areas.

Wheat is more often grown in arid and semi-arid regions of Turkey under rain-fed conditions thus drought is a main limiting factor in production (Yildirim et al., 2009). Most of the rainfall is received between November and April in these regions as Mediterranean countries. Though water scarcity might be experienced during all growth stages of wheat due to unfavorable rainfall distributions, effects of drought markedly increase in post-anthesis and grain filling stages (Ozturk, 1999). These crucial stages of wheat growth are considered as a most important period regarding to yield formation (Acevedo et al., 1999). Drought-inhibited reduction in post-anthesis photosynthesis and remobilization of dry matters to the grain lead to significant decrease in grain yield (Patla et al., 1994; Ercoli et al., 2008).

Nitrogen content of soils in rain-fed production systems is a crucial determinant of grain yield in cereal crops (Abaledo et al., 2008; Cossani et al., 2012). Passioura and Angus (2010) suggested that suitable nitrogen managements in drought-prone environments could be a useful agronomic tool to increase water use efficiency. For instance, nitrogen applications during earlier development stage of plants may lead to better root development and quicker canopy cover thus bigger biomass and lower bare soil evaporation (Borghi, 1999). However, on the contrary, Fischer and Kohn (1966) reported that quicker plant growth in early stages resulted higher transpiration and caused to increase drought risk during later developmental stages.

The purpose of the present study was to understand effects of different nitrogen applications on wheat plants grown under terminal drought stress conditions.

MATERIALS AND METHODS

A field experiment was conducted in two experimental sites of Izmir-Turkey during 2009-2010 growing season. The experimental sites, Bornova (CLs) and Menemen (LSs), were characterized with clay-loam (pH 7.8 and slightly calcareous) and loamy-sand (pH 7.5) soils respectively. Bread wheat cultivar Gönen (*Triticum aestivum* L.) was used as a plant material. Experimental design was a split-plot arrangement within a randomized complete block design with three replications. Plants were sown 21-22 November 2009 in Bornova and Menemen respectively. Plot sizes were 1.2 x 3 m and row distance were 20 cm for each treatments. Seeding density was 500 seed m^{-2}.

All plants were grown under rain-fed conditions until flowering stage. Then, rain-out shelters were constructed to exclude rainfalls after flowering stage in drought stress treatments (DT) while the control plants (CT) were kept under open field. Total rain amounts were 123.8 and 91.0 mm after the treatment in Bornova and Menemen respectively. Relative water content of the soil in both experimental site and each treatment after stress application were given in Figure 1. The same amount (90 kg/ha) but two different nitrogen applications were applied as a second factor of the experiment. Nitrogen was given in three times: 30 kg ha^{-1} top dressing, 30 kg ha^{-1} at the beginning of stem elongation stage and 30 kg ha^{-1} before flowering stage in N1 treatment. In N_2 treatment, nitrogen was applied two times: 60 kg ha^{-1} at top dressing and 30 kg ha^{-1} at the beginning of stem elongation stage. The fertilizer contained ammonium sulfate was used as top dressing and ammonium nitrate was used in other applications. All treatments received same amount of P_2O_5 (50 kg/ha).

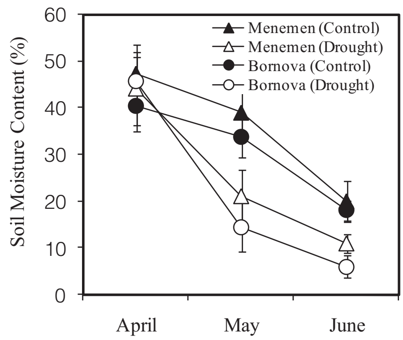

Figure 1. Relative moisture content of the soil under control and drought conditions in Menemen (LSs) and Bornova (CLs), after drought treatments

Plants were sampled and harvested after physiological maturity during second week of June. Yield parameters were determined according to the methods described by Bell and Fischer (1994).

RESULTS AND DISCUSSIONS

Decrease in soil moisture content in stress treatment was more remarkable after April in both locations (Figure 1). Final moister content of the soil in July was 18 % in control plots in both experimental sites while 10 % and 7 % in drought exposed plots in Menemen (LSs) and Bornova (CLs), respectively.

Grain yield of cv. Gönen significantly decreased from 3.0 t ha^{-1} to 2.2 t ha^{-1} as a result of drought conditions during grain filling stage (Figure 2). The nitrogen applications and environmental conditions of experimental sites significantly influenced grain yield of cv. Gönen. Higher grain yield was recorded in LSs (3.1 t ha^{-1}) than CLs (2.1 t ha^{-1}). N_1 treatment caused significantly higher grain yield (2.8 t ha^{1}) than N_2 treatment (2.3 t ha^{-1}) (Figure 2). There was no significant interaction between the experimental factors thus N_2 treatment had always better performance in all conditions.

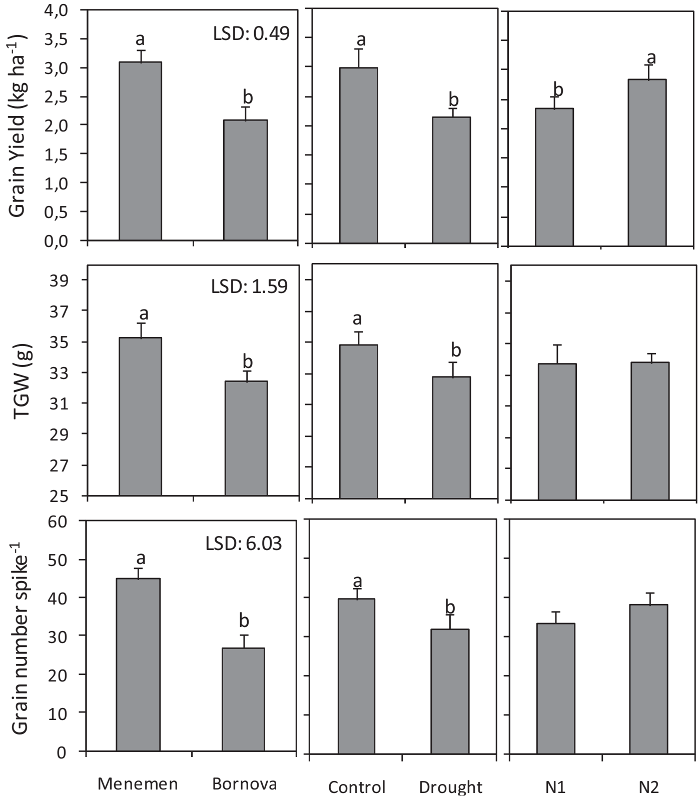

Figure 2. Effects of drought, nitrogen applications (N_1 and N_2) and experimental sites [Menemen (LSs) and Bornova (CLs)] on grain yield (kg ha^{-1}), thousand grain weight (TGW) and grain number per spike of wheat cv.Gönen (P=0.05)

Thousand grain weights (TGW) decreased under drought conditions during grain filling stage (Figure 2). TGW was 34.8 g under control conditions whereas it was 2.0 g lower under drought conditions. On the other hand, grain number per spike (GNS) had same trend with TGW as a response of drought and experimental sites (Figure 2). Relative decrease under drought conditions was 19.1 % in LSs whereas 40.1 % in CLs. Nitrogen application induced relation between biomass production and grain yield of cv. Gonen is demonstrated in Figure 3 whereas Figure 4 shows drought induced TGW and biomass production relation to grain yield.

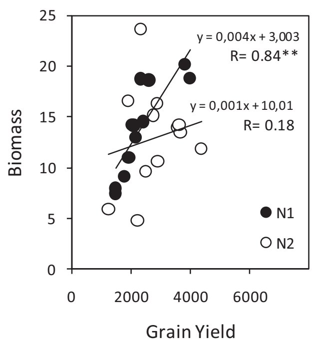

Figure 3. Nitrogen application induced relation between biomass production (g) and grain yield (kg ha^{-1}) of wheat cv.Gönen (* P=0.05, ** P=0.01)

A significant and positive correlation (r = 0.84**) was found between biomass and grain yield in N_1 treatment whereas there was no correlation in N_2 treatment (Figure 3). Higher grain yield was associated with higher TGW under control conditions (r = 0.81**) and more biomass in drought conditions (r = 0.64*). However, there was not any significant link between grain yield and TGW under drought conditions and biomass under controlled conditions (Figure 4).

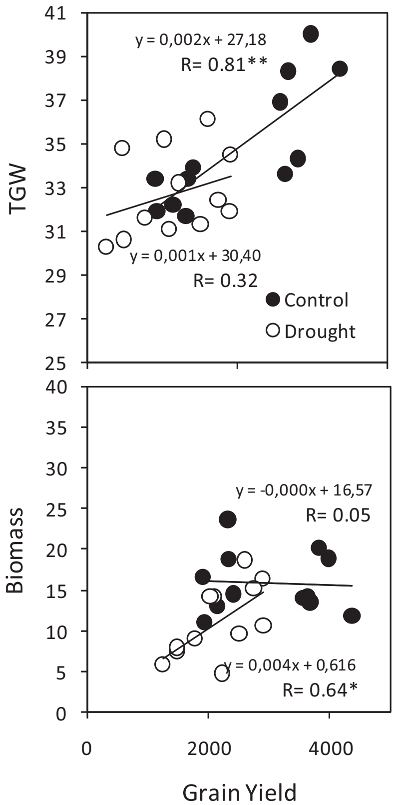

Figure 4. Drought induced thousand grain weight (TGW) and biomass production (g) relation to grain yield (kg ha^{-1}) of wheat cv.Gönen (* P=0.05, ** P=0.01)

Negative effects of drought conditions on grain yield of wheat have been previously reported in several studies (Dodig et al., 2008; Ilker et al., 2011; Tatar, 2011; Aykut Tonk et al., 2011). Acevedo et al. (1999), on the other hand, reported that post-anthesis stage is the most critical stage in terms of drought stress because of dry matter translocation to the grains. A drastic relative decrease (27.9 %) was also recorded in the present study. On the other hand grain yield significantly varied in different experimental sites. Heavy textured, higher calcareous and lower available potassium content of the soil of Bornova (Tatar, 2011) led to lower grain yield production than Menemen. Similar difference between these locations was reported by Altinbas et al. (2004).

N_1 treatment caused significantly higher grain yield than N_2 treatment in both experimental sites. Borghi (1999) demonstrated that earlier nitrogen applications resulted rapid plant development, soil cover by the canopy and better root development in wheat which had the advantage for the later water limited conditions. On the other hand, however, Fisher and Kohn (1966) reported that faster plant growth during earlier stages thus bigger canopy caused higher transpiration and quicker loss of limited water sources. Our data are in agreement with the idea suggested positive impact of earlier application of nitrogen to mitigate higher grain yield losses in wheat.

A wealth of data pointed out that drought lead to decrease thousand grain weights (TGW) and finally reduction in grain yield (Mollasadeghi et al., 2011; Ozturk, 1999). However, decrease in TGW as a result of lower dry matter translocation to grains has been perceived as a main reason in grain yield reduction under drought conditions during grain filling stage (Garcia del Moral et al., 2003; Tatar, 2011). Present findings also suggested that decrease in grain yield under drought conditions and different sites could be mainly attributed to decrease in TGW.

Miralles and Slafer (1999) stated that grain number per spike (GNS) is determined earlier than flowering stage in wheat. Gholami and Asadollahi (2008), however, reported that GNS was also affected by drought conditions after flowering stage. The similar reduction in the present study could be explained by pollen sterility due to drought effects during flowering stage. On the other hand, effect of experimental sites on GNS might be perceived as a result of better growth conditions in Menemen in terms of soil properties.

Despite the nitrogen effects on grain yield was significant, both TGW and GNS did not significantly differ under two different nitrogen applications (Figure 2). Figure 3 indicates nitrogen application induced relation between biomass production and grain yield of cv. Gonen. Since the biomass production was restricted by the lower nitrogen amount during earlier growth stages in N_1 treatment, grain yield of plants were determined mostly by biomass production (r = 0.84**). However, earlier nitrogen applications resulted in higher biomass production which had no correlations with grain yield in N_2 treatment. Madeni et al. (2012) reported that nitrogen application during flowering stage reduced negative effects of drought during grain filling stage. In the present study, similar to the results of Gevrek and Atasoy (2012), split application of nitrogen (N_1) included flowering stage had no positive effects on grain yield under drought conditions. Drought induced TGW and biomass production relation to grain yield were demonstrated in Figure 4. The results indicated that grain yield under control conditions mostly correlated with TGW (r =0.81**) whereas biomass production (r =0.64*) under drought conditions. Therefore, it might be suggested that wheat plants could better adapt to drought stress during grain filling stages by higher biomass production as a result of higher earlier nitrogen applications.

CONCLUSIONS

In conclusion, it could be suggested that water limited conditions during grain filling stage led to drastic decrease in grain yield in wheat which is mainly depends on a reduction in TGW and GNS. Plants were more productive because of favorable soil properties of Menemen (LSs) than Bornova (CLs) Location. Split nitrogen treatment included flowering stage caused a significant decrease in grain yield because of lower biomass production during earlier development stages. Therefore, we may propose that higher biomass which could be obtained by earlier nitrogen application may provide an advantage for later drought conditions.

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REFERENCES

Abaledo L.G., Savin R. Slafer G.A., 2008. Wheat Productivity in The Mediterranean Ebro Valley: Analyzing the Gap Between Attainable and Potential Yield With a Simulation Model. European Journal of Agronomy, 28: 541-550.

Acevedo E.H., Silva P.C., Silva H.R., Solar B.R., 1999. Wheat Production in Mediterranean Environments. In: Satorre E.H. and Slafer G.A. (ed.). Wheat: Ecology and Physiology of Yield Determination. Binghamton, New York, USA: Food Products Press. p. 295–331.

Altinbas M., Tosun M., Yuce S., Konak C., Kose E., Can R.A., 2004. Effects of Genotype and Location on the Grain Yield and Some Quality Traits in Bread Wheats (*T.aestivum* L.). Journal of Ege University Faculty of Agriculture, 41: 65-74.

Aykut Tonk F., Ilker E., Tatar O., Recber A., Tosun M., 2011. Effects of different rain amount and distributions on bread wheat yield. Journal of Ege University Faculty of Agriculture, 48: 125-130.

Ayranci R., Sade B., Soylu S., 2010. Drought stress and some approaches in drought tolerant bread wheat improvement. In: Symposium on Prevention of Desertification. Corum, Turkey. p: 194-204.

Bell M.A., Fischer R.A., 1994. Guide to plant and crop sampling: measurements and observations for agronomic and physiological research in small grain cereals, Wheat Special Report CIMMYT, No: 32.

Borghi B., 1999. Nitrogen as determinant of wheat growth and yield, Wheat Production in Mediterranean Environments. In: Satorre E.H. and Slafer G.A. (ed.). Wheat: Ecology and Physiology of Yield Determination. Binghamton, New York, USA: Food Products Press. p. 67-84.

Cline W.R., 2007. Global warming and agriculture: impact estimates by country, Washington, D.C., Center for Global Development, p: 250.

Cossani C.M., Slafer G.A., Savin R., 2012. Nitrogen and Water Use Efficiency of Wheat and Barley Under Mediterranean Environment In Catalonia, Field Crops Research, 128: 109-118.

Curtis B.C., Rajaram S., Macpherson H.G., 2002. Bread Wheat Improvement and Production, *FAO* Plant Production and Protection Services. Rome, Italy. No:30.

Dodig D., Zoric M.D., Knezevic S.R., King G., Surlan-Momirovic, 2008. Genotype x environment interaction for wheat yield in different drought stress conditions and agronomic traits suitable for selection, Australian Journal of Agricultural Research, 59: 537-545.

Ercoli L., Lulli L., Mariotti M., Masoni A., Arduini A., 2008. Post-anthesis dry matter and nitrogen dynamics in durum wheat as affected by nitrogen supply and soil water availability, European Journal of Agronomy, 28: 138-147.
FAO, 2006. Prospects for food, nutrition, agriculture and major commodity groups, World agriculture: Towards 2030/2050, Interim Report of Global Perspective Studies Unit, Food and Agriculture Organization of United Nations, Rome, Italy.
FAO, 2010. Statistical Year Book-2010, Statistic Division of Food and Agriculture Organization of the United Nations, Rome, Italy.
Fischer R.A., Kohn G.D., 1966. The Relationship of grain yield to vegetative growth and post-flowering leaf area in the wheat growth under conditions of limited soil moisture, Australian Journal of Agricultural Research, 17: 281-295.
Garcia del Moral L.F., Rharrabti Y., Villegas D., Royo C., 2003. Evaluation of grain yield and its components in durum wheat under Mediterranean conditions: an ontogenic approach. Agronomy Journal, 95: 266-274.
Gevrek M.N., Atasoy G.D., 2012. Effect of post anthesis drought on certain agronomical characteristics of wheat under two different nitrogen application conditions. Turkish Journal of Field Crops, 17: 19-23.
Gholami A., Asadollahi A.P., 2008. Improving wheat grain yield under water stress by stem hydrocarbon reserve utilization. Pakistan Journal of Biological Science, 11: 2484-2489.
Isendahl N., Schmidt G., 2006. Drought in the Mediterranean: WWF policy proposals, A WWF-World Wide Fund for Nature Report, July, Germany.
Ilker E., Tatar O., Aykut Tonk F., Tosun M., 2011. Determination of tolerance level of some wheat genotypes to post-anthesis drought, Turkish Journal of Field Crops 16: 59-63.
Madani A., Makarem A.H., Vazin F., Joudi M., 2012. The impact of post-anthesis nitrogen and water availability on yield formation of winter wheat. Plant Soil and Environment, 58: 9-14.
Miralles D.J., Slafer G.A., 1999. Wheat development, In: Satorre E.H. and Slafer G.A. (ed.). Wheat: Ecology and Physiology of Yield Determination. Binghamton, New York, USA: Food Products Press. p. 13-43.
Mollasadeghi V., Valizadeh M., Shahryari R., Imani A.A., 2011. Evaluation of drought tolerance of bread wheat genotypes using stress tolerance indices at presence of potassium humate. American Eurasian Journal of Agricultural and Environmental Science, 10: 151-156.
Ozturk A., 1999. The effect of drought on the growth and yield of winter wheat. Turkish Journal of Agriculture and Forestry, 23: 531-540.
Palta J.A., Kobata T., Turner N.C., Fillery I.R., 1994. Remobilization of carbon and nitrogen in wheat as influenced by postanthesis water deficits. Crop Science, 34: 118-124.
Passioura J.B., Angus J.F., 2010. Improving productivity of crops, in water-limited environments. Advence in Agronomy, 106: 37-75.
Tatar O., 2011. Physiological regulation of drought stress related with yield components of some wheat cultivars, PhD. Thesis, Ege University, Izmir.
Yildirim M., Akinci C., Koc M., Barutcular C., 2009. Applicability of canopy temperature depression and chlorophyll content in durum wheat breeding, Anadolu Journal of Agricultural Science, 24: 158-166.

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INFLUENCE OF ROW SPACING AND BIOREGULATORS APPLICATION ON SAFFLOWER YEILD

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Abstract

Safflower (Carthamus tinctorius) is one of the new crops for the Republic of Moldova. Its traditional climate conditions of cultivation are significantly different from those in Moldova. The research of optimal agronomic procedures related to the eco-geographical area is the main objective for introduction of this new culture. The aim of this study was to determine the safflower yield depending on distance between rows and pre-sowing treatment of seeds with natural bioregulators. Row spacing was 50 and 70 cm, as natural bioregulators were used glycosides compositions extracted from Linaria genistifolia (GG) and Verbascum densiflorum (*GV). The results showed that row spacing effect was significant on plants height, number of capitula per plant, number of seeds per plant and 100-seed weight. Enlarging of row spacing leads to increasing of branch number and seeds yield per plant. Number of seeds per plant of safflower grown on 70 cm row spacing was in 1.4…1.7 times more than the same parameter of plants grown on row distance of 50 cm. The increasing of row spacing increased seed yield per plant in all experimental variants: safflower grown from both treated and intact seeds. The highest number of capitula per plant and 100-seeds weight in both row spacing was obtained from safflower seeds treated by GV - natural bioregulator, composition of which contains the polyphenolic glycoside.*

Key words*: safflower, yield, row spacing, bioregulators.*

INTRODUCTION

As safflower (*Carthamus tinctorius*) is a new crop for the Republic of Moldova, its agronomic requirements for meteorological condition of the country have not been studied sufficiently yet. In our previous study (Ivanova, 2016), it was shown that the safflower plants have adapted to the drought conditions of 2015 season: temperature was 2.2…3.3ºC higher and amount of precipitation - lower by 100…200 mm than the long-term average. These properties were confirmed by the biological characteristics and seeds yield. However, vital yield attributes of safflower crop such as number of capitula and seeds per plant, 100-seeds weight depend not only on meteorological condition of growing season. The different agronomic procedures (planting pattern, application of bioregulators or fertilizer) also have the important influence on safflower crop.

Results of many studies showed that the sowing spacing between rows and plants in row had significant impact on plants growth and yield of safflower (Azari & Khajehpour, 2003; Fazeli et al., 2007; Pasary and Noormohamadi, 2011; Ruzheynikova et al., 2012; Mohammadi and Karimizadeh, 2013; Vaghar et al., 2014; Hamza, 2015).

Row spacing of safflower was diversified in large diapason from 15 cm to 90 cm, but demonstrated results are controversial. Amoghin et al. (2012) concluded that as plant density was decreased, the number of capitula per plant, 100-seed weight, and the number of seeds per plant were increased, but the number of seeds per capitula and yield per unit area were significantly decreased. In contrast, Mohammadi and Karimizadeh (2013) determined the highest number of seeds per capitula of safflower on larger row spacing. Pasary and Noormohamadi (2011) provided that the highest plant height related to lowest density, but the results reported by Hamza (2015) were opposite.

The research and testing of varying planting patterns of safflower indicated that its effectiveness has been also predetermined by the soil and climatic conditions, humidity and soil contamination, sowing date, growth regulators application, economic purpose, and high-quality features of genotypes (Ruzheynikova et al., 2012; Sharifi et al., 2012; Vaghar et al., 2014). Therefore, the differentiated approach should be applied for determination of optimal agronomic procedures connected with eco-geographical area.

The aim of this study was to determine yield parameters of safflower grown on different row spacing from intact seeds and seeds gone through pre-sowing treatment with bioregulators.

MATERIALS AND METHODS

Experiments were carried out at the research field station of the Institute of Genetics, Physiology and Plant Protection in Chisinau area of the Republic of Moldova (lat. 47^{o}01', long. 28^{o}75', alt. 85 m above sea level), in the seasons of 2016 (Figure 1).

Figure 1. Field station of the Institute of Genetics, Physiology and Plant Protection

Safflower seeds have been sowed in the last decade of March by using following planting patterns: row spacing 50 cm and 70 cm, intra-row spacing 15 cm. Moreover, part of seeds was subjected to presowing treatment by 0.01% solutions of two natural bioregulators - glycosides compositions extracted from *Linaria genistifolia* (GG), and *Verbascum densiflorum* (GV). The dry extracts GG and GV were obtained in laboratory conditions and already tested as regulators of plant growth and antioxidant (Ivanova et al., 2014; Mascenco et al., 2015a, 2015b; Borovskaia et al., 2016). Thus, each area of cultivations consisted of three plants variants (two treated – GV, GG; and control - intact seeds) in 5 repetitions. Plants were grown in poor and dry soil, without irrigation.

Weather in the spring and summer of 2016 was characterized as warm and rainy. During the growing season the average of air temperature in spring (March - May) was +10.9...+12.2°C, in the summer (June - August) was +20.8...+ 23.0ºC, being above the long-term average by 1.8...2.7°C and 1.5...2.4ºC, correspondingly. The amount of spring and summer precipitation has reached 148-216 mm (125-180% of the long-term average) and 275-330 mm (140-150% of the long-term average), respectively.

In order to evaluate the impact of planting patterns and application of bioregulators the following parameters of safflower plants were studied: plant height (cm), number of secondary branches per plant, number of capitula (Figure 2) and seeds per plant (Figure 3), seeds yield per plant (g), 100-seeds weight (g).

Figure 2. Flower and capitula of safflower plant

Figure 3. Safflower seeds from two different capitula

RESULTS AND DISCUSSIONS

Row spacing effects was significant for plants height, number of capitula per plant, number of seeds per plant and 100-seeds weight. The enlarging of row spacing leads to increasing of secondary branches number and seeds yield per plant (Table 1). Number of seeds per plant of safflower grown on 70 cm row spacing was in 1.4…1.7 times more than the same parameter of plants grown on row distance of 50 cm. However, the seeds obtained from safflower distanced by 70 cm, were smaller, and their 100-seeds weight was slightly less. In addition, analogical results have been established in all variants: plants obtained from both treated and intact seeds.

The results indicated that decreasing of row spacing caused increasing of plant height. Our data are in correlation with similar trend determined by Amoughin et al. (2012) and Hamza (2015) and could be explained by creating early competition of plants for light absorption. In the growing season of 2016 the safflower plant had 1.3…1.5 times more height than the plant of 2015 (Ivanova, 2016), which can be explained by very different environmental conditions of these years.

Bioregulators application for pre-sowing treatment of seeds had no significant effect on plants height (Table 1). However, by applying GV there was obtained the highest number of capitula per plant and 100-seeds weight in both row spacing. The use of GG for pre-sowing treatment of safflower seeds contributed to reduction of entire determined traits in comparison with control variant (intact seeds) (Table 1). Earlier there was discovered that the influences of natural bioregulators on vegetable cultures are species specific (Mascenco et al., 2016).

Undoubtedly the application of natural bioregulators containing either polyphenolic (GV), or iridoid glycosides (GG) plays a vital role in physiological processes of plants and their productivity (Florea et al., 2015; Mascenco et al., 2015a; 2015b), but it is necessary to take carefully into account the type of bioregulator, dose and application schemes.

Presented in this paper results indicated that the pre-sowing treatment of seeds was not sufficient for boosting up production of safflower. Additional foliar treatment at flowering stage could be more effective in yield improvement of safflower (Khaki-Moghadam & Rokhzadi, 2015). Ullah & Bano (2011) reported that plant growth regulators applied during flowering as foliar spray significantly increased the 100-seed weight.

CONCLUSIONS

The results suggest that the plants height, numbers of capitula per plant, seeds per plant and 100-seed weight were significantly influenced by row spacing of safflower growth.

The increasing of row spacing increased number of secondary branches and seeds yield per plant.

Application of natural bioregulator GV allowed us to obtain highest numbers of capitula per plant and 100-seeds weight in both row spacing as well as in whole experiment.

In order to recommend an optimal scheme of bioregulators usage it is necessary to repeat field experimental studies in different growing seasons, since its effect greatly depends on environmental factors.

Table 1. Growth and yield parameters of safflower plants grown in different row spacing from intact seeds (control) and seeds gone through pre-sowing treatment with bioregulators (GV and GG)

Trait	Control		Variant GV		Variant GG	
Row spacing, cm	50	70	50	70	50	70
Plant height, cm	86.66	79.61	86.46	76.62	86.32	78.68
Number of branches per plant	9.46	10.50	8.90	9.69	9.02	9.31
Number of capitula per plant	9,9	15,93	10,28	16,55	8,83	13,65
Number of seeds per plant	98.41	171.25	91.43	149.11	88.49	128.19
Seed yield per plant, g	3.72±1.15	3.78±0.36	3.52±1.37	3.85±0.31	3.23±0.67	3.65±0.18
100-seeds weight, g	3.78±0.36	3.27±0.32	3.84±0.31	3.38±0.22	3.65±0.18	3.37±0.45

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REFERENCES

Amoughin R.S., Tobeh A., Somarin S.J. 2012. Study on the effect of different plant density on some morphological traits and yield of safflower under irrigated and rain-fed planting conditions. International Journal of Agronomy and Plant Production, 3(8): 284-290. http://www.ijappjournal.com/.

Azari A., Khajehpour M.R., 2003. Effects of planting pattern on growth, development, yield components and seed yield of safflower, local variety of Isfahan, Koseh, in spring planting. Journal of Science and Technology of Agriculture and Natural Resources: Isfahan University of Technology, 7(1): 155-167. www.jstnar.iut.ac.ir.

Borovskaia A.D., Onica E.I., Mascenco N.E., Ivanova R.A., 2016. Application of glycosides from *Verbascum phlomoides* L. for rooting of cuttings from woody shrubs. Proceedings of Sixth international scientific conference "Biological diversity. Introduction of plants". St.-Petersburg: Komarov V. L. Botanical Institute, Russian Academy of Science, p. 312-314 (In Russian).

Fazeli F., Sadrabadi R., Zare F.A., Ezat A.M., 2007. The effect of sowing date and plant density on yield and yield components of safflower (*Carthamus tinctorious* L.) in Rokh plateau. Iranian Journal of Agricultural Sciences: Tehran University, College of Agriculture, 5(2): 327-332.

Florea V., Mascenco N., Ivanova R., 2015. Influence of some glycosides of plant origin on the seed yield of fenugreek (*Trigonella foenum-graecum* L.). *Abstract book of the Xth International congress of geneticists and breeders.* 28 June - 1 July, Chisinau: ASM, Republic of Moldova, 96.

Hamza M., 2015. Influence of different plant densities on crop yield of six safflower genotypes under Egyptian newly reclaimed soils conditions. International Journal of Agriculture and Crop Sciences. 8(2):168-173.

Ivanova R., 2016. Theoretical and practical aspects of the introduction of safflower (*Carthamus tinctorius* L.) in the Republic of Moldova. Muzeul Olteniei Craiova, Oltenia. Studii și comunicări. Ştiinţele Naturii, Romania, 32 (2): 48-51.

Ivanova R., Mascenco N., Chintea P., 2014. Studiul privind proprietățile antioxidante a glicozidelor de origine vegetală. Revista farmaceutică a Moldovei. Chisinau: USMF, 1, 33-35.

Mascenco N.E., Borovskaia A.D., Ciumac P.S., Onica E.I., 2016. Species specificity of natural bioregulators on the example of shrubs. In Proceedings of the 10th International conference "Actual problems of science of the 21st century", Part 1, Moscow: Cognitio, 32-37.

Mascenco N.E., Borovskaia A.D., Ivanova R.A., 2015a. Using of glycosides from common toadflax as growth regulators of vegetable cultures. Proceeding of International scientific symposium "Plant protection: achievements and prospects", Chisinau: ASM, Republic of Moldova, 174-177.

Mascenco N., Gurev A., Lupascu G., Gorincioi E., 2015b. Iridoid glycosides from *Linaria genistifilia* (L.) Mill. in biological control of soil-borne fungal pathogens of wheat and some structure consideration. Chemistry Journal of Moldova. General, Industrial and Ecological Chemistry: Academy of Sciences of Moldova, 10 (1): 57-63.

Khaki-Moghadam A., Rokhzadi A., 2015. Growth and yield parameters of safflower (*Carthamus tinctorius*) as influenced by foliar methanol application under well-watered and water deficit conditions. Environmental and Experimental Biology. 13: 93–97. http://eeb.lu.lv/EEB/201506/EEB_13_Khaki-Moghadam.pdf.

Mohammadi M., Karimizadeh R., 2013. Response of safflower to row spacing and intra-row plant distance in semi-warm dry land condition. Agriculture and Forestry: Podgorica 59(2): 147-155.

Pasary B., Noormohamadi G., 2011. Evaluation of growth pattern, seed and flower yield of safflower following winter crops. International Conference on Asia Agriculture and Animal. IPCBEE, IACSIT Press, Singapoore,13: 96-100.

Ruzheynikova N.M., Kuleva N.N., Zaitsev A.N., 2012. Adaptive technology of cultivation of safflower in the Saratov region: Recommendations of cultivation manufacturing. Saratov, Russia, 30 p.

Sharifi S., Naderidarbaghshahi M., Golparvar A., Nayerain-Jazy A.H., 2012. Effect of plant density on the PAR extinction coefficient and yield of safflower cultivars. Technical Journal of Engineering and Applied Sciences, 2(8): 223-227.

Ullah F., Bano A., 2011. Effect of plant growth regulators on oil yield and biodiesel production of safflower (*Carthamus tinctorius* L.). Brazilian Journal of Plant Physiology. 23(1):27-31. http://dx.doi.org/10.1590/ S1677-04202011000100005

Vaghar M.S., Shamsi K., Kobraee S., Behrooz R., 2014. The effect of planting row interval and plant density on the phonological traits of safflower (*Carthamus tinctorius* L.) dryland conditions. International Journal of Biosciences, 4(12): 202-208.

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GENOTYPIC PLASTICITY AND STABILITY OF YIELD COMPONENTS IN TRITICALE (x *Triticosecale* Wittm.)

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Abstract

In order to establish genotypic plasticity and stability of the yield components in triticale, data from three years field trial have been used. The main structural yield components (number of spikes per m^2; plant height, cm; spike length, cm, number of grain per spike; mass of grain per spike, g) of five triticale varieties are determined. The modified model of Eberhart and Russel was applied. The coefficients of the linear regressions b_k characterize the average variety reaction to changes in the climatic conditions, show his plasticity and give opportunity to prognosticate the researched parameter in the range of the investigated conditions. The main parameter, which estimates the variety stability, is the dispersion S_k. The more the dispersion of the stability S_k to zero tends, the less the empirical values of the signs distinguish from the theoretical values, located on the regression line. The plasticity of the indicator Nr. of spikes/m^2 is with the highest values by the varieties AD-7291, Sadovec and Rakita. According to the varieties Rojen and Zaryad this indicator is with lower values. By the both linear parameters – Plant height and Spike length the triticale varieties react on the same way. The triticale varieties react to the environmental conditions and to the components Nr. of grain/spike and Mass of grain/spike almost equally. The stability values are contrariwise proportional to the varieties plasticity regarding the components Nr. of spikes/m^2 Plant height and Spike length. According to the both signs, related to the grain (Nr. of grain/spike and Mass of grain/spike) no similar tendencies are have been observed. The yield plasticity coefficient correlates positive with all yield components. By the yield stability coefficient there is a positive correlation by the Nr. of spikes/m^2 and the Mass of grain/spike, and negative by the component Plant height.

***Key words**: triticale, plasticity, stability, yield components.*

INTRODUCTION

Genetically triticale (x *Triticosecale* Wittm.) is an amphiploid produced by crossing the genomes of two different species - wheat and rye. The first hybrids are fertile progenies arose from an intergeneric (interspecies) hybridization and followed by chromosome doubling between a female parent from the genus *Triticum* and the male parent from the genus *Secale*.

The majority of the today's varieties are descendants of a primary hybrids, which involve either common (*Triticum aestivum* L., 2n=42=AABBDD) or durum (*Triticum durum*, 2n=28=AABB) wheat as a female parent and cultivated diploid rye (*Secale cereale* L., 2n=14=RR) as a male parent (Oettler et al., 2001; Mergoum and Gómez-Macpherson, 2004; Siriamornpun et al., 2004; Varughese et al., 1996; Losert et al., 2017).

One from the most basic positive feature of triticale is its high productive potential. This is due to the composition of the yield components inherited from the wheat and rye (Estrada-Campuzano et al., 2012; Gerdzhikova, 2014; Ivanova and Kirchev, 2014; Ivanova and Tsenov, 2014; Royo and Blanco, 1999; Ramazani et al., 2016; Stoyanov and Baychev, 2015).

Namely the big genetic diversity of the created triticale varieties is a requirement for their different reaction to the environmental conditions. This demand to pay attention on their genotypic plasticity and stability.

MATERIALS AND METHODS

For determining the plasticity and stability of the main structural yield components in triticale, data from a two parallel field trials have been used.

The one was carried out in the northern Bulgaria in the region of Dobrogea (43°39'33.0"N 28°02'05.5"E), and the other – in the southern Bulgaria, the region of Thracian valley (42°08'26.2"N 24°48'21.1"E). Five varieties have been examined – AD-7291 (standart), Rojen, Sadovec, Rakita and Zaryad.

The genotypic plasticity and stability of the tested varieties are determined by the main structural components, which have bearing on the yield like - number of spikes per m^2; plant height, cm; spike length, cm, number of grain per spike; mass of grain per spike, g.

Plasticity (b_k) and stability (S_k) coefficients are calculated on the basis of the Eberhart and Russel model, 1966.

The model of Eberhart and Russel (1) looks like this:

(1) $Yijk = Y .. + Gi + Pj + rij + eijk$,

where G ist the effect of the genotype, and P – of the investigated region.

There was used two-way ANOVA to define statistically significant differences between the examined varieties. To calculate the dependents between the yield and the investigated signs, correlation analysis have been used.

RESULTS AND DISCUSSIONS

The regression coefficient and the deviations from the regression line were being estimated and so the diffraction can be determined by use of dispersion analysis (Table 1).

The model of Eberhart and Russel can be applied under condition that the interaction „genotype G x region P'' is statistically significant, because it is supposed, that the changes in the feature are based on genetic and plants will change estimated parameter by different environment. To give a mathematical expression of the terms „ecological plasticity'' and „stability'' Eberhart and Russel give them the following definition: under ecological plasticity is to understand the average variety reaction to environmental changes, and under stability – the deviation of the empirical data from this average reaction at any condition of the environment.

The coefficients b_k of the linear regressions characterize the average variety reaction to changes in the climatic conditions, show his plasticity and give opportunity to prognosticate the researched parameter in the range of the investigated conditions (Table 2).

Geometrical the regressions coefficients b_k can be interpreted as an angular coefficients of the regression straight lines. It is clarified, that by b_k increase the variety will be more responsive to the growing conditions. In most cases b_k coefficients are positive, but they can also acquire a negative values, as for example yield decrease as result from lodge or disease attack. If the coefficient $b_k > 0$, it means that the variety does not react to the environmental changes.

The plasticity b_k of the indicator Nr. of spikes/m^2, who determine in major ratio the sowing density, is higher than one in the varieties AD-7291, Sadovec and Rakita, as proved the standard AD-7291 is the most plastic. The values of this indicator are lower in the varieties Rojen and Zaryad and the both belong to the same statistical group. According to the both linear parameters– Plant height and Spike length the examined triticale varieties react to the same way. For the most plastic in relation to these signs changes are remarkable the varieties Rojen and Rakita and the varieties Sadovec and AD-7291 are influenced in lower ratio by the environmental changes according the changes in the linear parameters Plant height and Spike length. However, the variety Zaryad reacts different – is more plastic to changes in the Plant height, whereas to the Spike length lower changes are indicated depending on the conditions of the relevant region. Similar to the both previous indicators, the triticale varieties react to the environmental conditions almost on the same way concerning the components Nr. of grain/spike and Mass of grain/spike. The most plastic, regarding the both yield components, are the varieties Rakita and Zaryad, followed by the standard AD-7291, while by Rojen and Sadovec the plasticity of the Nr. of grain/spike and Mass of grain/spike is lowest.

The main parameter, which estimates the variety stability, is the dispersion S_k. The more the dispersion of the stability S_k to zero tends, the less the empirical values of the signs distinguish from the theoretical values, located on the regression line. According to the applied models of Eberhart and Russel, as a goal for „ecological plastic and stable variety'' can be accepted any sort who possess the both values: $b_k > 1$ and $S_k > 0$.

Rates of dispersion S_k which define the variety stability, are in the present research positive in every varieties and at any yield components, what according to Eberhart and Russel them as stable determine, concerning the received yield components (Table 3).

Table 1. The two-way ANOVA mean squares (MS) analysis of variance of triticale genotypes x region

Source of Variation	df	Nr. spikes/m^2	Plant height	Spike length	Nr. grain/spike	Mass grain/spike
Genotype (G)	1	2133.6	2539.2*	10.09**	662.7**	0.163
Region (P)	4	9653.9**	122.1	1.12	91.4	0.564**
Interaction (GxP)	4	2423.2*	467.8**	2.08*	131.9*	0.286*
Within	20	3387.7	125.5	0.58	17.7	0.041

,: Significant at 0.05 and 0.01 probability levels, respectively.*

Table 2. Ecological plasticity of yield components in triticale varieties

Yield components Varieties	Nr. spikes/m^2	Plant height	Spike length	Nr. grain/spike	Mass grain/spike
AD-7291	1.481c	0.811a	0.800b	0.941b	1.576b
Rojen	0.652a	1.091a	1.159b	0.424a	0.151a
Sadovec	1.037b	0.658a	0.663a	0.364a	0.652a
Rakita	1.277b	1.283b	1.884c	1.673c	2.498c
Zaryad	0.552a	1.158b	0.493a	1.598c	1.735b

Values with the same letters do not differ significantly

Table 3. Ecological stability of yield components in triticale varieties

Yield components Varieties	Nr. spikes/m^2	Plant height	Spike length	Nr. grain/spike	Mass grain/spike
AD-7291	0.181a	1.311b	0.025a	0.221a	0.816b
Rojen	1.319b	0.170a	1.995c	0.239a	0.351a
Sadovec	0.653a	1.354b	0.661b	1.300c	0.509a
Rakita	1.802c	0.979b	0.025a	1.468c	1.151b
Zaryad	0.764b	1.970c	0.746b	1.005b	0.385a

Values with the same letters do not differ significantly

It is logical some of the stability values S_k of the examined yield components to be counter proportional to the varieties plasticity b_k. Similar tendencies were determined in the present study. By the component Nr. of spikes/m^2 with the lowest stability is the variety with the highest plasticity namely the standard AD-7291. The variety Sadovec, who exhibits high plasticity is also with low stability, while the varieties Rojen and Zaryad manifest low plasticity to Nr. of spikes/m^2 and have also high stability regarding this sign. By Plant height are observed converse stability and plasticity values by some of the varieties. The varieties AD-7291 and Sadovec are with the lowest plasticity, but also with high stability regarding the Plant height, while by Rojen and Rakita, where the plasticity is high, the stability to the same sign – Plant height, is low. By the variety Zaryad no similar tendencies are observed – the variety is with high stability, although it exhibits a high plasticity to the environmental conditions. The stability of the component Spike length is very low by the varieties AD-7291 and Rakita, which manifest high plasticity to this sign. The variety Rojen is the most stable regarding this linear yield component.

Table 4. Correlations between yield and yield components plasticity coefficients

b_k	Grain yield	Nr spikes	Plant height	Spike length	Nr grains
Nr spikes	0.314				
Plant height	0.629*	-0.311			
Spike length	0.878*	0.351	0.593*		
Nr grains	0.601	0.068	0.718*	0.310	
Mass grain	0.684*	0.438	0.494	0.400*	0.920*

*Significant at 0.05 level

The yield component Nr. of grain/spike is with the lowest stability by the standard AD-7291, followed by Rojen. The variety Zaryad is having values of one and Rakita and Sadovec are with the highest indicators of stability. By the weight component Mass of grain/spike like the most unstable manifest the varieties Rojen, Sadovec and Zaryad, while by AD-7291 and Rakita the stability is high. By the both signs, related with the grain (Nr. of grain/spike and Mass of grain/spike) no similar tendencies for converse proportional to the plasticity relation are observed, in contrast to the previous signs.

In our previous study (Kirchev et al., 2016) the yield plasticity and stability of the same varieties were determined. Through correlation analysis in this investigation is defined the relation between yield plasticity and the examined yield components (Table 4). The yield plasticity coefficient correlate positive with all yield components, as statistically significant values of correlation are indicated by the components Plant height, Spike length and Mass of grain/spike.

Table 5. Correlations between yield and yield components stability coefficients

S_k	Grain yield	Nr spikes	Plant height	Spike length	Nr grains
Nr spikes	0.751*				
Plant height	-0.639*	-0.511*			
Spike length	-0.154	0.210	-0.582*		
Nr grains	0.179	0.422	0.396	-0.420	
Mass grain	0.741*	0.330	-0.013	-0.775*	0.358

*Significant at 0.05 level

By the yield stability coefficient compared correlatively with the yield components, a positive correlation is proven by the Nr. of spikes/m^2 and the Mass of grain/spike. Only by the component Plant heigh there is a negative proven correlation regarding the yield (Table 5).

CONCLUSIONS

The plasticity of the indicator Nr. of spikes/m^2 is with the highest values by the varieties AD-7291, Sadovec and Rakita. According to the varieties Rojen and Zaryad this indicator is with lower values. By the both linear parameters – Plant height and Spike length the tested triticale varieties react on the same way. The triticale varieties react to the environmental conditions and to the components Nr. of grain/spike and Mass of grain/spike almost equally.

The stability values of the examined yield components are contrariwise proportional to the varieties plasticity regarding the components Nr. of spikes/m^2, Plant height and Spike length. According to the both signs, related to the grain (Nr. of grain/spike and Mass of grain/spike) no similar tendencies are have been observed.

The yield plasticity coefficient correlates positive with all yield components. By the yield stability coefficient there is a positive correlation by the Nr. of spikes/m^2 and the Mass of grain/spike, and negative by the component Plant height.

REFERENCES

Eberhart S.A., Russel W. A., 1966. Stability parameters for comparing varieties. Crop Science, 6, 36-40.

Estrada-Campuzano G., Slafer G.A., Miralles D.J., 2012. Differences in yield, biomass and their components between triticale and wheat grown under contrasting water and nitrogen environments. Field Crops Research, 128, 167-179.

Gerdzhikova M., 2014. Influence of N fertilization and predecessors on triticale yield structure characteristics, Turkish Journal of Agricultural and Natural Sciences. Special Issue 2, 1922-1932.

Ivanova A., Kirchev H., 2014. Agronomy performance of new triticale varieties (x *Triticosecale* Wittm.) grown under different regions. Global Journal of Scientific Researches 2(3), 71-75.

Ivanova A., Tsenov N., 2014. Production potential of new triticale varieties grown in the region of Dobrudzha. Agricultural Science and Technology 6(3), 243-246

Kirchev H., Penchev E., Georgieva R., 2016. Yield plasticity and stability of triticale varieties (x *Triticosecale* Wittm.) under increasing nitrogen fertilization norms. Research Journal of Agricultural Science, 48 (2), 65-68.

Losert D., Maurer H.P., Marulanda J.J., Würschum T., 2017. Phenotypic and genotypic analyses of diversity and breeding progress in European triticale (x *Triticosecale* Wittmack). Plant Breeding, 136(1), 18-27.

Mergoum M., Gómez-Macpherson H., 2004. Triticale improvement and production. FAO Plant Production and Protection Paper, 179, 1-59.

Oettler G., Becker H.C., Hoppe G., 2001. Heterosis for yield and other agronomic traits of winter triticale F1 and F2 hybrids. Plant breeding, 120, 4, 351-353.

Ramazani S.R., Tajalli H., Ghoudsi M., 2016. Evaluation of grain yield stability of superior triticale genotypes. Bulgarian Journal of Agricultural Science, 22(6), 976-981.

Royo C., Blanco R., 1999. Growth analysis of five spring and five winter triticale genotypes. Agronomy Journal, 91, 2, 305-311.

Siriamornpun S., Wootton M., Schultheiss J.B., 2004. Potential of capillary electrophoresis for identification of Australian triticale varieties. Australian Journal of Agricultural Research. 55(5), 595–598.

Stoyanov H., Baychev V., 2015. Correlations between spike parameters of first generation direct and reciprocal crosses of triticale (x *Triticosecale* Wittm.). Agrarni Nauki, 7(18), 25-34.

Varughese G., Pfeiffer W.H., Peña R.J., 1996. Triticale: a successful alternative crop. Cereal Foods World, 41(7): 474-482.

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CHARACTERIZATION OF SOME TURKISH SESAME POPULATIONS AND CULTIVARS FOR AGRONOMICAL AND SOME QUALITY TRAITS

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Abstract

Sesame (Sesamum indicum L., Pedaliaceae) is one of the oldest and important oil seed crops known by mankind. Sesame was grown during the ancient Harappan, Mesopotamian, and Anatolian areas for its edible seed and its oil but now it is grown in more than 60 countries. Landraces of sesame represent a valuable genetic resources for breeding and genetics studies. The aim of this study was to determine agronomical and quality traits of some sesame genotypes (17 landraces and 7 commercial cultivars). The field experiment was arranged in randomized complete block design with three replications at the research farm of Department of Field Crops, Faculty of Agriculture University of Cukurova in 2010 and 2011. The results of the study showed that the differences between the landraces and cultivars were statistically significant for lowest branch height, lowest capsules height, number of capsules, number of branch, 1000 seeds weight, seed yield, oil content and protein content. According to a two-year average, the highest seed yield was obtained from Adana-Saricam population (1952 kg/ha), while the lowest seed yield was obtained from Mugla-Ortaca population (615 kg/ha). The highest oil content was obtained from Kahramanmaras population (53.28%), while the lowest value was obtained from Adana-Yumurtalik3 population (49.3%).

Key words*: Turkish sesame, genetic diversity, morphology.*

INTRODUCTION

Sesame (*Sesamum indicum* L. - *Pedaliaceae*) is one of the oldest and important oil seed crops known to mankind. Sesame seeds are used on bread, cakes and especially simit in Turkey. The seed can also be made into a paste called tahini which is rich in protein and a very good energy source and confection called halvah. Sesame seed contains 50-60% oil and 25% protein with antioxidants lignans such as sesamolin, sesamin and has been used as active ingredients in antiseptics, bactericides, viricides, disinfectants, moth repellants, anti-tubercular agents (Bedigian et al., 1985) and considerable source of calcium, tryptophan, methionine and many minerals (Johnson et al., 1979). Sesame was grown during the ancient Harappan, Mesopotamian and Anatolian areas for its edible seed and its oil (Bedigian et al. 1985; Bedigian 2004) but now it is grown in more than 60 countries. There are great number sesame landraces which are adapted to various ecological conditions throughout the Turkey (Demir, 1962).

Despite sesame has been grown in various ecological regions of Turkey during hundreds years, sesame yield and production is very low. The low production is due to a number of reasons such as low inputs and poor management occurrence of biotic and abiotic stresses and more importantly, a lack of improved varieties for use by the farmers in Turkey (Baydar, 2005). This situation can be changed by selecting varieties of good quality and high adaptive potential to the different climatic conditions (Nyongesa et al., 2013). Sesame landraces are an important source of genetic diversity for breeders. Information on genetic diversity and relationship among landraces is important for plant breeders to select the adequate genetic material to be used (Ganesh and Thangavelu, 1995). Genetic diversity in crop species can be determined using morphological (phenotypic), biochemical, and molecular (DNA) markers. Studies on sesame genetic diversity and divergence have been mainly based on agro-morphological traits.

The purpose of this study was to evaluate morphology of sesame varieties from different region of Turkey regarding morphological and some quality characters such as oil and protein content, and 1000 seeds weight.

MATERIALS AND METHODS

The study was carried out using 17 sesame landraces population which were collected from different region in Turkey and 7 commercials in Adana region in 2010 and 2011 to compare and determine the plant height, capsule number per plant, first capsule height, branch number per plant, 1000-seeds weight, protein content, oil content and seed yield of cultivated sesame genotypes (Table 1).

Table 1. The list of some Turkish sesame population and cultivars

Genotype Name	Genotype Name
Kahramanmaras	Adana-Saricam
Antalya-Kumluca	Adana-Yumurtalik1
Aydın-Cine	Adana
Adana-Kozan	Adana-Yumurtalik3
Balikesir-Koseler	Adana-Yumurtalik7
Diyarbakir-Silvan	Baydar-2001 ©
Osmaniye	Muganli-57©
Manisa-Salihli	Kepsut-99©
Mugla-Ortaca	Osmanlı-99©
Şanlıurfa-Bozova-Cukurkoy 2	Orhangazi-99©
Diyarbakir-Bismil-Bakacak2	Tan-99©
Manisa-Alasehir-Ulubentdere	Cumhuriyet-99©

©: Cultivar

The experiment was conducted at Adana province of Turkey (35°18′ E latitude, 37°01′ N longitude, and 23 m above sea level) in 2010 and 2011. The accessions were grown in four row plots of 5 m row length with a row spacing of 70 cm and intra-row spacing of 15 cm. Thinning was carried out after 25 days of sowing to secure one plant at 15 cm. Sprinkler irrigation was established immediately after sowing and thereafter used when necessary based on soil and plant conditions. Nitrogen, phosphorus and potassium were applied at a rate of 60 kg per hectare at sowing as a complete fertilizer. Weeding were carried out by hand weeding and no herbicides were applied during the growing seasons. All the plants were harvested in the last week of September, 2010 and 2011.

The data obtained were statistically analyzed by the computing MSTAT-C package program in accord with the Randomized Complete Block Design. The means of the treatment were compared by using the LSD as described by Steel and Torrie (1997).

RESULTS AND DISCUSSIONS

Plant Height, First Capsule Height and Number of Capsule

The results about the plant height, first capsule height and number of capsules were shown in Table 2.

There was a no statistically significant differ-rence in plant height between sesame geno-types in a two-year average. The genotypes showed variation in plant height between 156-177.2 cm in a two-year average. The half of the genotypes shorter than average plant height value.

It can be seen in Table 2, the significant differences were observed for first capsule between sesame populations and cultivars. The highest first capsule height was recorded for Mugla-Ortaca population (62.25 cm) while the lowest first capsule height was recorded for Antalya-Kumluca (45.97 cm) (Table 2). Similar results were reported by Curat (2010) and Ulukutuk (2011).

The average performance of the accessions over the two years shown in Table 2 indicated significant differences among the accessions in number of capsule. The result shows that the highest number of capsule was obtained from Adana population (169.4 capsule/plant), while the lowest value was obtained from Adana-Yumurtalik7 population (119.3 capsule/plant). The average number of capsule was 142.4 capsule/plant and of ten genotypes higher average.

Number of branch, 1000-seeds weight, oil and protein content

All accessions and cultivars were branching with an average of 4.4 primary branches per plant. The highest branches number was obtained from Orhangazi-99 Turkish sesame cultivar (5.4 branch/per plant), while the lowest value was obtained from Aydin-Cine popu-lation (3.4 branch/per plant). Indeed, number of branches showed a positive correlation ($r = 0.392^{**}$) to number of capsules, but no signi-ficant correlation to seed yield.

The average for 1000-seeds weight, oil content and protein content, among the genotypes were 3.42, 51.46 and 21.68, respectively (Table 3).

Table 2. Plant height, first capsule height and number of capsule of some Turkish sesame populations and cultivars

Genotypes	Plant Height (cm)	First Capsule Height (cm)	Number of Capsule (no. plant^{-1})
Kahramanmaras	167.3	51.08 abcd	161.8 abc
Antalya-Kumluca	157.6	45.97 d	140.8 abcdef
Aydin-Cine	157.7	51.33 abcd	121.3 ef
Adana-Kozan	165.6	53.78 abcd	127.1 def
Balikesir-Koseler	164.9	55.85 abcd	129.9 def
Diyarbakir-Silvan	161.1	58.18 abcd	140.0 abcdef
Osmaniye	166.9	55.60 abcd	137.1 bcdef
Manisa-Salihli	167.3	48.53 cd	138.4 abcdef
Mugla-Ortaca	178.4	62.25 a	121.9 def
Sanliurfa-Bozova-Cukurkoy 2	158.1	53.58 abcd	161.7 abc
Diyarbakir-Bismil-Bakacak2	176.2	57.57 abcd	149.1 abcdef
Manisa-Alasehir-Ulubentdere	170.5	58.37 abcd	138.4 abcdef
Adana-Saricam	173.0	53.88 abcd	132.5 bcdef
Adana-Yumurtalik1	158.2	49.88 abcd	151.4 abcde
Adana	161.8	51.33 abcd	169.4 a
Adana-Yumurtalik3	172.1	62.08 ab	130.4 cdef
Adana-Yumurtalik7	161.5	48.72 bcd	119.3 f
Baydar-2001	166.6	47.18 d	147.7 abcdef
Muganli-57	175.7	54.22 abcd	153.6 abcd
Kepsut-99	176.5	59.42 abcd	148.9 abcdef
Osmanli-99	171.6	50.62 abcd	127.1 def
Orhangazi-99	156.0	61.45 abc	145.0 abcdef
Tan-99	167.5	58.08 abcd	136.7 bcdef
Cumhuriyet-99	177.2	62.15 ab	163.9 ab
Average	**167.1**	**54.6**	**142.4**
LSD (% 5)	**N.S.**	**10.92**	**26.04**

Table 3. Number of branch, 1000-seed weight, oil content and protein content of some Turkish sesame populations and cultivars

Genotypes	Number of Branch	1000 Seeds Weight	Oil Content	Protein Content
Kahramanmaras	5.2 ab	3.273 hıj	53.28 a	21.75 cdefg
Antalya-Kumluca	4.1 efghı	3.513 defg	50.90 cdefgh	21.10 fghıj
Aydin-Cine	3.4 ı	3.522 cdefg	50.68 cdefgh	21.55 defghı
Adana-Kozan	5.2 abcd	3.632 abcd	50.60 cdefgh	21.17 fghıj
Balikesir-Koseler	4.7 abcdefg	3.355 ghı	52.20 abcde	21.27 fghıj
Diyarbakir-Silvan	4.7 abcdefgh	3.145 j	52.12 abcde	22.45 bc
Osmaniye	4.9 abcde	3.418 efgh	49.77 fgh	22.05 cde
Manisa-Salihli	4.2 defghı	3.738 a	51.73 abcdef	21.75 cdefg
Mugla-Ortaca	4.8 abcdef	3.312 hıj	50.90 cdefgh	23.13 a
Sanliurfa-Bozova-Cukurkoy 2	4.9 abcde	3.700 ab	51.77 abcdef	21.77 cdef
Diyarbakir-Bismil-Bakacak2	4.2 cdefghı	3.415 efgh	52.15 abcde	21.02 hıj
Manisa-Alasehir-Ulubentdere	4.5 abcdefgh	3.250 hıj	51.43 abcdefg	20.70 j
Adana-Saricam	4.0 efghı	3.680 abc	51.82 abcdef	21.55 defghı
Adana-Yumurtalik1	4.5 abcdefgh	3.478 defg	50.42 defgh	22.23 cd
Adana	4.0 efghı	3.420 efgh	50.13 efgh	20.92 ıj
Adana-Yumurtalik3	3.7 hı	3.172 j	49.10 h	21.75 cdefg
Adana-Yumurtalik7	3.9 fghı	3.505 defg	53.18 ab	21.75 defg
Baydar-2001	4.2 defghı	3.297 hıj	52.40 abcde	21.45 efghı
Muganli-57	4.0 efghı	3.225 ıj	51.88 abcdef	21.67 defgh
Kepsut-99	3.7 ghı	3.547 bcdef	51.82 abcdef	22.17 cde
Osmanli-99	3.8 ghı	3.270 hıj	52.23 abcde	20.88 ıj
Orhangazi-99	5.4 a	3.377 fghı	52.55 abcd	22.17 cde
Tan-99	4.3 bcdefghı	3.565 bcde	52.78 abc	21.03 ghıj
Cumhuriyet-99	5.1 abc	3.218 ıj	49.30 gh	23.02 ab
Average	**4.4**	**3.42**	**51.46**	**21.68**
LSD (% 5)	**0.8173**	**0.1450**	**1.809**	**0.6057**

The range for 1000-seeds weight was 3.145 g (Diyarbakir-Silvan population) and 3.738 g (Manisa-Salihli population), oil content varied from 49.1% (Adana-Yumurtalik 3 population) and 53.28% (Kahramanmaras population), and protein content was 20.7% (Manisa-Alasehir-Ulubentdere population) and 23.13% (Mugla-Ortaca) in a two-year average. These traits showed genetic variation and accessions with such a large level of genetic diversity often used for the determination of best genotypes for diverse ecological conditions. Earlier reports by other researchers also indicated significant variation among sesame genotypes in 1000-seed weight, oil and protein content (Solanki et al., 2001; Adebisi et al., 2005; Baydar, 2005; Parameshwarappa and Salimath, 2009; Furat and Uzun, 2010; Pham et al., 2010; Yol and Uzun, 2012).

Seed yield

There was a great deal of seed yield variation observed among all the sesame germplasm.

The differences between the genotypes were statistically significant for the seed yield in both years and in a two-year average.

The seed yield values varied between 538.3-1990 kg/ha in 2010, 692.7-1959 kg/ha in 2011 and 615.5-1952 kg/ha in a two-year average. This variation can be contributed to the cultivation conditions and strongly supported the idea that local sesame germplasm still commonly sustained by the farmers due to the absence of improved breeding cultivars for diverse environmental conditions (Furat and Uzun, 2010).

Table 4. Seed yield (kg/ha) of some Turkish sesame populations and cultivars in 2010, 2011 and in a two-year average

Genotypes	**2010**	**2011**	**Average**
Kahramanmaras	1793 abc	1786 abcd	1789 ab
Antalya-Kumluca	1663 abc	1464 bcdef	1564 bcd
Aydin-Cine	1291 c	1314 ef	1302 d
Adana-Kozan	1361 bc	1245 f	1303 d
Balikesir-Koseler	1346 bc	1614 abcdef	1480 bcd
Diyarbakir-Silvan	1314 c	1300 ef	1307 d
Osmaniye	1392 abc	1255 f	1323 d
Manisa-Salihli	1490 abc	1686 abcdef	1588 abcd
Mugla-Ortaca	538.3 d	692.7 g	615.5 e
Sanliurfa-Bozova-Cukurkoy 2	1842 abc	1759 abcde	1801 ab
Diyarbakir-Bismil-Bakacak2	1581 abc	1700 abcdef	1641 abcd
Manisa-Alasehir-Ulubentdere	1554 abc	1441 bcdef	1497 bcd
Adana-Saricam	1945 ab	1959 a	1952 a
Adana-Yumurtalik1	1695 abc	1410 cdef	1552 bcd
Adana	1876 abc	1612 abcdef	1744 abc
Adana-Yumurtalik3	1428 abc	1348 cdef	1388 cd
Adana-Yumurtalik7	1372 bc	1326 def	1349 d
Baydar-2001	1572 abc	1426 bcdef	1499 bcd
Muganli-57	1990 a	1607 abcdef	1799 ab
Kepsut-99	1541 abc	1788 abc	1664 abcd
Osmanli-99	1622 abc	1617 abcdef	1620 abcd
Orhangazi-99	1498 abc	1505 abcdef	1501 bcd
Tan-99	1493 abc	1645 abcdef	1569 bcd
Cumhuriyet-99	1815 abc	1881 ab	1848 ab
Average	**1542**	**155.2**	**1529**
LSD (% 5)	**50.30**	**38.16**	**31.15**

CONCLUSIONS

Our results indicated that there is significant variability among the genotypes in the yield and yield component parameters measured. It also revealed that some genotypes are showed better yield performance under Mediterranean condition. Adana-Saricam (1952 kg/ha) and Sanliurfa-Bozova-Cukurkoy 2 (1801 kg/ha) populations with Cumhuriyet-99 (1848 kg/ha) and Muganli-57 (1799 kg/ha) which showed outstanding performances in seed yield in both years are therefore recommended for cultivation in the Adana.

REFERANCES

Adebisi M.A., Ajala M.O., Ojo D.K., Salau A.W., 2005. Influence of population density and season on seed yield and its components in Nigeria sesame genotypes. J. Trop. Agric. 43(1-2):13-18.

Baydar H., 2005. Susamda (*Sesamum indicum* L.) verim, yağ, oleik ve linoleik tipi hatların tarımsal ve teknolojik özellikleri. Akdeniz Üniversitesi Ziraat Fakültesi Dergisi, 18 (2), 267-272 (Turkish).

Bedigian D., Seigler David S., Harlan Jack R., 1985. Sesamin, sesamolin and the origin of sesame. Biochemical Systematics and Ecology, vol. 13, no. 2, p. 133-139.

Bedigian D., 2004. History and lore of sesame in Southwest Asia. Econ. Bot. 58(3), 329-353.

Curat D., 2010. Kilis ve Yöresinde Yetiştirilen Yerel Susam (*Sesamum indicum* L.) Populasyonlarının Biyolojik ve Kimyasal Özelliklerinin Belirlenmesi. MsC Thesis, Kilis 7 Aralık University (Turkish).

Demir I., 1962. An investigation of the main morphological, biological and cytological characteristics of important sesame species grown in Turkey. Ege University Agriculture Faculty Publications, Izmir, Turkey, 53.

Furat S., Uzun B., 2010. The use of agro-morphological characters for the assessment of genetic diversity in sesame (*Sesamum indicum* L.). Plant Omics J. 3:85-91.

Ganesh S.K., Thangavelu S., 1995. Genetic divergence in sesame (*Sesamum indicum*). Mad. Agric. J. 82(4), 263-265.

Johnson L.A., Suleiman T.M., Lusas E.W., 1979. Sesame protein: a review and prospectus. Journal of the American Oil Chemists' Society, vol. 56, no. 3, p. 463-468.

Nyongesa B.O., Were B.A., Gudu S., Dangasuk O.G., Onkware A.O., 2013. Genetic Diversity in Cultivated Sesame (*Sesamum indicum* L.) and Related Wild Species in East Africa. J. Crop Sci. Biotech., (March) 16 (1) : 9-15.

Parameshwarappa S.G., Salimath P.M., 2010. Studies on combining ability and heterosis for yield and yield components in sesame (*Sesamum indicum* L.). Green Farming 3(2), 91-94.

Pham D.T., Nguyen T.T.D., Carlsson A.S., Bui M.T., 2010. Morphological evaluation of sesame (*Sesamum indicum* L.) varieties from different origins. Australian Journal of Crop Science 4(7), 498-504.

Solanki Z.S., Ve Gupta D., 2001. Combiningg ability and heterosis studies for seed yield and its components in Sesame. Sesame and Safflower Newsletter No. 16.

Steel R.G.D., Torrie J.A., Ditchkay D.A., 1997. Principles and Procedures of Statistics. A.Biometrical Approach 3rd Edi. McGrow. Hill Book. INC. N.Y.

Ulukutuk E., 2011. Kilis Yöresinden Toplanan Yerel Susam (*Sesamum indicum* L.) Populasyonlarının Verim Ve Kalite Parametrelerinin Karşılaştırılması. MsC Thesis, Kilis 7 Aralık University (Turkish).

Yol E., Uzun B., 2012. Geographical patterns of sesame accessions grown under mediterranean environmental conditions, and establishment of a core collection. Crop Sci., 52: 2206-2214.

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THE EFFECT OF APPLICATION OF PHYTOTOXIC LEVELS OF BORON ALONG WITH SULPHUR ON NUTRIENT CONTENT IN COTTON (G*ossypium hirsutum* L.*)*

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Abstract

This study was carried out determining the effect of phytotoxic boron along with sulphur fertilizers on nutrient content in cotton in the research field of the department of field crops at Dicle University between 2013 and 2014. In the trial designed in randomized complete split block, the effect of two sulphur doses (0-100 kg da^{-1}) and four boron doses (0, 2.5, 5 and 15 mg kg^{-1}) on nutrient concentrations of cotton leaves were examined. According to the results, 5 and 15 mg kg^{-1} of B treatments with and without sulphur did not cause any visible toxic symptoms in cotton. Moreover, the treatments resulted in uptake of N, P, K, Fe, Zn and Mn nutrients in sufficiency ranges whereas Ca, S, Mg, Cu and Mo concentrations were lower than required concentration ranges of these nutrients. B content of leaves was found in sufficient range in plots where phytotoxic level of B was used. The effect of S application over N, K, Ca, B, Mn and Mo content of leaves showed decrease of these nutrients' concentrations but an increase the concentrations of S, Mg, Fe, Zn and Cu. In addition to this, the content of Mo was the lowest among nutrients. In terms of B and S interaction, P concentrations showed inconsistent results during the study.

Key words: c*otton, sulphur, boron toxicity, nutrient content.*

INTRODUCTION

Sulphur (S) has an important role in synthesis of essential amino acids and chlorophyll and nitrogen fixation mechanism in leguminous plants (Kopáček et al., 2014). Also, S is either a component of molecules such as RNA, DNA, amino acids, proteins, sulfolipids, flavonoids, lipids, glucosinates, polysaccharides, and nucleotide or a factor used in sustaining hormonal activities.

Boron (B) is one of the most essential nutrients for plant growth and should be applied to plants sufficiently (Tanaka and Fujiware, 2008) and be available in soil throughout vegetation period of cotton (Bogiani et al., 2014).

B toxicity symptoms appear in crops in many arid regions where irrigation water or soil has excessive B content (Karabal et al., 2003). Besides, B toxicity may emerge through either fertilization or mining (Nable et al., 1997).

Although the tolerance of plants to boron toxicity is different, this mechanism is not fully understood yet. However, it was thought that boron tolerance of plants is related to limiting factors making B available for plant roots (Cord et al., 2010). Clay content, soil moisture, soil temperature, pH (Goldberg et al., 1997) and carbonates (Keren et al., 1985) are factors affecting B availability in soils. High soil pH along with clay minerals play important role in B adsorption from soil solution. When pH is below 7, boron is available in soil as $B(OH)_3$ (boric acid), which is not favored by clay minerals. As pH increases the boric acid concentration decreases and $B(OH)_4$ (borate anion) concentration increases resulting in reduction of B absorption by plants (Hu and Brown, 1997). Consequently, in order for B be available in soil and be taken up by plants pH should be slight acid or neutral (Herrera-Rodriguez et al., 2010)

Other than these factors, it is reported that adding calcium to soil reduces B toxicity (Tariq and Mott, 2007) and several authors reported that calcium fertilization reduced effects of boron toxicity in tomato (Singaram and Prabha, 1997) and in wheat (Turan et al., 2009).

Similar to these results a strong negative relationship also was reported between boron content of cotton and calcareous soils with high pH by Ahmed et al., 2013.

Few studies about B and S fertilization are present in cotton.

However, it is not well kown how phytotoxic levels of B affect cotton which is grown in clay soils with high calcium content. Therefore, in this study the effect of sulphur on sufficient and toxic levels of B in cotton (*Gossypium hirsutum* L.) was investigated.

In this respect, the effect of the boron and sulphur treatments and their interactions on macro and micronutrients of cotton leaves were examined.

MATERIALS AND METHODS

Soil sampling and analysis

The study was conducted in cotton (*Gossypium hirsutum* L.*)* during 2013 and 2014 at the experimental field of the Faculty of Agriculture, Dicle University, Diyarbakir, Turkey.

Composite soil samples (0-30 cm) were taken from the field at different locations in October, 2013. The samples were analyzed as described by Ryan et. al. (2001).

The SO_4-S analysis was performed by Fox et. al. (1964) while boron content of the soil was determined by hot water method of Dible et al. (1954), which is a modified method of Berger and Troug (1944).

The soil was clay, moderately alkaline (pH 7.8), non-saline (EC, 0.66 m S cm^{-1}), moderately calcareous ($CaCO_3$, 11.70 %) and low in organic matter (0.97 %).

The nutrient compositon of the soil was determined as follows: Olsen P (5.18 mg kg^{-1}), NH_4OAc-extractable K (723.67 mg kg^1), NH_4OAc-extractable Ca (18517.67 mg kg^{-1}), NH_4OAc-extractable Mg (1173.67 mg kg^{-1}), NH_4OAc-extractable Na (423 mg kg-1), DTPA-extractable (1.21 mg kg^{-1}), Fe DTPA-extractable Mn (2.74 mg kg^{-1}), DTPA-extractable Zn (0.78 mg kg^{-1}), DTPA-extractable Cu (1.30 mg kg^{-1}), SO_4-S (4.89 mg kg^{-1}) and hot water extractable-B (0.58 mg kg^{-1}). In order to observe pH changes, the soil pH was measured three times during the cultivation: at thinning, at first squaring and at first flowering.

Experimental design and growth conditions

Sulphur and boron doses were applied as treatments arranged in randomized complete split block design with four replications.

Main plots were treated with two doses of elemental S (0-100 kg S da^{-1}) whereas subplots were applied with four boron levels (0, 2.5, 5 and 15 B mg kg^{-1}) as disodium octaborate tetrahydrate ($Na_2B_8O_{13}\cdot 4H_2O$, 20.9 % B).

All treatments were broadcast and incorporated prior to planting with basal fertilizer as 20-20-0 compound fertilizer (35 kg da^{-1}).

The incomplete nitrogen was completed using ammonium nitrate (33 %) as 30 kg da^{-1} before the first irrigation.

Furrow irrigation was adopted as irrigation method and the irrigation was applied when necessary. Plots were formed 10 m long with 5.6 m wide consisting of 8 rows with 70 cm spacing.

Overseeded plots were thinned to one plant with 20 cm spacing. Stonevielle 468 (ST 468) was used as the variety of seed cotton. The standard plant protection management practices together with agronomic practices were employed for the crop cultivation.

Determination of Macro and Micro Nutrients of the Leave Samples

Total nitrogen (N) levels of leave samples were analysed by Dumas method using elemental combustion system (Coshtech ecs 4010). Phosphorous (P), potassium (K), calcium (Ca), sulphur (S), magnesium (Mg), molybdenum (Mo), manganese (Mn), iron (Fe), copper (Cu), zinc (Zn) and boron (B) concentrations of leave tissues were analyzed, as described by Halvin ve Soltanpour (1980), using ICP-OES (Varian 4.1.0).

Table 1. pH values by years

Uygulama	2013			2014		
	pH1	**pH2**	**pH3**	**pH1**	**pH2**	**pH3**
S	7.4	7.55	7.73	7.71	7.57	7.75
S	7.53	7.53	7.73	7.51	7.48	7.65
S	7.77	7.57	7.77	7.61	7.52	7.87
S	7.74	7.52	7.63	7.63	7.42	7.75
S+2.5 ppm B	7.43	7.59	7.75	7.64	7.44	7.65
S+2.5 ppm B	7.59	7.53	7.81	7.75	7.52	7.82
S+2.5 ppm B	7.74	7.51	7.82	7.68	7.52	7.84
S+2.5 ppm B	7.69	7.53	7.86	7.71	7.56	7.75
S+5 ppm B	7.37	7.61	7.65	7.77	7.52	7.68
S+5 ppm B	7.57	7.54	7.78	7.69	7.55	7.83
S+5 ppm B	7.68	7.53	8.11	7.64	7.54	7.94
S+5 ppm B	7.68	7.52	7.8	7.65	7.68	7.87
S+ 15 ppm B	7.6	7.51	7.73	7.62	7.53	7.86
S+ 15 ppm B	7.6	7.63	7.76	7.68	7.42	7.79
S+ 15 ppm B	7.73	7.57	7.87	7.64	7.45	7.87
S+ 15 ppm B	7.73	7.58	7.69	7.61	7.42	7.89
Control	7.58	7.65	7.85	7.6	7.8	8
Control	7.7	7.8	7.93	7.74	7.94	7.98
Control	7.75	7.72	8.1	7.66	7.86	7.94
Control	7.65	7.69	7.93	7.68	7.68	7.87
2.5 ppm B	7.62	7.75	8	7.79	7.86	8.03
2.5 ppm B	7.71	7.7	7.8	7.77	7.81	8.1
2.5 ppm B	7.63	7.74	8.09	7.65	7.74	8
2.5 ppm B	7.73	7.79	8.05	7.56	7.71	7.92
5 ppm B	7.63	7.75	7.99	7.67	7.85	7.99
5 ppm B	7.62	7.74	8.05	7.65	7.84	8.1
5 ppm B	7.83	7.78	8.06	7.69	7.75	7.86
5 ppm B	7.64	7.62	7.97	7.63	7.52	7.77
15 ppm B	7.6	7.7	8.07	7.61	7.67	8.05
15 ppm B	7.75	7.79	8.04	7.65	7.84	8
15 ppm B	7.77	7.73	8.03	7.64	7.75	8.03
15 ppm B	7.62	7.65	7.91	7.62	7.7	8.04

RESULTS AND DISCUSSIONS

pH values

The pH values of the plots with S are not much different from the plots without S at the first measurement.

It has been determined that the values obtained at the beginning of squaring in the S applied plots showed a noticable decrease compared to the plots without S.

This may be explained slow decompositon process of the elemental S into the soil.

On the other hand, the pH of the plots without S increases gradually (Table 1).

Nutrient Contents

First of all, no visible toxicity symptoms originating from any of B levels were observed. The effect of B and S applications on nutrient contents of cotton leaves were shown in Table 2 and Table 3. N, P, K, Ca and Cu concentrations of leaves showed inconsistencies depending on years and B application levels.

The concentrations of N, P, K, Ca and Cu were found significant only in 2013 at B4, B3, B2, B3 and B3 levels, respectively. As for S, Mg and B contents, they showed significant difference regarding B levels during both years. The highest nutrient concentrations of S, Mg and B were obtained at B4, B3 and B4 levels, respectively. Similarly, Fe, Zn, Mo and Mn concentrations significantly differed in 2013 and 2014.

Nonetheless the highest values of Fe and Mn were uneven in terms of B levels.

Conversely, Zn and Mo contents showed smooth results at B3 and at B3, respectively, by years.

The effect of S application on N, P and K content of leaves was found insignificant during 2013 and 2014. By contrast Ca, B, Mo,and Mn concentrations significantly differed and lower concentrations of these elements were determined depending on S application during both years.

Nevertheless, S, Mg and Fe contents of leaves significantly increased after S application in the years of the study.

As for Zn and Cu concentrations of cotton leaves, they were found significant only in 2013 showing inconsistency between years (Table 2 and Table 3).

Ahmed et al. (2008) and Turan et al., (2009) stated that B toxicity symptoms became apparent when 5 mg B kg^{-1} applied to soil in cotton and in wheat respectively.

Our results contradicted these results.

The lack of B toxicity symptoms in both with and without S plots may be explained with physical and chemical soil properties of experimental area.

Soils with high content of organic matter, oxide minerals, clay minerals, and carbonates play an important role in reduction of the phytotoxic effects of excessive B since these organic or mineral surfaces serve as sinks for B with their adsorption sites.

Once B is adsorbed by any mineral or organic surfaces, it is neither available nor toxic to plants. Therefore, soils with high clay content have enormous potential in attenuation of boron toxicity (Goldberg et al., 2005).

pH is another factor for B to be adsorbed onto organic and mineral surfaces (Goldberg and Forster, 1991).

The adsorption of B onto Al and Fe oxides and clay minerals such as kaolinite, montmorillonite and illite intensifies at low pH levels.

Nonetheless, while the sorption of B peaks in pH range 7-8 for Al and Fe oxides, the adsorption peak shifts to pH 8-10 for clays (Goldberg and Forster, 1991).

At these pH ranges, B forms primarily as borate anion and cannot be available to plants (Herrera-Rodriguez *et al*., 2010; Römheld and Marshner, 1991).

The pH level of the experimental field was moderately alkaline and in spite of S application the lowest pH was recorded as 7.37 in 2013 (Table 1).

However due to the buffering capacity of the soil, pH values returned to their initial state in the following weeks in which the adsorption of B may be the highest in this pH range.

Table 2. Nutrient content of cotton leaves by years and applications

	N (%)		P ($mg\ kg^{-1}$)		K ($mg\ kg^{-1}$)		Ca ($mg\ kg^{-1}$)		S ($mg\ kg^{-1}$)		Mg ($mg\ kg^{-1}$)	
Applications/Years	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
B1 (0 $mg\ kg^{-1}$)	3.85b	3.90	2744.50c	2703.75b	19158.13b	19396.25b	11324.63c	11425.88	2139.38c	2136.25c	2353.25a	2345.50a
B2 (2.5 $mg\ kg^{-1}$)	3.80b	3.90	2883.75b	2963.75a	20993.88a	20351.63a	11906.00bc	12161.38	2311.75b	2277.88bc	2366.25a	2389.38a
B3 (5 $mg\ kg^{-1}$)	3.78b	3.92	3006.63a	2948a	19539.13b	19726.75ab	12639a	12659.13	2297.75b	2390.13ab	2315.13a	2337.38a
B4 (15 $mg\ kg^{-1}$)	4.13a	4.11	2710.00c	2741.63b	19139.00b	19168.38b	12148.88ab	12549.50	2517.88a	2520.38a	2248.13b	2187.75b
LSD	0.21*	-	99.03**	115.75	829.31**	715.69*	615.36**	1046.11	118.11**	157.29**	52.19**	92.64**
S1 (100 kg S da^{-1})	3.82	3.93	2837.44	2830.69	19539.56	19485.25	11516.44b	11803.75b	2516.06a	2537.94a	2378.44a	2349a
S2 (0 kg S da^{-1})	3.96	3.99	2835	2847.88	19875.50	19836.25	12492.81a	12594.19a	2117.31b	2124.38b	2262.94b	2281b
LSD	-	-	-	-	-	-	435.12**	739.71*	83.52**	111.22**	36.90**	65.51*
General Mean	3.89	3.96	2838.22	2839.28	196707.53	19660.75	12004.63	12198.97	2316.69	2331.16	2320.69	2315

Mean values with different letters in each column represent significant difference at the ** $P < 0.01$ and *$P < 0.05$ level based on LSD test.

Table 3. Nutrient content of cotton leaves by years and applications

	B ($mg\ kg^{-1}$)		Fe ($mg\ kg^{-1}$)		Zn ($mg\ kg^{-1}$)		Mo ($mg\ kg^{-1}$)		Mn ($mg\ kg^{-1}$)		Cu ($mg\ kg^{-1}$)	
Applications/Years	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
B1 (0 $mg\ kg^{-1}$)	13.04c	13.40d	140.25c	139.75c	28.74b	29.04b	1.93b	2.09b	34.25b	33.80b	16.84b	15.85
B2 (2.5 $mg\ kg^{-1}$)	15.87b	15.98c	156.00a	152.63ab	28.84b	28.72b	2.18a	2.26a	35.00b	37.06ab	18.23a	16.85
B3 (5 $mg\ kg^{-1}$)	20.13a	18.47b	141.63c	141.75bc	31.73a	30.70a	2.12a	2.17ab	35.75b	37.45a	19.04a	17.62
B4 (15 $mg\ kg^{-1}$)	20.51a	20.31a	149.63b	154.63a	28.28b	28.83b	2.23a	2.28a	38.25a	39.79a	16.13b	16.55
LSD	1.32**	0.83**	4.40**	8.39*	0.61**	1.02*	0.12**	0.09*	1.30**	2.53*	0.66**	-
S1 (100 kg S da^{-1})	13.33b	13.48b	158.56a	156.19a	30.11a	29.69	1.90b	1.95b	33.56b	34.23b	17.95a	17.08
S2 (0 kg S da^{-1})	21.45a	20.60a	135.19b	138.19b	28.69b	28.96	2.33a	2.45a	38.06a	39.82a	17.18b	16.35
LSD	1.87**	1.17**	6.23**	11.86**	0.86**	-	0.17**	0.12**	1.84**	3.58**	0.93*	-
General Mean	17.39	17.04	146.88	147.19	29.40	29.32	2.12	2.20	35.81	37.02	17.56	16.72

Mean values with different letters in each column represent significant difference at the ** $P < 0.01$ and *$P < 0.05$ level based on LSD test.

Calcareous soils are also important with regard to adsorption of B. The high ionic strength of soil solution, particularly with divalent ions, increases boron adsorption (Majidi et al., 2010). Clays saturated with calcium (Ca) are more prone to adsorb B compared to sodium (Na) saturated clays (Harter, 1991). Moreover, B retention by calcite in calcareous soils increases in low pH and adsorption is reversed after reaching peak level at 9.5. Since calcite removal decreases B retention in calcareous soils, calcite is conceded as a sink for B. Therefore, toxic effect of excess of B in calcareous soils may be abated by the presence of carbonates (Goldberg and Forster, 1991). The high calcium content along with clay soil of the experimental field may cause more adsorption of excessive B and prevent observation of B toxicity in the study.

Depending on clay mineralogy of soil, increasing soil temperature is another factor affecting adsorption and desorption of B. B adsorption increases between pH 3-7 range and peaks at 7.5-10 in all different clay types (Goldberg et al., 1993). The air temperature in the trial field increases from April to August and reaches its highest value within this month. Due to the increased air temperature, the soil temperature increases. The pH values of the plot without sulfur application showed a uniform increase in pH values for two study years. Therefore, this may have caused the high doses of applied B to be adsorbed to the soil.

Soil temperature along with soil moisture also affect diffusion of ions to plant roots causing different crop responses from one growing season to another (Schaff and Skogley, 1982). In this vein, in our study, pH decrease took place in soil samples taken after planting in sulphur treated plots but after a short period pH increased reaching 7.7-7.8 peak range. Nevertheless, in plots without sulfur pH constantly increased becoming stable at 7.8-8 range. This pH ranges along with increasing soil temperatures during cultivation period of cotton may bring about retention of B on oxide minerals and clays decreasing phytotoxic effect of high B treatments.

In terms of macro and micro nutrient contents of leaves, the evaluation was made with respect to sufficiency ranges reported by Mithchel and Baker (2000). According to this, the uptake of N, P, K, Fe, Zn and Mn were found within sufficiency ranges as response to B and S treatments. Ca, S, Mg and Cu content of leaves were sufficient depending on treatments. As for B concentrations, they were found sufficient in higher doses of B treatments. Mo content of leaves established very low in B and S treated plots. Furthermore, sulphur treatment decreased the concentrations of N, K, Ca, B, Mn and Mo. The uptake of S, Mg Fe, Zn, and Cu increased. As for P concentration, it did not show consistency as response to sulphur fertilization. In this study Mo concentration particularly was found very low, ranging from 1 to 2.45 mg kg^{-1}. This range was extremely low compared with that in study in which zero Mo treated sand resulted in obtaining 3 mg kg^{-1} Mo in cotton (Joham, 1953). As for Mn concentration values they were between 25-350 mg kg^{-1} which is accepted in sufficiency range (Dordas, 2009). Mn concentration levels observed in this study were within sufficiency range. Besides, Anderson and Boswell (1968) and Joham et al. (1967) reported that Mn content of cotton leaf tissues grown in sand was between 14-2000 mg kg^{-1} and above or below this range of Mg concentrations should be interpreted as deficiency or toxicity levels. Ahmed et al. (2008) found that different B rates decreased Ca, Mg, Mn, Zn and Fe contents of leaf tissues of cotton while they increased B, P, K and Cu concentrations significantly. Ahmed et al. (2011), reported that N, P, K, Cu, Fe Zn, and B constitution of cotton increased depending on different levels of B. However, Ca, Mg, and Mn concentrations of different parts of the cotton decreased. Turan et al. (2010) observed that application at 0, 1, 3 and 9 kg B ha^{-1} increased N, P, K, Mg, Fe and Mn concentrations of lucerne while it decreased Ca, Zn, and Cu concentrations. Razmjoo and Henderlong (1997) observed no important P, Ca, Mg content increase after S, K, B and Mo fertilization in alfalfa (*Medicago sativa* L.). Moreover, S application increased K content of alfalfa while B treatment did not change K levels significantly. Aires et al. (2007) suggested that S fertilization along with N significantly increased the uptake of N, S, K, Ca, Mg, Na, Cl and Si in broccoli sprouts

(*Brassica oleracea* var. *italica*). Salvagiotti et al. (2009) reported that the effect of S treatment on N uptake in wheat depended on the highest rate of N fertilizer. This can be explained by the interaction between S and N fertilizers Jamal et al. (2010) suggested that inadequate S fertilizer affects N metabolism negatively and vice versa. Rahman et al. (2011) observed that the application S at 5 t ha^{-1} together with N at 0.34 t ha^{-1} in maize (*Zea mays*) increased uptake of Fe, Mn and Zn in calcareous soil. Mamatha (2007) reported that application of 25 kg ha^{-1} Zn, S and Zn fertilizer in cotton resulted in highest uptake of N, P, K, S, Fe and Zn nutrients in clay soil.

CONCLUSIONS

Overall, 5 and 15 mg kg^{-1} of B treatments with and without sulphur did not cause any visible toxic symptoms in cotton. Therefore, toxic levels of B for clay soils with high Ca content should be determined. Also, a special caution should be taken for cotton cultivation in soils having insufficient Ca, S, Mg and Mo as regards B and S fertilizers.

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REFERENCES

Ahmed N., Ahmed W., Zia M.H., Malhi S.S., 2013. Relationship of soil extractable and fertilizer boron to some soil properties, crop yields, and total boron in cotton and wheat plants on selected soils of Punjab. Pakistan Journal of Plant Nutrition 36, 343-356.

Ahmed N., Abid M., Ahmad F., 2008. Boron Toxicity in Irrigated Cotton (*Gossypium hirsitum* L.*)*. Pak. J. Bot. 40(6): 2443-2452.

Ahmed N., Abid M., Ahmad F., Amanullah M., Javaid Q., Ali M. A., 2011. Impact of Boron Fertilization on Dry Matter Production And Mineral Constituent of Irrigated Cotton. Pak. J. Bot. 43(6): 2903-2910.

Aires A., Rosa E., Carvalho R., Haneklaus S., Schung E., 2007. Influence of Nitrogen and Sulfur Fertilization on the Mineral Composition of Broccoli Sprouts. Journal of Plant Nutrition. 30: 1035–1046.

Anderson O., Boswell F.C., 1968. Boron and Manganese Effects on Cotton Yield, Lint Quality, and Earliness of Harvest. Agronomy Journal. Vol. 60.

Berger K. C., Truog E., 1944. Boron Test and Determination for Soils and Plants. Soil Sci. 57:25–36.

Bogiani J. C., Sampaio T. F., Abreu-Junior C. H., Rosolem C.A., 2014. Boron Uptake and Translocation in Some Cotton Cultivars. Plant Soil. 375:241–253.

Dible W. T., Truog E., Berger K.C., 1954. Boron Determination in Soils and Plants. Simplified Curcumin Procedure. Anal. Chem. 26: 418–421.

Dordas C., 2009. Foliar application of manganese increases seed yield and improves seed quality of cotton grown on calcereous soils. Journal of Plant Nutrition. 32:1, 160-176.

Fox R. L., Olson R.A., Rhoades H.F., 1964. Evaluating the Sulfur Status of Soils by Plants and Soil Tests. Soil Sci. Soc. Am. Proc. 28: 243-246.

Goldberg S., 1997. Reactions of Boron with Soils (Chapter 3). Plant and Soil. 193: 35–48, 1997. 35.

Goldberg S., Forster H., 1991. Boron Sorption on Calcareous Soils and Reference Calcites. Soil Science. Vol: 152, No:4, 304-310.

Goldberg S., Corwin D.L., Shouse P.J., Suarez D. L., 2005. Prediction of Boron Adsorption by Field Samples of Diverse Textures. Soil Sci. Soc. Am. J. 69:1379–1388.

Goldberg S., Forster H.S., Heick E.L., 1993. Temperature Effects of Boron Adsorption by Reference Minerals and Soils. Soil Science. Vol: 156, No: 5, 316-321.

Halvin J.L., Soltanpour P.N., 1980. A Nitric Acid Plant Tissue Digest Method for Use With Inductivelycoupled Plasma Spectrometry. Com. Soil Sci. and Plant Anal. 11:969-80.

Harter R., 1991. Function of Micronutrients in Plants (Chapter 3). Micronutrients in Agriculture. 2nd ed.-SSSA Book Series, No: 4.

Herrera-Rodriguez H.M.B., Fontes A.G., Rexach J., Camacho-Cristobal J.J., Maldo J.M., Navarro-Goechicoa M.T., 2010. Role of Boron in Vascular Plants and Response Mechanisms to Boron Stresses. Plant Stress. (Spesical Issue 2), 115-122.

Hu H., Brown P.H., 1997. Absorption of boron by plant roots. Plant and Soil 193: 49–58.

Jamal A., Moon Y., Abdin M.Z., 2010. Sulphur -a General Overview and Interaction with Nitrogen. Australian Journal of Crop Science. 4(7), 523-529.

Joham H., 1953. Accumulation and Distribution of Molybdenum in the Cotton Plant. Plant Physiol. 1953 Apr; 28(2): 275–280.

Joham H., 1967. The influence of foliar and substrate application of manganese on cotton. Plant and Soil. Vol. 26, No. 2, pp. 369-379.

Karabal E., Yücel M., Öktem H.A., 2003. Antioxidant Responses of Tolerant and Sensitive Barley Cultivars to Boron Toxicity. Plant Science. 164:925-933.

Keren R., Bingham F. T., Rhoades J. D., 1985. Plant Uptake of Boron as Affected by Boron Distribution Between Liquid and Solid Phases in Soil. Soil Sci. Soc. Am. J. 49:297–302.

Kopáček J., Hejzlar J., Porcal P., Posch M., 2014. Sulphate Leaching from Diffuse Agricultural and Forest Sources in a Large Central European Catchment During 1900–2010. Science of the Total Environment. 470–471:543–50.

Kord M., Derakhshan L., Memarian H., Tajabadipour A., 2010. Effects of high boron concentration on boron uptake and growth of pistachio Seedlings.19th World Congress of Soil Science, Soil Solutions for a Changing World

Majidi A., Rahnemaje R., Hassani A., Malakouti M.J., 2010. Adsorption and Desorption Processes of Boron in Calcareous Soils. Chemosphere. 80 (2010) 733–739.

Mamatha N., 2007. Effect of Sulphur and Micronutrients (Iron and Zinc) on Yield and Quality of Cotton in a Vertisol. Master of Science (Agriculture), College of Agriculture, Dharwad University of Agricultural Sciences, India.

Mitchell C., Baker W., 2000. Cotton. Editör: Campbell, C., R., Reference sufficiency ranges for plant analysis in the southern region of the United States, Southern Cooperative Series Bulletin, 15-19, No: 394, Raleigh, N. C., USA.

Nable R.O., Banuelos G., Paull J.G., 1997. Boron Toxicity. Plant and Soil. 193: 181–198.

Rahman M.M., Soaud A.A., Al Darwish F.H., Sofian-Azirun M., 2011. Responses of Sulfur, Nitrogen and Irrigation Water on Zea Mays Growth and Nutrients Uptake. Australian Journal of Crop Science (AJCS). 5(3):350-360.

Razmjoo K., Henderlong P.R., 1997. Effect of Potassium, Sulfur, Boron, and Molybdenum Fertilization on Alfalfa Production and Herbage Macronutrient Contents. Journal of Plant Nutrition, 20:12, 1681-1696.

Römheld V., Marschner H., 1991. Function of Micronutrients in Plants (Chapter 9). Micronutrients in Agriculture, 2nd ed.-SSSA Book Series, No:4.

Ryan J., Estfan G., Rashid A. 2001. Soil and Plant Analysis Laboratory Manual. Aleppo, Syria: ICARDA.

Salvagiotti F., Castellarin J.M., Miralles D.J., Hugo M.P., 2009. Sulfur Fertilization Improves Nitrogen Use Efficiency in Wheat by Increasing Nitrogen Uptake. Field Crops Research. 113:170–177.

Schaff B.E., Skogley E.O., 1982. Diffusion of Potassium, Calcium and Magnesium in Bozeman Silt Loam as Influenced by Temperature and Moisture. Soil Science Society of America Journal. Vol: 46, No:3, 521-524.

Singaram P., Prabha K., 1997. Calcium boron interaction studies in tomato grown in a calcareous soil Plant Nutrition for Sustainable Food Production and Environment Volume 78 of the series Developments in Plant and Soil Sciences pp 649-650 Proceedings of the XIII International Plant Nutrition Colloquium, 13–19 September 1997, Tokyo, Japan.

Tanaka M., Fujiwara T., 2008. Physiological Roles and Transport Mechanisms af Boron: Perspectives from Plants. Eur. J. Physiol. 456: 671–677.

Tariq M., Mote C.J.B., 2007. Calcium-Boron Interactıon in Radısh Plants Grown in Sand Culture Pak. J. Agri. Sci., Vol. 44(1).

Turan M. A., Taban N., Taban S., 2009. Effect of Calcium on the Alleviation of Boron Toxicity and Localization of Boron and Calcium in Cell Wall of Wheat. Notulae Botanicae Horti Agrobotanici. 37-2, 99-103.

Turan M., Ketterings Q.M., Gunes A., Ataoglu N., Esringu A., Bilgili A.V., Huang Y.M., 2010. Boron Fertilization of Mediterranean Aridisols Improves Lucerne (*Medicago sativa* L.) Yields and Quality. Acta Agriculturae Scandinavica, Section B- Soil and Plant Science. 60: 427-436.

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SUGAR BEET LEAF CHARACTREISTICS AND WITE SUGAR CONTENTS CHANGE BY ZINC AND PHOSPHORUS

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Abstract

The aim of current study was to verify the effect of zinc and phosphorus application in soil on leaf characteristics and sugar content in sugar beet root. For this purpose, Sugar beet was grown under field conditions for 2009-2010 cropping season in Arak, Navazen, Iran. The experiment was a completely randomized block design with a factorial arrangement in three replications. Zinc treatment was from two levels of zinc (Z) soil application. Z1 as control and Z2 was 25 kg/ha $ZnSO_4$ as soil application and phosphorus treatment were P1 to P4 with four levels of 125, 250, 375 kg/ha ammonium super phosphate (ASP) and non as control, respectively. In young sugar beet fields, the use of low amounts of ammonium super phosphate will show the best response for zinc interaction. In our experiment at 45 days after sowing date, the sugar beet leaf chlorosise could decrease by 25 kg/ha $ZnSO_4$ as soil application. In all recorded data in 70, 85 and 100 days after sugar beet seed sowing date the number of yellow leaves was decreased when zinc sulfate insert in soils. In addition, phosphorus and zinc interaction had significant effects on petiole water content. Petiole water content is a much related treat to viability of sugar beet leaf and its functions especially in young stage of plant. Petiole RWC at 85 days after planting date has significant changes too. LAI was significant changes when plants were 45 days old.

***Key words**: sugar beet, zinc, phosphorus, leaf, petiole, LAI.*

INTRODUCTION

In most calcareous Iranian soils, the solubility of micronutrients is far less due to high soil pH, low organic material and also water limitation condition (Shirinyan and Ponomarenko, 1981). This kind of chemical and biologic nutrient interaction is the main cause for limiting micronutrient elements uptake by plants (Madani et al., 2014). In sugar beet plants the leaf organs playing important roles in photo-synthesis and assimilation those are very influents on plant growth characteristics and sugar accumulation in roots. The other most important roles of sugar beet leave regard to ability of wide sugar leaf tissues to stay green or yellow.

Root system with a large size in sugar beet plant need to a wide range of macronutrients (Hopkins and Ellsworth, 2003). Phosphorus is one of the impact factors in root yield and sugar assimilation (Salimpour et al., 2010). Root crops needs to simple way to option and accumulate microelements (Alloway, 2008; Khorgamy and Farnia, 2009). Total value of zinc is depending to other chemicals in soil and their interaction. Zinc is in different forms in the soil as water-soluble, exchange, connected to organic matter and stabilized by the secondary clay minerals (Alloway, 2008). Zinc mobility and uptake in soil is dependent on many factors such as soil acidity, zinc total value in the soil, organic matter and soil type (Simms and Smith, 2001; Alloway, 2008). Zinc is essential micronutrients for proteins production in plants. In addition, it seems that soil application of zinc can considerably improve root yield especially in poor soils (Sagardoy et al., 2009). In maize, zinc concentration in roots and shoots were increased by zinc application both in soil and foliar. Regarding the form of application, zinc concentrations in roots and shoots showed a similar trend. The highest zinc doses promoted the maximum zinc concentration in plants both for soil and foliar application (Carolina et al., 2011). Zinc is also essential for plants, and Zn deficiency is a common problem in plants grown in high pH, calcareous soils (Cakmak et al., 1996), whereas in low pH soils Zn availability is generally high (Chaney, 1993). Phosphorus is a component of nucleic acids and lipids and is important in the production and transport of sugars, fat and protein during sugar beet production. Phosphorus is especially important during early root development. A good supply of phosphorus ensures rapid root growth and good uptake of other nutrients. Phosphorus is very immobile in the soil and is only taken up within 1-2 mm from the root.

The objective of the present study was to investigate the effects of soil application of different levels of phosphorus chemical fertilizer and Zinc soil application on total number of leaf formation, no. of active and non active leave and growth, photosynthetic characteristics and water content, leaf area index and white sugar content in sugar beet (*Beta vulgaris* L.).

MATERIALS AND METHODS

A field experiment was conducted during 2010 in the research farms in Arak, Navazen (49° 46´N, 34°06´E and elevation 1710 m above sea level), Iran. The experiment was a factorial arrangement in a completely randomized block design with three replications. Zinc treatment was from two levels of zinc (Z) soil application. Z1 as control and Z2 was 25 kg/ha $ZnSO_4$ as soil application and phosphorus treatment were P1 to P4 with four levels of 125, 250, 375 kg/ha ammonium super phosphate (ASP) and non as control, respectively. The soil zinc and phosphorus content measured according to Black. 1983 (Table 1). Then total needs of fertilizers insert to the soil before planting time.

Table 1. Soil test properties results

Physical properties	0-40 depth (cm)
Soil texture	Clay loam
Clay (%)	42
Silt (%)	39
Fine send (%)	19
Chemical analysis	
Available (K) (mg/1000 g soil)	123
Available (P) (mg/1000 g soil)	5.7
Total nitrogen (mg/1000 g soil)	0.12
Zn (mg/1000 g soil)	2.3
Mn (mg/1000 g soil)	0.2
Cu (mg/1000 g soil)	0.2
Fe (mg/1000 g soil)	1.6
CaCO3 (%)	28
Organic matter (%)	1.1
EC (ds/m/25°C)	0.6
pH	8.0

In this experiment the sugar beet (SBSI005 Crouse cv.) seeds were obtained from the Sugar Beet Research Institute, Karaj. Iran. The field was plowed in autumn 2009 and then was used two cross over disk in spring 2010. The experimental unit area was 18 square meters consisting of six rows (6 m long and 3 m with 50 cm between rows). Seeds were hand sown on June 10^{th} and harvesting time was 10^{th} October 2010 in 2.5×6 m plots with a inter row space of 0.5 m. Nitrogen and potassium fertilizers were added before sowing at a rate of 300 and 200 kg/ha as a form of urea (46% N) in three equal portions and potassium sulfate (50% K_2O), respectively. Thinning operation was done twice. Number of green and yellow leave and trash leaf were measured at 45, 60, 70, 85 and 100 days after sowing date. At harvest time, the petiole water content (PWC), leaf area index (LAI) and white sugar content (WSC) parameters were recorded. The sucrose percentage was determined according to Dutton and Bowler (1984) obtained data were statistically analyzed as factorial experiments in complete randomize design and the treatments means were compared by using Duncan multiple test and 5% of probability.

RESULTS AND DISCUSSIONS

The results presented in Table 2 indicated that green, yellow and trash leaf numbers of sugar beet plants were significantly differed responses to zinc, phosphorus treatments and Z.P interaction. Zinc treatment had not significant effect on change of number of green leaf per plants from 45 to 100 days after planting date. The yellow leaf number in sugar beet was changed by zinc significantly at 45, 70, 85 and 100 days after planting. Number of trash leaf also, had no significant changes from 45 to 85 days after sowing date. Phosphorus treatment could change the number of green leaf at 70 days after sowing date significantly. Number of yellow leaf except for 70 days after sowing date in all other sugar beet stages significantly changed. But number of trash leaf changed in all sugar beet stages significantly except for 60 and 100 days after sowing date. Furthermore, the interaction effects of Z and P treatments in 45 days after sowing date had no effect on number of green leaf. the number of yellow leaf showed significant change from 45 and 70 to 100 days after sowing significantly. Number of dry leaf in case of ZP interaction was significant changes at 85 to 100 days after sowing date. The trash leaf number of sugar beets in 100 days after sowing date increased significantly more by using 250 kg/ha ammonium super phosphate compared to the control treatment but, by zinc application in case of 25 kg/ha $ZnSO_4$ as soil application the number of trash leaf reduced from 2.8 to 1.2 significantly. It showed that zinc application could improve the number of loss leaf in 100 days after sowing date as a good point. Sagardoy et al. (2009) also, reported same trends. Therefore, leaf photosynthesis duration and sugar accumulation could increase by zinc application in calcareous soil. Use of large amount of P (more than 250 kg/ha ammonium super phosphate) in similar soil condition would decrease trash leaf numbers when zinc application was used.

Table 2. Effect of zinc and phosphorus soil application on leaf number of sugar beet

Treatments	Zinc			Phosphorus			Z.P Interaction		
D.F	1			3			3		
Day after planting	No. of leaf			No. of leaf			No. of leaf		
	Green	Yellow	Trash	Green	Yellow	Trash	Green	Yellow	Trash
45	ns	*	n/a	ns	**	n/a	ns	**	n/a
60	ns	ns	ns	ns	ns	*	ns	ns	ns
70	ns	**	ns	*	**	ns	ns	**	ns
85	ns	**	ns	ns	**	ns	ns	**	**
100	ns	*	**	ns	**	**	ns	**	**

ns, *,** = nonsignificant and significant probability level at 5%, respectively

The control treatments for P application also, had same effect on trash leaf numbers too. Thus, zinc application was the most cause for stay greening the leaf and prevention for leaf maturity and dried. Figure 1 will show that in poor soils of P, zinc application has not sharp effect on increase of green leaf age and sugar assimilation duration. In young sugar beet fields, the use of low amounts of ammonium super phosphate will show the best response for zinc interaction. In our experiment at 45 days after sowing date, the leaf chlorosise could decrease by 25 kg/ha $ZnSO_4$ as soil application. In all recorded data in 70, 85 and 100 days after sugar beet seed sowing date the numbers of yellow leaf were decreased when zinc sulphate insert in soils. Simms and Smith (2001) and Dahdoh et al. (1988) reported same results.

Table 3. Effect of zinc and phosphorus soil application on some plant characteristics in sugar beet

Treatments	Zinc			Phosphorus			Z.P Interaction		
D.F	1			3			3		
Day after planting	PWC	LAI	WSC	PWC	LAI	WSC	PWC	LAI	WSC
45	ns	ns	n/a	**	*	N/A	**	**	n/a
60	ns	ns	n/a	ns	**	N/A	ns	Ns	n/a
70	ns	ns	n/a	ns	ns	N/A	ns	Ns	n/a
85	ns	ns	n/a	ns	ns	N/A	**	Ns	n/a
100	ns	ns	n/a	ns	**	N/A	ns	Ns	n/a
Ripening stage	n/a	n/a	ns	n/a	n/a	ns	n/a	n/a	ns

n/a: nonapplicant, ns: nonsignificant, * and **: significant at 5% and 1% validity levels

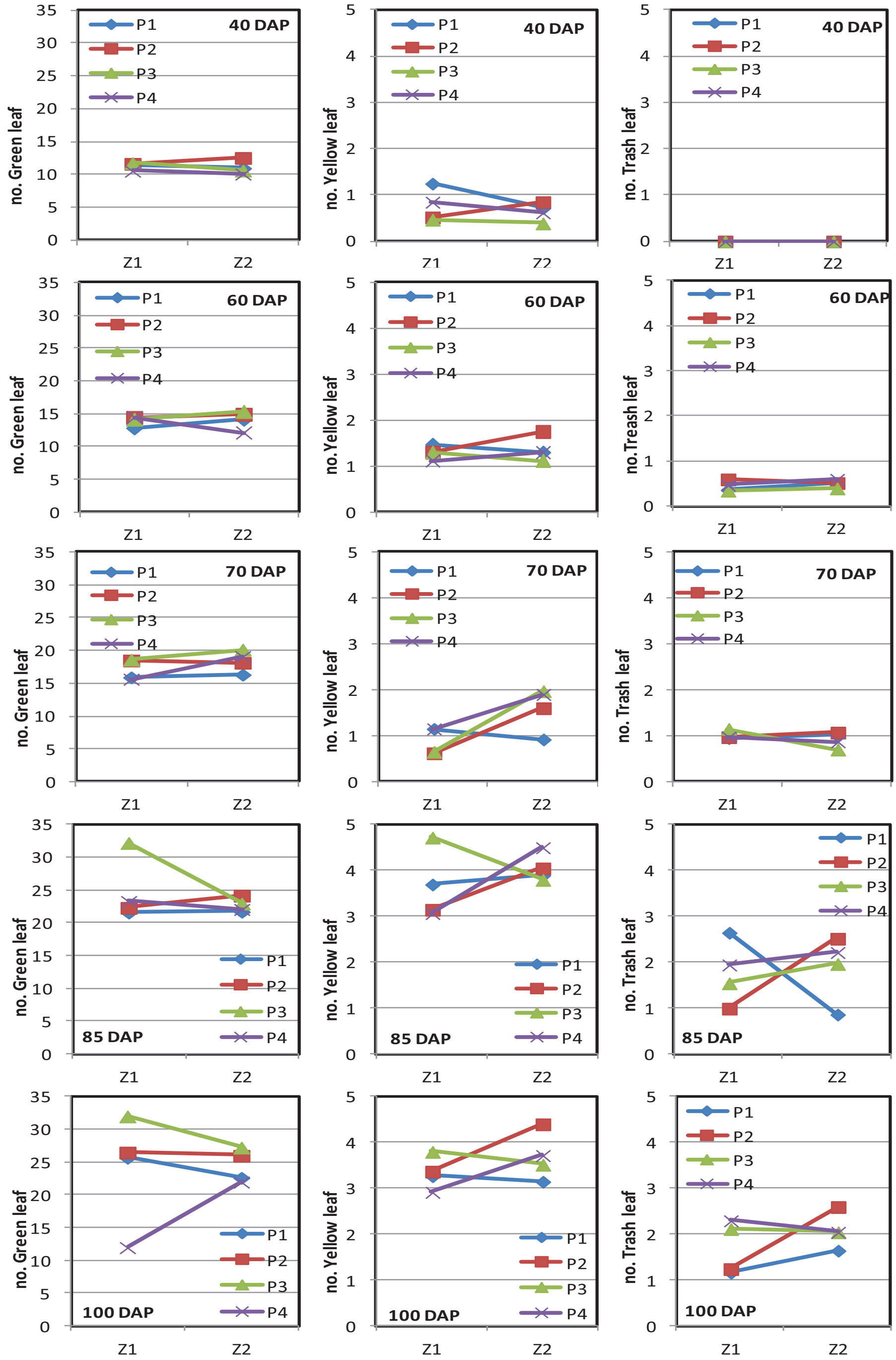

Figure 1. Zinc and phosphorus interaction effects on leaf number of sugar beet. Z1: control and Z2 were 25 kg/ha $ZnSO_4$ as soil application and P1 to P4 were 125, 250, 375 kg/ha ammonium super phosphate (ASP) and control, respectively

CONCLUSIONS

The results presented in Table 3 indicated that zinc effects on petiole water content and leaf area index in sugar beet plant were non significant changed from 45 to 100 days after sowing. Phosphorus effects on petiole water content and leaf area index in sugar beet plant were significant changed in plants with 45 days old. This significant change was stable for leaf area index for 15 days more and 100 days after sowing simultaneously (60 and 100 days old in sugar beet plant). Phosphorus and zinc interaction effects had significant effects on petiole water content as a very related treat to viability of sugar beet leaf and its functions in young stage of plant and also, in 85 days after sowing date. LAI was significant changes when plants were 45 days old. Zinc and phosphorus interaction had nonsignificant effect on white sugar contents compared to the control treatment in sugar beet roots.

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REFERENCES

Alloway B.J., 2008. Zinc in Soils and Crop Nutrition. IZA Publications. International Zinc Association, Brussels.

Black C.A., 1983. Methods of Soil Analysis. Soil Sci. Soc. Am. Inc. Publ. Madison, Wisconsin, USA.

Cakmak I., Yilmaz A., Ekiz H., Torun B., Erenoglu B., Braun H.J., 1996. Zinc deficiency as a critical nutritional problem in wheat production in Central Anatolia. Plant and Soil, 180, 165-172.

Carolina A., Vasconcelos F.D., Williams C., Nascimento A., Fernando F.C.F., 2011. Distribution of zinc in maize plants as a function of soil and foliar Zn supply. International Research Journal of Agricultural Science, 1(1): 001-005.

Chaney R.L., 1993. Zinc phytotoxicity. In: Robson A.D. (Ed.), Zinc in soil and plants. Kluwer Academic Publishers, Dordrecht,the Netherlands: 135-150.

Dahdoh M.S.A., Kamh R.N., El-Kadi M.A., El-Hassanin A.S., 1988. The productivity of sugar beets grown in calcareous soils with regard to Zn, P and K fertilization. Desert Inst Bull, ARE 38(2): 229-237.

Dutton J., Bowler G., 1984. Money is still being wasted on nitrogen fertilizer. British Sugar Beet Review 52, No 4, 75-7.

Hopkins B., Ellsworth J., 2003. Phosphorus nutrition in potato production. Idaho Potato Conference.

Khorgamy A., Farnia A., 2009. Effect of phosphorus and zinc fertilisation on yield and yield components of chick pea cultivars. African Crop Science Conference Proceedings, 9: 205-208.

Madani H., Borji S., Sajedi N.A., 2014. Effect of zinc and phosphorus fertilizers on sugar beet (*Beta vulgaris* cv. SBSI005 Crouse) yield in Iranian high zinc alkaline soil condition. Scientific Papers. Series A. Agronomy, Vol. LVII, ISSN 2285-5827, 240-245.

Sagardoy R., Morales F., López-Millán A.F., Abadía A., Abadía J., 2009. Effects of zinc toxicity on sugar beet (*Beta vulgaris* L.) plants grown in hydroponics. Plant Biology (Stuttg). 11(3): 339-50.

Salimpour S., Khavazi K., Nadian H., Besharati H., Miransari M., 2010. Enhancing phosphorous availability to canola (*Brassica napus* L.) using P solubilizing and sulfur oxidizing bacteria. Australian Journal of Crop Science 4(5): 330-333.

Shirinyan M.K.H., Ponomarenko G.T., 1981. Response of sugar beet to fertilizer application in relation to phosphorus and potassium contents of soil. Agroch 4: 66-70.

Simms A.L., Smith L.J., 2001. Early growth response of sugar beet to fertilizer phosphorus in phosphorus deficient soil of the Red River Valley. J. Sugar beet Res., 38: 1-17.

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UNMASKING GENETIC RELATIONSHIPS AMONG *Corypha umbraculifera* POPULATIONS FROM KARNATAKA IN INDIA USING SIMPLE SEQUENCE REPEAT MARKERS

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Abstract

Corypha umbraculifera L., is a monocarpic, endangered plant and show endemism to India and Sri Lanka. Natural population of this species occurs in semi-wild conditions in Karnataka and Kerala regions of Western Ghats, India and in addition it is found as a cultivated ornamental plant in other parts of India. Simple sequence repeat (SSR) analysis was used to determine the genetic diversity and relatedness among 14 C. umbraculifera populations collected from different locations within Karnataka, India. Among the 10 SSR primer pairs used for the study, 9 could amplify polymorphic SSRs from all the 14 populations. 168 alleles were detected at 22 loci ranging from 1 to 14 alleles, with average score of 7.63 alleles per locus. The statistical analysis of the results revealed that allelic frequency ranged from 7.1% to 100% with a mean of 54.51%. Polymorphism of alleles and genetic diversity measured by polymorphic information content (PIC) revealed that PIC of the loci was ranged from 0.23 to 0.83 with an average value of 0.61. The UPGMA-based clustering analysis showed the genetic similarity index ranged from 0.316-0.917. The similarity coefficients were used as input data for cluster analysis performed by a dendrogram construction utility (DendroUPGMA online server, Garcia-Vallve et al., 1999) and similarity matrix was calculated based on Jaccard index. The dendrogram divided the collected 14 populations into 2 major groups as the first group, i.e. cluster A included 7 populations, viz. Dndi, Manr, Sond, Nari, Bakl, Mtrd and Bltd, whereas cluster B included 7 populations, viz. Yana, Ytgd, Chpi, Honr, Bdag, Uppi and Udne. Thus, results indicated the presence of genetic diversity among the plant samples. These results suggest that SSR markers are efficient for determining genetic diversity and relatedness in C. umbraculifera. The present study endorses further the use of several other molecular marker systems that will help in germplasm characterization of semi-wild populations of C. umbraculifera for further conservation and sustainable utilization.

Key words*: Corypha umbraculifera, genetic diversity, Karnataka, SSR markers, UPGMA Dendrogram.*

INTRODUCTION

Western Ghats is recognized as one of the richest mega biodiversity centres of the world, wherein 30% of the area is covered by forest and considered as richest ecological region. Nearly more than 15,000 plant species have been documented until now, of which more than 4,000 plant species exhibit endemism (Chenniappan and Kadarkarai, 2010). Several tribal communities inhabit in this region because of rich natural diversity and abundance found across Western Ghats (Khan et al., 2008). Several prominent plant species that are medicinally and economically important have been reported from this ecologically sensitive region (Pushpangadan and Atal, 1984).

Palms are the third most economically important plants; they are extensively used as ornamental plants and also for making furniture and thatching material for roof as they are rigid, and exhibit ultimate tensile strength. Palm oil is an important commodity across the globe, which is used for daily cooking as it is known for its health benefits (Johnson, 1996; Renuka, 1992, 1998, 2001). Various palm species are found in their natural habitats that are attractive and represents as a unique niche among the wide diversity of different plant species. Karnataka region of Western Ghats comprises wide distribution of palms with about 21 species belonging to 7 genera. *Corypha umbraculifera* is one among them and is commonly called as centurion palm belonging to *Arecaceae* family that requires moist climate and commonly found across coastal plains, the unique feature of this palm is flower sets once in its lifetime. This palm is endemic to India and Sri Lanka. In India, it is commonly found across coastal regions of Kerala, Karnataka and Maharashtra. Previously it has been reported in Kozhikode, Kottayam and Palakkad districts of

Kerala (Renuka, 1999) and also distributed in forests of North Canara and South Canara districts of Karnataka including *Yana*, *Arebail*, *Udane*, *Naravi* and *Hosmar*. In Karnataka it has limited population and locally called as *Panolimara* or *Pane* (Bhat, 2011). Prehistorically, leaves of *C. umbraculifera* were used as thatching material for constructing houses and the leaves were used as manuscripts because of their distinctive characters such as size, shape, rigidness and greater strength and life. Further it yields a greater amount of starch which is widely utilized for multiple purposes locally (Chandran, 1996). However, according to previous reports, due to urbanization and shear lack of knowledge, this plant faces a serious threat and has been considered as one of the endangered species.

Recent advancement and innovations in molecular biology tools and technologies has enabled the researchers to find the variation within and between the different species of an organism (Robarts and Wolfe, 2014). A molecular marker acts as an enhanced tool for distinguishing variations and genetic distances in a population. Utilization of suitable molecular markers is dependent on DNA polymorphism (Ouborg et al., 1999). Genetic markers are best tools for efficient diversity evaluation and selection. Molecular markers exhibit distinctive properties and these genetic markers as single or two gene loci are not affected by the environment. They are polymorphic, co-dominant, occur repetitively and abundantly in a genome (Morgante et al., 2002). Apart from these inherent properties, they are also considered as best tools as they show better reproducibility, reliability and easy sharing of information between research laboratories.

The microsatellites are popularly known for identification of genetic diversity and relatedness among closely associated individuals. Microsatellite markers are commonly referred as short tandem repeats (STR) or simple sequence repeats (SSR) (Vincent et al., 2016). They are considered to be most efficient molecular markers, because they confer better understanding of population structure there by offering high degree of variability and also favours in the identification of closely linked species (Smith and Devey, 1994). In the present study, we attempted an SSR based molecular analysis in order to evaluate the genetic diversity or relatedness among the 14 semi-wild populations of *C. umbraculifera* collected from different locations of Karnataka, India.

MATERIALS AND METHODS

Plant material

The plant, being an endemic species has a limited distribution range and only available in selected regions. The plant samples were collected from along the Western Ghats area of Karnataka covering Uttara Kannada, Shimoga, Mangalore and Udupi districts. The young leaf samples of *C. umbraculifera* (14 populations) were collected in wild condition from their natural habitats in a zip pouch bags and transported to the laboratory in icebox. Upon arrival to the laboratory the samples were washed in 70% alcohol, blotted with tissue paper, quickly frozen by dipping in liquid nitrogen and stored at -80ºC for further use. The details of plant collection, their accession name and location of collection is given in Table 1.

DNA extraction and quantification

CTAB method was followed for the extraction and isolation of DNA as prescribed by Doyle and Doyle (1987). Several modifications were made to the original protocol in order to suit our experimental conditions. The 2× CTAB lysis buffer was prepared using 2% cetyltrimethylammonium bromide, 100 mM Tris-HCl pH 8.0, 20 mM EDTA pH 8.0, 1.4 M NaCl, 2% β-mercaptoethanol and 2% PVP. About 2 g leaf sample was ground in to fine powder using liquid nitrogen in a mortar and pestle and 8 ml of preheated 2× CTAB lysis buffer at 65ºC to make the paste. The mixture is incubated at 65ºC for 60 min for lysis and lysate was extracted with phenol:chloroform:isoamylalcohol (25:24:1) upon cooling to room temperature. The DNA is precipitated by adding equal quantity of prechilled isopropanol. The DNA pellet is washed in 70% alcohol, air dried, dissolved in $T_{10}E_1$ and stored at −20ºC until further use.

The isolated DNA was profiled using gel electrophoresis unit (Mini Sub System, Bio-Rad, India) and quantified by Nano Drop technique using bioanalyzer (Q3000, Quawell

Technology Inc., San Jose, CA, USA). Gel electrophoresis of the genomic DNA was done with 0.8% agarose gel in 1× TAE buffer using horizontal gel electrophoresis unit. Gel imaging was performed using gel documentation system (Infinity-1000/26M, Vilber Lourmat, France).

SSR primers

A total of ten palm specific SSR markers (Sigma-Aldrich, Bangalore) were selected based on literature and was screened to assess the genetic diversity among the 14 accessions of *C. umbraculifera* considered for this study. SSR primer selection was made based on the reports of Ngoot-Chin et al. (2010) and Noorhariza et al. (2012). SSR analysis was performed following the protocol of Singh et al. (2008) with necessary minor modifications.

PCR amplification

PCR amplification was carried out in a 20 µl reaction volume containing 100ng of genomic DNA, 5 pM of forward primer, 5 pM of reverse primer, 100 µm of dNTP mix, 1× Taq buffer, 1U Taq DNA polymerase and total volume is adjusted using molecular biology grade water. The PCR amplification was performed using Eppendorf MasterCycler Gradient 5331 Thermal Cycler (Germany) under the initial denaturation temperature set at 95°C for 30 sec followed by 40 cycles of denaturation temperature set at 95°C for 15 sec. The annealing temperature was set depending on the standardized annealing temperature of each SSR primer, with common duration of 15 sec for all primers. The extension temperature was set at 68°C for 1 min and the final extension for 5 min temperature was set at 68°C.

Agarose gel electrophoresis

Agarose gels were prepared using 1.5% (for PCR products) dissolved in 1× TAE buffer. 0.6µl of ethidium bromide (10mg/ml) was added to stain bands for better visualization. The PCR products were loaded along with the loading dye bromophenol blue. The PCR amplicons (bands) were visualized using UV transilluminator.

Statistical scoring of amplified fragments

Only those fragments that could be clearly scored were used in the data analysis. Total number of alleles profiled was documented along with the number of alleles per locus, average number of alleles per loci, frequency of alleles and average frequency of alleles. Polymorphism information content (Botstein et al., 1980; Anderson et al., 1993) value calculation was performed as described by Sharma et al. (2009). Each band thus generated was considered as a single unit and the populations were scored for their presence (1) or absence (0) of a band on a gel (Botstein et al., 1980; Anderson et al., 1993) and the cluster analysis was performed. The dendrogram was constructed using a dendrogram construction utility (DendroUPGMA online server, Garcia-Vallve et al., 1999) and similarity matrix was computed with Jaccard index (Tanimoto).

RESULTS AND DISCUSSIONS

The present study was undertaken to evaluate genetic relationship among the 14 accessions of *C. umbraculifera*. Plant samples of *C. umbraculifera* were collected from 14 different geographic locations of Karnataka State in India (Table 1, Figure 1). It is very important to understand the genetic diversity and relatedness of *C. umbraculifera* in order to work on genetic improvement and germplasm conservation of this palm. Thus, in this study, we have made an attempt to unmask the genetic diversity of this plant by using SSR markers. A total of 10 SSR primers that were reported earlier to be specific for palm species, were selected and tested for their ability to generate expected polymorphic SSR bands in collected palm species (Singh et al., 2008; Ngoot-Chin et al., 2010; Noorhariza et al., 2012). The detailed information about the primers used is tabulated in Table 2. Among them 9 primers successfully demonstrated the ability to generate amplicons of expected DNA band sizes. The primers sEg00090, sEg00113, sEg00036, sEg00066, sMo00020, sEg00038, sMo00130, sEg00067 and sMo00154 were able to produce robust and reproducible bands in tested 14 populations of *C. umbraculifera* (Figure 2).

Among the analysed primers, primer sEg00067 amplified highest polymorphic bands as compared with the rest of the primers screened.

Figure 1. *Corypha umbraculifera*. A - young plant; B – habitat; C – leaf; D - fruits

Table 1. List of regions of plant collection and their accession names

Collection site	Accession name
Uppinangadi, Dakshina Kannada	Uppi
Udane, Dakshina Kannada	Udne
Honnavara, Uttar Kannada	Honr
Badabag, Uttar Kannada	Bdag
Yaana, Uttar Kannada	Yana
Yattin gudda, Dharwad	Ytgd
Chipgi, Sirsi, Uttar Kannada	Chpi
Mantraddi, Dakshina Kannada	Mtrd
Beltangadi, Dakshina Kannada	Bltd
Naravi, Dakshina Kannada	Nari
Dandelli, Uttar Kannada	Dndi
Bakkal, Sirsi, Uttar Kannada	Bakl
Sonda, Sirsi, Uttar Kannada	Sond
Mansur, Dharwad	Manr

The above mentioned primers were efficient in amplifying a total of 168 alleles from a total of 22 loci with a range of 01 to 14 alleles and an average of 7.63 alleles per locus. Similar investigation was carried out by Rupp et al. (2009) on sweet corn using SSR markers. Vincent et al. (2016) have also reported the importance of SSR markers is detecting the genetic diversity among *Triticum aestivum* cultivars. In this study, SSR markers proved to be an efficient tool for detecting genetic variation in genotypes of *C. umbraculifera* based on their habitat and regional soil.

In this study, only those fragments that could be clearly scored were used in the statistical data analysis. The statistical analysis of the results revealed that polymorphic frequency of the amplified alleles ranged from 7.1 to 100% with a mean of 54.51%, indicating efficiency of the selected SSR primers. Genetic diversity or relatedness among the 14 populations of *C. umbraculifera* was calculated at each locus for allelic PIC based on allele frequencies at 22 loci amplified among all 14 populations that were analyzed following standardized methods (Botstein et al., 1980; Anderson et al., 1993). According to the prescribed standards, the PIC value must be almost zero (0) if the primer is not demonstrating any allelic variation; however PIC value may be one (1) at the maximum depending upon the allelic variation indicating the diversity of a gene or DNA segment in a gene pool of *C. umbraculifera.* The polymorphism of alleles and genetic diversity revealed that PIC of the loci ranged from 0.23 to 0.83 with a mean of 0.61. Mean PIC value >0.5 indicates the efficiency of selected primer. Thus the primer used in this study demonstrated efficient polymorphism among the related populations of *C. umbraculifera.*

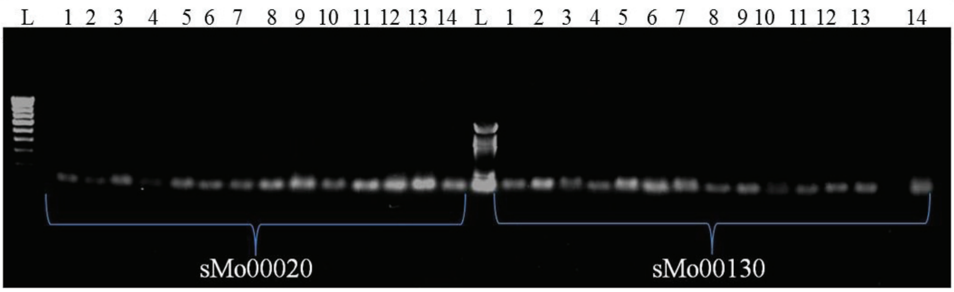

Figure 2. Gel profile showing the amplicons produced by two primers (sMo00020 and sMo00130): 1 – Uppi; 2 – Udne; 3 – Honr; 4 - Bdag; 5 – Yana; 6 – Ytgd; 7 – Chpi; 8 – Mtrd; 9 – Bltd; 10 – Nari; 11 – Dndi; 12 – Bakl; 13 – Sond; 14 - Manr

Table 2. List of SSR primers used for amplification with their SSR motif, number of alleles and annealing temperature

SSR primer	Sequence 5′–3′	SSR motif	Number of alleles	Annealing temperature (°C)
sEg00090	F: TCAGAAATGCCTACATCAAAC R: AGGGACACGAGAATACATACA	(AT)9	1	62.3
sEg00113	F: GTCACCGAACCCTAATAAAAT R: ATGCAGTTGAGGACAAAAAG	(CT)15	1	62.3
sEg00036	F: GGACCCTTTTGTTACTGTTT R: AGCCTACCACAACTTCCTTT	(AG)9	1	62.3
sEg00066	F: ACTGATGCAGGAAAGAGGAA R: GAAGTACACAAGGTAAGTTCATAG	(AT)8	1	65.4
sMo00020	F: CCTTTCTCTCCCTCTCCTTTTG R: CCTCCCTCCCTCTCACCATA	(AG)15	1	60.7
sEg00038	F: ATCAAGCGGCAGTTATGAGAT R: ATACATTATTCCCACCACCA	(AAT)9	6	60.7
sMo00130	F: TAAGCAAAAGATCAGGGCACTC R: GGCTGGTGAAAATAGGTTTACAAAG	(AAG)11	1	60.7
sEg00067	F: GATTAAGTCCCAACCGTCTC R: TAAGAGAGCACGCAGTTCAG	(TGTA)6	2	60.7
sMo00154	F: CAAAAGGGTTGTTTGTATACGTG R: TGCATGAATATCCTCTCAAAGTTAC	(TG)7cgcgcgt gtgcgcgtg(TA)8	4	60.7
sMo00138	F: AGGGTTGTCGCTCCAATTTAT R: GGCATCTTTTTGACCTGTAGAAG	(TTTTC)6	-	66.7

Table 3. The degree of similarity index among 14 populations of *C. umbraculifera*

	Uppi	Udne	Honr	Bdag	Yana	Ytgd	Chpi	Mtrd	Bltd	Nari	Dndi	Bakl	Sond	Manr
Uppi	1	0.909	0.643	0.667	0.625	0.471	0.600	0.571	0.533	0.714	0.714	0.643	0.571	0.533
Udne		1	0.692	0.727	0.667	0.500	0.643	0.615	0.571	0.769	0.769	0.692	0.615	0.571
Honr			1	0.750	0.688	0.625	0.667	0.533	0.500	0.562	0.562	0.500	0.438	0.412
Bdag				1	0.600	0.643	0.692	0.538	0.500	0.571	0.571	0.500	0.429	0.500
Yana					1	0.706	0.750	0.444	0.421	0.556	0.556	0.500	0.444	0.421
Ytgd						1	0.800	0.389	0.368	0.421	0.421	0.368	0.316	0.444
Chpi							1	0.500	0.471	0.529	0.529	0.471	0.412	0.471
Mtrd								1	0.917	0.846	0.714	0.917	0.833	0.643
Bltd									1	0.786	0.786	0.846	0.769	0.714
Nari										1	0.857	0.923	0.846	0.667
Dndi											1	0.786	0.714	0.786
Bakl												1	0.917	0.714
Sond													1	0.643
Manr														1

Based on the generated SSR profiles across all the examined populations, cluster analysis of the genetic diversity was calculated using Jaccard index and unweighted pair group method with arithmatic mean (UPGMA) was used to plot a dendrogram that represented overall genetic diversity among the different populations (Figure 3). The intrapecific genetic similarity indices ranged from 0.316 to 0.917 (Table 3). Further, cluster analysis categorised the total populations into two major groups. Cluster A consists of seven populations, *viz*. Dndi, Manr, Sond, Nari, Bakl, Mtrd and Mltd1, whereas cluster B also comprises seven populations, *viz*. Yana, Ytgd, Chpi, Honr, Bdag, Uppi and Udne. Among the accessions grouped in cluster I, high level of genetic similarity is evident between Dndi (accession from Dandeli) and Manr (Mansur) while the least genetic similarity was recorded between Udne (Udane) and Manr (Mansur). The cluster II consists of seven accessions, of which the Ytgd (Yattin gudda) and Chpi (Chipgi) were more closely related followed by Honr (Honnavara) and Bdag (Badabag). The least genetic similarity was observed between Yana (Yaana) and Udne (Udane), whereas Sond (Sonda) and Yana (Yaana) both from different cluster appear to belong to different lineage. This study revealed the presence of genetic diversity among the populations used for analysis, suggesting that SSR markers are the important tool to assess the genetic diversity and relatedness in *C. umbraculifera* semi wild populations.

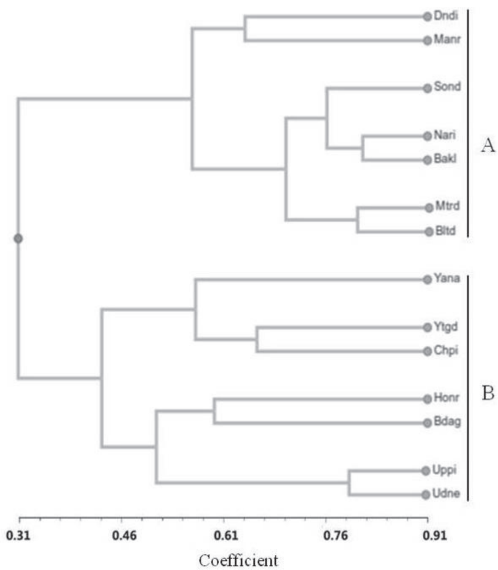

Figure 3. Dendrogram of fourteen *C. umbraculifera* populations constructed using UPGMA cluster analysis based on Jaccard similarity index

CONCLUSIONS

In this study, SSR markers were used to assess the molecular diversity among 14 populations of *C. umbraculifera* collected across different geographic locations. Results observed in the present study reflect the level of polymorphism within the populations and strongly suggest that SSR markers can be solely used to study the genetic polymorphism among the populations because of their high specificity and reproducibility. Despite the use of morphological tools, there are limited reports on molecular phylogeny in relation to the genus *Corypha*. Hence, SSR molecular markers can be efficiently used to evaluate the genetic polymorphism and to establish the conservation strategy for endemic palm species like *C. umbraculifera*.

REFERENCES

Anderson J.A., Churchill G.A., Sutrique J.E., Tanksley S.D., Sorrells M.E., 1993. Optimizing parental selection for genetic linkage maps. Genome, 36:181-186.

Bhat K.G., 2011. Palms of Karnataka. Udupi, India, 1-91.

Botstein D., White R.L., Skolnick M., Davis R.W., 1980. Construction of genetic linkage map in man using restriction fragment length polymorphisms. American Journal of Human Genetics, 32:314-331.

Chandran M.D.S., 1996. Talipot: a forgotten palm of the Western Ghats - a plea for its conservation. Resonance, 1(11):69-75.

Chenniappan K., Kadarkarai M., 2010. *In vitro* antimalarial activity of traditionally used Western Ghats plants from India and their interactions with chloroquine against chloroquine-resistant *Plasmodium falciparum*. Parasitology Research, 107(6):1351-1364.

Daniel W.H.R., Andrea D.W., 2014. Sequence-related amplified polymorphism (SRAP) markers: a potential resource for studies in plant molecular biology. Applications in Plant Sciences, 2(7):1400017, doi:10.3732/apps.1400017.

Doyle J.J., Doyle J.L., 1987. A rapid isolation procedure for small quantities of fresh leaf tissue. Phytochem. Bull., 19:11-15.

Garcia-Vallve S., Palau J., Romeu A., 1999. Horizontal gene transfer in glycosyl hydrolases inferred from codon usage in *Escherichia coli* and *Bacillus subtilis*. Mol. Biol. Evol., 16(9):1125-1134.

Johnson, D.V., 1996. Palms: their conservation and sustained utilization. IUCN, Gland, Switzerland.

Khan, M.L., Khumbongmayum A.D., Tripathi R.S., 2008. The sacred groves and their significance in conserving biodiversity: an overview. International Journal of Ecology and Environmental Sciences, 34:277-291.

Morgante M., Hanafey M., Powell W., 2002. Microsatellites are preferentially associated with nonrepetitive DNA in plant genome. Nature Genet., 30:194-200.

Ngoot-Chin T., Noorhariza M.Z., Rozana R., Eng-Ti L.L., Maizura I., Suan-Choo C., Soon-Guan T., Rajinder S., 2010. SSR mining in oil palm EST

database: application in oil palm germplasm diversity studies. Journal of Genetics, 89(2):135-145.
Noorhariza M.Z., Rajinder S., Rozana R., Ismanizan I., 2012. *Elaeis oleifera* genomic-SSR markers: exploitation in oil palm germplasm diversity and cross-amplification in Arecaceae. International Journal of Molecular Sciences, 13:4069-4088.
Ouborg N.J., Piquot Y., Van-Groenendael J.M., 1999. Population genetics, molecular markers and the study of dispersal in plants. Journal of Ecology, 87(4):551-568.
Pushpangadan P., Atal C.K., 1984. Ethno-medico-botanical investigations in Kerala I - some primitive tribals of Western Ghats and their herbal medicine. Journal of Ethnopharmacology, 11(1):59-77.
Renuka C., 1992. Rattans of Western Ghats, a taxonomic manual. Kerala Forest Research Institute, Peechi, India.
Renuka C., 1996. Palm resources of Kerala and their utilization. Kerala Forest Research Institute, Peechi, Kerala. India.
Renuka C., 1998. Palm resources of Kerala, their distribution and conservation. Journal of Tropical Forests, 14(3):167-172.
Renuka C., 1999. Indian rattan distribution – an update. Indian Forester, 125(6):591-598.
Renuka C., 2001. Palms of India: status, threats and conservation strategies. In: Shanker R.U., Ganeshaiah K.N., Bawa K.S. (Eds.), Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India, 197-209.
Robarts D.W.H., Wolfe A.D., 2014. Sequence-related amplified polymorphism (SRAP) markers: a potential resource for studies in plant molecular biology. Appl. Plant Sci., 2(7):1-13.
Rupp J.V., Mangolin C.A., Scapim C.A., Pires da Silva Machado M.F., 2009. Genetic structure and diversity among sweet corn (*su1*-germplasm) progenies using SSR markers. Maydica 54:125-132.
Sharma M.V., Kantartzi S.K., Stewart J.M., 2009. Molecular diversity and polymorphism information content of selected *Gossypium hirsutum* accessions. AAES Research Series, 582:124-127.
Singh, R., Noorhariza M.Z., Ting N.C., Rozana R., Tan S.G., Low L.E.T., Ithnin M., Cheah S.C., 2008. Exploiting an oil palm EST the development of gene-derived and their exploitation for assessment of genetic diversity. Biologia, 63:1-9.
Smith D.N., Devey M.E., 1994. Occurrence and inheritance of microsatellites in *Pinus radia.* Genome, 37(6):977-983.
Vincent M.M., Xiuli T., Eric C., 2016. Assessment of genetic diversity among sixty bread wheat (*Triticum aestivum*) cultivars using microsatellite markers. African Journal of Biotechnology, 15(21):960-973.

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OPPORTUNITIES FOR SINGLE AND COMBINE APPLICATION OF HERBICIDES AT WINTER WHEAT

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Abstract

A field trial with winter wheat (Triticum aestivum L.), variety "Enola" was conducted in 2015. The trial was state don the experimental field of the Dobroudja Agricultural Institute, General Toshevo, Bulgaria.
The study was performed by the randomized block designin 4 replications. Theaim of the study was to establish the opportunities for singleand combine application of herbicides for weed management at winter wheat. The efficacy of the following 6 herbicides applied alone and in combinations was evaluated: Derby Super (150.2 g/kg florasulam + 300.5 g/kg aminopyralid-potassium), Secator OD (100 g/l amidosulphuron + 25 g/l iodosulfuron + 250 g/l mefenpyr-diethyl), Maton 600 EC (600 g/l 2.4 D ester), Pallas 75 WG (75 g/kg pyroxsulam), Hussar Max OD (7.5 g/l mezosulfuron + 7.5 g/l iodosulfuron + 22.5 g/l mefenpyr-diethyl) and Puma Super 7.5 EW (69 g/l fenoxaprop-p-ethyl + antidot). The herbicides were applied in the spring at phenophase end of tillering – beginning of spindling of the winter wheat (BBCH 29-31). The efficacy of the studied products was recorded by the 10 score visual scale of EWRS (European Weed Research Society). The obtained results were compared with un treated control. The selectivity of the single and combine application of herbicides against the wheat was established by the 9 score scale for phytotoxicity of EWRS. At the particular weed infestation the highest herbicide efficacy and the highest yield (5.78 t.ha^{-1}) were recorded at the variant with combine application of Pallas 75 WG + Derby Super.

Key words: *winter wheat, weed management, herbicides, selectivity, efficacy*.

INTRODUCTION

The effective weed control at winter field crops is a main part of successful and profitable agriculture production. The weeds concur the crops for water, nutrients and light that lead to yield decrease (Brookeand McMaster, 2016). The high weed infestation at winter wheat (*Triticum aestivum* L.) can decrease the yields up to 70% (Tonev et al., 2007; Tonev et al., 2011). In dependence of the crop management and the climatic conditions, the different weed species can bein different density and are forming different weed associations (Dimitrov et al., 2016). In modern agriculture the weed control is performed mainly by chemical means. The choice of proper herbicide, optimal time and rate of application are one of the most important and responsible moments for the winter wheat agrotechnique (Sherawatand, 2005). To solve the problem of weed infestation at winter wheat large numbers of trials are conducted. After the application of the herbicide combination Derby Super (150 g/kg florasulam + 300.5 g/kg aminopyralid-potassium (33 g ha^{-1}) + Puma Super (69 g/l fenoxaprop-p-ethyl) (1000 ml ha^{-1}) 90% of the broad leaf and 83.3% of the grass weeds were controlled, and for the concrete variant the highest yield was achieved 5.568 t ha^{-1} (Delibaltova et al., 2009). Semenovetal (2009) established that the biggest part of the resistant dicotyledonous weeds at winter wheat and barley are controlled by the herbicide products Logran (riasulfuron), Magnum (prosulfuron) and Secator (amidosulfuron + iodosulfuron). For control of *Descurainiasophia, Capsella bursa-pastoris and Galiumaparine* in wheat the herbicides fluroxypyr + carfentrazone-ethyl, florasulam+carfentrazone-ethylcan be applied (Wang et al., 2016).
The aim of the study was to establish the opportunities for single and combine application of herbicides at winter wheat.

MATERIALS AND METHODS

In 2015 a field trail with the winter wheat variety "Enola" was conducted. The trial was stated on the experimental field of the Dobroudja Agriculture Institute, General Toshevo, Bulgaria.

The efficacy of the following six herbicides applied alone and in combinations was evaluated: DerbySuper WG (150.2 g/kg florasulam + 300.5 g/kg aminopyralid), Secator OD (100 g/l amidosulphuron + 25 g/l iodosulfuron + 250 g/l mefenpyr-diethyl), Maton 600 EC (600 g/l 2.4 D ester), Pallas 75 WG (75 g/kg pyroxsulam), HussarMax OD (7.5 g/l mezosulfuron + 7.5 g/l iodosulfuron + 22.5 g/l mefenpyr-diethyl) and PumaSuper 7.5 EW (69 g/lfenoxaprop-p-ethyl + antidot). The study was performed by the randomized block design in 4 replications. The size of the harvesting plots was 25 m². On the trial field six typical weed specimens were recorded: common poppy (*Papaver rhoeas* L.), corn chamomile (*Anthemis arvensis* L.), charlock-mustard (*Sinapis arvensis* L.), creepingthistle (*Cirsium arvense* L.), wild oat (*Avena fatua* L.) and bromes (*Bromus arvensis* L.).

Table 1. Variants of the trial

1. Derby Super WG - 33 g ha^{-1}
2. Secator OD– 100mlha^{-1}
3. Maton600 EK– 1500ml ha^{-1}
4. Pallas 75 WG – 250g ha^{-1}
5. Hussar Max OD - 1000 ml ha^{-1}
6. Puma Super 7.5 EW – 1000ml ha^{-1}
7. Pallas 75 WG + Maton 600 EK - 250 g ha^{-1} + 1500 ml ha^{-1}
8. Pallas 75 WG + Derby Super WG- 250g ha^{-1} + 33 g ha^{-1}
9. Secator OD + Puma Super 7,5 EW - 100ml ha^{-1} + 1000ml ha^{-1}
10. Untreted control

The studied herbicide products were applied at the registered rates in Bulgaria. The applications were done in spring at phenophase of the crop tillering-beginning of spindling - BBCH 29-31. The spray solution was 300 l ha^{-1}. The herbicide efficacy was reported three times during the vegetation - on 14^{th}, 28^{th} and 56^{th} day after treatments. For evaluating of the efficacy the 10 score scale of EWRS (European Weed research Society) was used. For evaluation of the selectivity of the products the 9 score scale for phytotoxicity of EWRS was used (at score 0 - there is not damage on the crop, andat score 9 the crop is totally destroyed). The obtained data was compared with untreated control. The grain yield was recorded by harvesting the whole plot from each variant. After harvesting the four plots the grain yields were recalculated to yields per hectare.

RESULTS AND DISCUSSIONS

The average density of the existing weeds on the experimental field was as follows: common poppy - 4, corn chamomile - 4; charlock-mustard - 8; creeping thistle - 4; wild oat - 5 and bromes 10 specimens per 1 m^2.

On table 2 is shown the efficacy of the studied herbicides against the common poppy (*P. rhoeas*). The weed was very successfully controlled by the herbicide products Derby Super WG, Secator OD and Hussar Max. From the 14^{th} day after treatments to the end of the vegetation, the efficacy of these herbicides was 100%. The efficacy of the product Maton 600 EK was with low efficacy (50%). The most unsatisfactory efficacy (from 20 to 40%) against the poppy was recorded after the treatment with Pallas 75 WG. Puma Super showed 0% efficacy, because the mode of action of the active substance (fenoxaprop-p-ethyl) is only against the grass weeds. The efficacy of the combine application of Pallas 75 WG + Maton 600 EK was even lower than the results recorded after the alone application of the both products. This was probably due to antagonism of the active substancec of the herbicide products (pyroxsulam + 2.4 D ester). For the combinations of Pallas 75 WG + Derby Super and Secator OD + Puma Super there was a synergism observed and the efficacy was 100%.

The herbicide products Derby Super WG, Secator OD and Hussar Max showed 100% efficacy against corn chamomile (*A.arvensis*) at the three dates of reporting (Table 3). A lot of studies have been performed for establishing the efficacy of different herbicides against the broadleaf weeds. The results showed high efficacy of amidosulfuron + iodosulfuron (Secator 6.25 WG; Secator andSekator Progress) against the corn chamomile and other broadleaf weeds (Adamczewski and Miklaszewska, 2001; Sorokaand Soroka, 2003; Vilau, 2010).In our study, after the treatments with Maton600 EK unsatisfactory efficacy against the corn chamomile was recorded. That was due to resistance of the weed to the active substance of the herbicide product. Puma Super

7.5 EW has grass weed control spectrum that was the reason for the 0% efficacy for this variant. At the combine application of Pallas 75 WG + Maton 600 EK the efficacy against the corn chamomile decreasedto 70 – 75%. This indicates that the active substances of the herbicide products (piroksulam and 2.4 D) should not be combined because of the observed antagonism. At the variant with combine usage ofPallas 75 WG + Derby Super WG and Secator OD + Puma Super 7.5 EW 100% efficacy was recorded (Table 4). These combinations should not be performed, because if on the field the control is only against this weed, the cost of production will be increased rapidly.

In our trial conditions, secondary infestation with corn chamomile was not observed. This was probably due to the fact that winter wheat hadvery competitive abilities with the weed at time of phenophases spindling and ear formation. That led tolimitedliving space for a new germination of the weed.

The lowest efficacy from all evaluated herbicides was observed for the root sprouting weed creeping thistle (*C. arvense*). After the treatment with Pallas 75 WG the efficacy against the weed varied from 75 to 80%, but on the last reporting date, secondary growth of the thistle was recorded (Table 5). For the alone application of Derby Super WG and Secator OD sustainable efficacy against the creeping thistle was reported - from 85 to 90% on the 14th and 100% on the 28th day after treatments. On the 56th day the efficacy was decreased with 10%. The efficacy of Hussar Max ODwas 85%. The lowest efficacy against the weed was recorded for the variant treated with Maton 600 EK65 - 70%. For this variant the secondary growth was 30-35%. At the combine usage of Pallas 75 WG + Maton 600 EK the efficacy was decreased to 55 - 60%. After the combination of Pallas 75 WG + Derby Super WG, the active substances were synergetic and were very effective for the control of this root sprouting weed - to 100%. The efficacy of the combination of Secator OD + Puma Super 7.5 EW was also excellent – 100%.

Against the wild oat (*A. fatua*) was not observed efficacy of the herbicide products Derby Super WG, Secator OD and Maton 600 EK. On Table 6 is shown that the herbicide products Pallas 75 WG and Hussar Max OD, that have mixed mode of action, had approximately equal efficacy against this grass weed. The efficacy of both products was sharply decreased when the weed started phenophase spindling. In a trial conducted by Aslam et al. (2007) the efficacy of Puma Super had 80% efficacy against the grass weeds. In our experiment Puma super showed excellent efficacy against the weed 90-100%. After combining Pallas 75 WG with Maton 600 EK unsatisfactory efficacy was reported.

Pallas 75 WG was the most efficient against the bromes (B.arvensis) - 100% (Table 7). Hussar Max OD showed very low efficacy - 40 – 60%. Derby Super WG, Secator OD, Maton 600 EKand Puma Super 7.5 EW had 0% efficacy against this weed. The tank mixture of Pallas 75 WG + DerbySuper WG showed excellent 100% efficacy against the bromes.

On Table 8 are shown the winter wheat grain yields. Because of the concurrent relationship of the crop plants with the weeds, the yields from the untreated control (2.34 t ha^{-1}) and the variant treated only with Puma Super 7.5 EW (2.33t ha^{-1}) were the lowest. By degree of statistical provement 5 treatment groups were formed (a,b,c,d,e). It was recorded that the treatment with Pallas 75 WG + Derby Super WG was from group (e) and had the highest yields in the study - 5.78t ha^{-1}. The yield from the variants treated Derby Super WG and Secator OD were lower. After the treatments with Maton 600 EK alone or in combination the yields were more decreased.

Table 2. Efficacy (%) of the studied herbicides against the common poppy (*P. rhoeas*)

Treatments	Days after treatments		
	14 day	28 day	56 day
Derby Super WG	100	100	100
Secator OD	100	100	100
Maton 600 EK	50	50	45
Pallas 75 WG	20	30	40
Hussar MaxOD	100	100	100
Puma Super 7.5 EW	0	0	0
Pallas 75 WG + Maton 600 EK	20	25	25
Pallas 75 WG + Derby Super WG	100	100	100
Secator OD + Puma Super 7.5 EW	100	100	100

Table 3. Efficacy (%) of the studied herbicides against the corn chamomile (*A. arvensis*)

Treatments	Days after treatments		
	14 day	28 day	56day
Derby Super WG	100	100	100
Secator OD	100	100	100
Maton 600 EK	40	35	30
Pallas 75 WG	100	100	100
Hussar Max OD	100	100	100
Puma Super 7.5 EW	0	0	0
Pallas 75 WG + Maton 600 EK	70	70	75
Pallas 75 WG + Derby Super WG	100	100	100
Secator OD + Puma Super 7.5 EW	100	100	100

Table 4. Efficacy (%) of the studied herbicides against the charlock mustard (*S. arvensis*)

Treatments	Days after treatments		
	14 day	28day	56day
Derby Super WG	100	100	100
Secator OD	100	100	100
Maton 600 EK	100	100	100
Pallas 75 WG	100	100	100
Hussar Max OD	100	100	100
Puma Super 7.5 EW	0	0	0
Pallas 75 WG + Maton 600 EK	80	80	85
Pallas 75 WG + Derby Super WG	100	100	100
Secator OD + Puma Super 7.5 EW	100	100	100

Table 5. Efficacy (%) of the studied herbicides against the creeping thitle (*C. arvense*)

Treatments	Days after treatments		
	14 day	28day	56day
Derby Super WG	85	100	90
Secator OD	85	100	90
Maton 600 EK	70	70	65
Pallas 75 WG	75	80	75
Hussar Max OD	90	85	85
Puma Super 7.5 EW	0	0	0
Pallas 75 WG + Maton 600 EK	55	60	60
Pallas 75 WG + Derby Super WG	100	100	100
Secator OD + Puma Super 7.5 EW	100	100	100

Table 6. Efficacy (%) of the studied herbicides against the wild oat (*A. fatua*)

Treatments	Days after treatments		
	14 day	28day	56day
Derby Super WG	0	0	0
Secator OD	0	0	0
Maton 600 EK	0	0	0
Pallas 75 WG	80	100	100
Hussar Max OD	85	90	100
Puma Super 7.5 EW	90	95	100
Pallas 75 WG + Maton 600 EK	70	70	70
Pallas 75 WG + Derby Super WG	100	100	100
Secator OD + Puma Super 7.5 EW	100	100	100

Table 7. Efficacy (%) of the studied herbicides against the bromes (*B.arvensis*)

Treatments	Days after treatments		
	14 day	28 day	56day
Derby Super WG	0	0	0
Secator OD	0	0	0
Maton 600 EK	0	0	0
Pallas 75 WG	100	100	100
Hussar Max OD	40	60	60
Puma Super 7.5 EW	0	0	0
Pallas 75 WG + Maton 600 EK	65	70	70
Pallas 75 WG + Derby Super WG	100	100	100
Secator OD + Puma Super 7.5 EW	0	0	0

Table 8. Winter wheat grain yield, t ha^{-1}

Treatments	Yields	ByDuncan
Derby Super WG	4,90*	c
Secator OD	4,90*	c
Maton 600 EK	3.55*	b
Pallas 75 WG	5.22*	d
Hussar Max OD	5.20*	d
Puma Super 7.5 EW	2.33	a
Pallas 75 WG + Maton 600 EK	3.56*	b
Pallas 75 WG + Derby Super WG	5.78*	e
Secator OD + Puma Super 7.5 EW	5.22*	d
Untreated control	2.34	a

All variants with star (*) do not have considerable difference with the untreated control.

CONCLUSIONS

Hussar Max OD prevailed Pallas 75 WG with the efficacy against the common poppy. Pallas 75 WG was more efficient for control of the bromes.

Derby Super WG and Sec OD showed higher efficacy against the common poppy, corn chamomile and creeping thistle.

The herbicide product Puma Super 7.5 EW had efficacy only against the wild oat. That was the reason for the lowest grain yields among the all treated variants of the trail - 2.33 t ha^{-1}. The grain yield of this variant was even lower from the yield of the untreated control - 2.34 t ha^{-1}.

After the application of the herbicide products that control both grass and broadleaf weeds – Pallas 75 WG and Hussar Max WG, the grain yields were higher in comparison with the applied herbicide products that control only broadleaf weeds – Derby Super WG, Secator OD and Maton 600 EK.

The highest grain yield in the study was recorded after the combine application of Pallas

75 WG + Derby Super WG – 5.78 t ha^{-1}, followed by Secator OD + Puma Super 7.5 EW – 5.22 t ha^{-1}).

After the combine treatment of the products Pallas 75 WG + Maton 600 EK the obtained grain yield (3.55 t ha^{-1}) which was 32% lower in comparison with the yield of the variant treated only with Pallas 75 WG (5.22 t ha^{-1}).

REFERENCES

Aslam M., Hussain M., Hussain G., Rashid A., 2007. Efficacy of Herbicides for Weed Control in Wheat crop. Pak. J. Weed Sci. Res. 13 (1-2). p. 1-7.

Adamczewski K., Miklaszewska K., 2001. Evaluation of iodosulfuron and amidosulfuron mixture to control broad-leaved weeds in winter and spring cereals. Journal of Plant Protection Research 41 (2) Poznan: InstytutOchronyRoślin (Institute of Plant Protection), 101-108.

Brooke G., McMaster C., 2016. Weed control in winter crops. NSW DPI Management Guide. 132 pp. http://www.dpi.nsw.gov.au.

Delibaltova V., Zheljazkov I., Tonev T., 2009. Effect of some herbicides on the weeds and productivity of the *Triticum aestivum* L., winter wheat. Agricultural Sciences, Volume I, Issue 2, pp. 19-24.

Dimitrov Ya., Dimitrova M., Palagacheva Ne., Vitanova M., Yordanova Ne., Minev N., 2016. Wheat and Barley. Pests, Diseases, Weeds, Fertilization. Academic Publisher: Videnov and Son. 172 pp (In Bulgarian).

Semenov D., Galapova V., Vasilev A., 2009. Sulfonylurea herbicides in crops of barley and winter wheat. Zashchitai Karantin Rastenii (3) Moscow: Izdatel'stvoKolos, 31

Sherawat I., Ahmad M., 2005. Bio-efficacy of different graminicides and their effect on the growth and yield of wheat crop. International Journal of Agriculture & Biology, 7, (6) 438-440.

Soroka S.V., Soroka L. I., 2003. Chemical weeding is also required in the autumn. Belorusskoe Sel'skoe Khozyaistvo (9) Minsk: Ministerstvo Sel'skogo Khozyaistvai Prodovol'stviya Minsk, 18-19.

Tonev T., Dimitrova M., Kalinova Sht., Zhalnov I., Spasov V., 2007. Herbology (Textbook). Academic publisher of Agricultural University of Plovdiv. (In Bulgarian).

Tonev T., Tityanov M., Vasilev A., 2011. Guide to Integrated Weed Management and Proficiency of Agriculture. Publisher: "Biblioteka Zemedelsko Obrazovanie". 108 pages.

Vilau F., Vilau N., Rosculete C.A., Mutafa I., 2010. Research concerning wheat crop weed control and herbicide influence on bread quality. Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series 40 (1) Craiova: Faculty of Agriculture, University of Craiova, 251-254

WangCang S., QianQian Z., Ren Hai W., Fei X., Chang'an M. Jun J., YaFang Q., ChuanTao Lu, 2016. Control effect of several herbicides and mixtures on broadleaf weeds in wheat field. Journal of Henan Agricultural Sciences 45 (5) Zhengzhou: Henan Agricultural Sciences, 106-110.

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POSSIBILITIES FOR CHEMICAL WEED CONTROL AT OIL SEED RAPE

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Abstract

During the period from 2014 to 2016, a field trail with the oilseed rape (Brassica napus L.) hybrid "PX 111 CL" (Clearfield® hybrid) was conducted. The experiment was carried out in the experimental base of the department of "Agriculture and Herbology" of the Agricultural University of Plovdiv, Bulgaria. The aim of the study was to establish the possibilities of chemical weed control during the vegetation of the oilseed rape with perspective herbicides. The following 6 herbicide product were evaluated: Salsa 75 WG (750 g/kg Ethametsulfuron-Methyl), Galera Super (240 g/l clopyralid + 80 g/l picloram + 40 g/l aminopyralid), Modaon 4 F (480 g/l bifenox), Fusilade Forte 150 EC (150 g/l fluazifop-p-butyl), Stratos Ultra (100 g/l cycloxydim + tenzid) and Cleranda SC (17.5 g/l imazamox + 375 g/l metazachlor). The efficacy of the products was recorded by the 10 score scale of EWRS (European Weed Research Society). The productivity of the oilseed rape was also studied. The dispersion analyses showed that there were proved differences between the variants of the tail. The highest herbicide efficacy against the existing weed infestation as well as the highest yield (4.098 t.ha^{-1}) was recorded for the variant with the combine application of the herbicide products Galera Super + Fusilade Forte 150 EC.

Key words: *oilseed rape, weeds, herbicides, efficacy.*

INTRODUCTION

Every year the agricultural production has enormous losses because of the concurrence of the cultural plants with the weeds. They deservedly could be qualified as "The green enemy of humanity" (Tonev et al., 2007). The appearance and amplicon of the weeds are due to different factors as the soil type, crop rotation, soil tillage, crop density, fertilization levels etc. (Hanzlik and Gerowitt, 2011). There are a large number of literature sources that prove the harmful consequences caused by the weeds and also the huge amount of mechanical and chemical weed control (Fetvadzieva et al., 1991; Spasov, 1995). To be economically proved, the herbicide treatment should be performed in accordance with the existing weeds (Klaus, 1992). The winter oilseed rape is slow-growing crop and is also very sensitive to weed infestation (Roshdy et al., 2008). The high weed infestation with *Raphanus raphanistrum*, *Sinapis arvensis*, *Stellaria media*, *Solanum nigrum* and *Chenopodium hybridum* decreased the yields and quality of the production because their development is faster than the development of rapeseed (Pavlović, 2015). Salsa® is selective herbicide for the rapeseed that controls the broadleaf weeds, started their vegetation in the autumn (Drobny and Schlang, 2012). By the Clearfield® technology, the herbicide product Cleranda® shows very high efficacy against grass and broadleaf weeds, as well as volunteer crop plants. The herbicide products Salsa® and Modaon® have very good efficacy against *Sinapis arvensis* and *Raphanus raphanistrum* (Delchev, 2014).
The aim of the study is to establish possibilities for chemical weed control at winter oilseed rape.

MATERIALS AND METHODS

During 2014 - 2016 field experiment with winter oilseed rape hybrid PX 111 CL (Clearfield® hybrid) was conducted. The experiment was carried out in the experimental base of the department of "Agriculture and Herbology" of the Agricultural University of Plovdiv, Bulgaria. The following 6 herbicide product were evaluated: Salsa 75 WG (750 g/kg Ethametsulfuron-Methyl), Galera Super (240 g/l clopyralid + 80 g/l picloram + 40 g/l aminopyralid), Modaon 4 F (480 g/l bifenox), Fusilade Forte 150 EC (150 g/l fluazifop-p-butyl), Stratos Ultra (100 g/l cycloxydim + tenzid) and Cleranda SC (17.5 g/l imazamox + 375 g/l metazachlor). The trial field was infested with typical weeds for the crop: common poppy (*Papaver rhoeas* L); cleavers (*Galium aparine* L.); corn chamomile (*Anthemis arvensis* L.); ryegrass (*Lolium rigidum* L.) and winter wheat (*Triticum aestivum* L.) as volunteer. The trial was conducted by the randomized block design in 4 replications. The size of the harvesting plot was 33 m². The herbicide treatment was done at BBCH 14-15 with spryer for plot trails. The expense of spray solution was 300 l ha^{-1}.

The herbicide efficacy was recorded on the 14^{th}, 28^{th} and 56^{th} day after treatments by the 10 score scale for efficacy of EWRS (European Weed Research Society). The results were compared with untreated control. The selectivity of the herbicides to the oilseed rape was measured by the 9 score scale for phytotoxisity of EWRS (at score 0 there is no damage, at score 9 the crop is completely destroyed).

Table 1. Variants of the experiment

V1	Untreated control
V2	Salsa 75 WG - 25 g/ha (750 g/kg ethametsulfuron-methyl)
V3	Galera Super - 200 ml/ha (240 g/l clopyralide + 80 g/l picloram + 40 g/l aminopyralid)
V4	Modaon 4 F - 1000 ml/ha (480 g/l bifenox)
V5	Galera Super + Fusilade Forte - 200 ml/ha + 500 ml/ha (150 g/l fluazifop-P -butyl)
V6	Salsa 75 WG + Stratos Ultra - 25 g/ha + 1000 ml/ha (100 g/l cycloxydim)
V7	Modaon 4 F + Stratos Ultra - 1000 ml/ha +1000 ml/ha
V8	Cleranda SK - 2000 ml/ha (375 g/l metazachlor + 17.5 g/l imazamox)

The oilseed predecessor for both experimental years was winter wheat. After harvesting of the wheat on the experimental field shallow plowing at 15 cm, followed by two surface tillages was done. Fertilization with 200 kg ha^{-1} $N_{15}P_{15}K_{15}$ was achieved before sowing of the crop. The sowing was performed with seeder for plot trials. After sowing the field was rolled. In spring, dressing with 300 kg ha^{-1} NH_4NO_3 was performed. The rapeseed yield was recorded by harvesting plants from area 50x50 cm of the experimental plots for each replication and the results were recalculated to yields per hectare.

Statistical analysis of the yields was performed by using Duncan's multiple range test of SPSS 17 program. Statistical differences were considered significant at $p<0.05$.

RESULTS AND DISCUSSIONS

The average density of the weeds per 1 m^2 on the experimental field was as follows: common poppy – 8.5 specimens, cleavers – 5.5 specimens, corn chamomile – 6.5 specimens, ryegrass - 22 specimens and winter wheat volunteer - 24 specimens, average for the period of investigation. These weed species are typical in rapeseed fields. The quantitative method for recording the weeds number per 1 m^2 after treatments is not precise enough, because at the time of reporting the efficacy, the weeds were with depressed development. That is the reason we recorded the herbicide efficacy by the 10 score scale of EWRS.

Berry et al. (2014) reported that the possibilities of chemical control of the common poppy are limited to application of metazachlor before germination or in the early stages of development of the crop. On Table 2 is shown the dynamic of the efficacy of the studied herbicides against the common poppy (*P. rhoeas*). In a study conducted by Dimitrova et al. (2014) Butizan S (metazachlor) applied at rate 2000 ml ha^{-1} had 82% efficacy against this weed. The results from our study showed that the alone herbicide applications of Galera Super, Salsa 75 WG and Cleranda SK successfully control the common poppy. The herbicide product Modaon 4 F showed limited efficacy against the common poppy 70-75%.

At the combine usage of Galera Super + Fusilade Forte, Salsa 75 WG + Stratos Ultra and Modaon 4 F + Stratos Ultra, the efficacy was excellent against the weed.

The cleavers are among the most resistant weeds to herbicides. The control should be performed in the early development stages. The developed specimens could be depressed by the herbicides, but later they overcome the damages and regrow again.

On Table 3 is shown the efficacy against the cleavers (*G. aparine*). After application of Salsa 75 WG, Galera Super, Galera Super +

Fusilade Forte, Salsa 75 WG + Stratos Ultra and Cleranda SK the efficacy on the 56th day after the treatments was from 90 to 97.5% average for the period. On the first date of reporting (14th day after treatments) the cleavers was relatively sustainable of these herbicides. The herbicide efficacy varied from 72.5 to 85%. On the 28th day after the treatments with these herbicides the efficacy was average from 82.5 to 90 %, and on the 56th day the weed was highly depressed in its development. Only for the herbicide product Galera Super, the efficacy reached 97.5%. After the application of the herbicide products Maton 4 F and its combine usage with Stratos Ultra non satisfactory efficacy was recorded (75%). On the next reporting dates, the efficacy decreased to 70%. The reason is that Maton 4 F has contact mode of action, and Stratos Ultra controls the grass weeds.

Average for the the period on 56th day after the treatments, the herbicide products Salsa 75 WG, Galera Super, as well as at the variants with combined application of broadleaf + grass herbicides, the efficacy against the corn chamomile (*A. arvensis*) was 100% (Table 4). The efficacy of Cleranda was 97.5%.

The ryegrass (*L. rigidum*) is among the grass weeds that are very often observed in the winter oilseed rape fields (Mitkov et al., 2015). The natural level of infestation with this weed can lead to high concurrence interactions with the oilseed crop. The efficacy of the herbicide combinations Galera Super + Fusilade Forte, Salsa 75 WG + Stratos Ultra and Modaon 4 F + Stratos Ultra against this weed was approximately equal with the efficacy of Cleranda SK (Table 5). On the 56th day after treatments, the variants with combine herbicide application, the efficacy was 100%. For Cleranda SK the efficacy was 95% average for the period. at the variants with alone application of Salsa 75 WG, Galera Super and Modaon 4 F the recorded efficacy was 0%. That is because of the mode of action of the herbicides which is only against the broadleaf weeds.

The winter wheat very often can be in a concurrent relationship with the next crop in the crop rotation and is usually in high density (Ogg and Parker, 2000). In our trial the winter wheat volunteer was the easiest to control, but before tillering. Still on the 14th day after the treatments with Salsa 75 WG, Galera Super and Modaon 4 the efficacy was from 92.5% to 97.5%. On the next two reporting dates the efficacy was 100% (Table 6).

At variants V2, V3, V5, V6 and V8 the used herbicide products in the study were selective for the crop. On the 14th day after treatments at variant V4 phytotoxicity signs (score 2) expressed in local spitting of the crop's leafs were observed. At variants V7 the phytotoxicity signs were more severely expressed (score 4). On the 56th day after herbicide application, the phitotoxicity signs totally disappeared.

The unsuccessful weed control at the winter oilseed rape can lead to total yield losses (Pacanoski, 2014). The oilseed rape seed yields are presented on Table 7. The differences in the yields were overcome by the herbicide efficacy and the selectivity of the studied herbicide products and their ability to control the existing weeds. The natural weed infestation leads to very low yields for the untreated control, 2.00 t ha^{-1}. By the degree of statistical provement five groups (a, b, c, d, e) average for the period were formed. It was recorded that variant V6 (Galera Super + Fusilade Forte) was from group (e) with the highest yield (3.99 t ha^{-1}) and was the most distant from the group of the untreated control (a). Because of the fact, that the herbicide products Galera Super and Salsa 75 WG controlled only broadleaf weeds, the yields after these treatments were lower. The yields from the variants treated with Modaon 4 F and the combination of Modaon 4 F + Stratos Ultra were very low (2.33 and 2.26 t ha^{-1}). The decrease was a consequence of the phytotoxicity that was recorded.

Table 2. Efficacy of the studied herbicide products against the common poppy (*Papaver rhoeas* L.)

Treatments		2015			2016			Average		
		14 day	28 day	56 day	14 day	28 day	56 day	14 day	28 day	56 day
V1	Untreated control	-	-	-	-	-	-	-	-	-
V2	Salsa 75 WG	70	80	90	75	85	95	72.5	82.5	92.5
V3	Galera Super	80	90	100	90	95	100	85	92.5	100
V4	Modaon 4 F	75	70	70	80	75	75	77.5	72.5	72.5
V5	Galera Super + Fusilade Forte	80	90	100	90	95	100	85	92.5	100
V6	Salsa 75 WG + Stratos Ultra	70	80	90	75	85	95	72.5	82.5	92.5
V7	Modaon 4 F + Stratos Ultra	75	70	70	80	75	75	77.5	72.5	72.5
V8	Cleranda SK	85	90	100	90	95	100	87.5	92.5	100

Table 3. Efficacy of the studied herbicide products against the clevers (*Galium aparine* L.)

Treatments		2015			2016			Average		
		14 day	28 day	56 day	14 day	28 day	56 day	14 day	28 day	56 Day
V1	Untreated control	-	-	-	-	-	-	-	-	-
V2	Salsa 75 WG	70	85	90	75	85	90	72.5	85	90
V3	Galera Super	85	90	95	85	90	100	85	90	97.5
V4	Modaon 4 F	75	70	70	75	70	70	75	70	70
V5	Galera Super + Fusilade Forte	85	90	95	85	90	100	85	90	97.5
V6	Salsa 75 WG + Stratos Ultra	70	85	90	75	85	90	72.5	85	90
V7	Modaon 4 F + Stratos Ultra	75	70	70	75	70	70	75	70	70
V8	Cleranda SK	75	80	90	80	85	95	77.5	82.5	92.5

Table 4. Efficacy of the studied herbicide products against the corn chamomile (*Anthemis arvensis* L.)

Treatments		2015			2016			Average		
		14 day	28 day	56 day	14 day	28 day	56 day	14 day	28 day	56 day
V1	Untreated control	-	-	-	-	-	-	-	-	-
V2	Salsa 75 WG	70	85	100	75	85	100	72.5	85	100
V3	Galera Super	80	90	100	85	95	100	82.5	92.5	100
V4	Modaon 4 F	75	85	90	80	90	90	77.5	87.5	90
V5	Galera Super + Fusilade Forte	80	90	100	85	95	100	82.5	92.5	100
V6	Salsa 75 WG + Stratos Ultra	70	85	100	75	85	100	72.5	85	100
V7	Modaon 4 F + Stratos Ultra	75	85	90	80	90	90	77.5	87.5	90
V8	Cleranda SK	80	90	95	85	95	100	82.5	92.5	97.5

Table 5. Efficacy of the studied herbicide products against the ryegrass *(Lolium rigidum* L.*)*

Treatments		2015			2016			Average		
		14 day	28 day	56 day	14 day	28 day	56 day	14 day	28 day	56 day
V1	Untreated control	-	-	-	-	-	-	-	-	-
V2	Salsa 75 WG	0	0	0	0	0	0	0	0	0
V3	Galera Super	0	0	0	0	0	0	0	0	0
V4	Modaon 4 F	0	0	0	0	0	0	0	0	0
V5	Galera Super + Fusilade Forte	80	90	100	85	95	100	82.5	92.5	100
V6	Salsa 75 WG + Stratos Ultra	75	85	100	80	90	100	77.5	87.5	100
V7	Modaon 4 F + Stratos Ultra	85	95	100	90	95	100	87.5	95	100
V8	Cleranda SK	75	85	95	80	90	95	77.5	87.5	95

Table 6. Efficacy of the studied herbicide products against the wheat volunteer (*Triticum aestivum* L.)

Treatments		2015			2016			Average		
		14 day	28 day	56 day	14 day	28 day	56 day	14 day	28 day	56 day
V1	Untreated control	-	-	-	-	-	-	-	-	-
V2	Salsa 75 WG	0	0	0	0	0	0	0	0	0
V3	Galera Super	0	0	0	0	0	0	0	0	0
V4	Modaon 4 F	0	0	0	0	0	0	0	0	0
V5	Galera Super + Fusilade Forte	95	100	100	100	100	100	97.5	100	100
V6	Salsa 75 WG + Stratos Ultra	95	100	100	100	100	100	97.5	100	100
V7	Modaon 4 F + Stratos Ultra	90	100	100	95	100	100	92.5	100	100
V8	Cleranda SK	90	100	100	95	100	100	92.5	100	100

Table 7. Yields of oilseed rape seeds, t ha^{-1}

Treatments		2015		2016		Average	
		With U.c.	By Duncan	With U.c.	By Duncan	With U.c.	By Duncan
V1	Untreated control	1.95	a	2.06	A	2.00	A
V2	Salsa 75 WG	3.80*	c	3.88*	D	3.84*	C
V3	Galera Super	3.82*	c	3.91*	D	3.86*	C
V4	Modaon 4 F	2.28*	b	2.38*	C	2.33*	B
V5	Galera Super + Fusilade Forte	4.03*	e	4.17*	F	4.10*	E
V6	Salsa 75 WG + Stratos Ultra	3.94*	d	4.04*	E	3.99*	D
V7	Modaon 4 F + Stratos Ultra	2.20*	b	2.31*	B	2.26*	B
V8	Cleranda SK	3.94*	d	4.03*	E	3.98*	D

Legend: All variants with star (*) do not have considerable difference with the untreated control. The numbers followed by different letters are with proved differences at $p<0.05$; U.c. – Untreted control

CONCLUSIONS

The herbicide products Galera Super, Cleranda SK, and Salsa 75 WG exceeded Modaon 4 F in their control of *P. rhoeas*, *G. aparine* and *A. arvensis*. Galera Super and Cleranda SK showed higher efficacy CK. In comparison with Salsa 75 WG against *P. rhoeas*, Salsa 75 WG and Galera Super were more efficient against *A. arvensis*. Fusilade Forte and Stratos Ultra were more efficient against *L. rigidum*, than Cleranda SK.

The highest average yield was recorded after the combined treatment with Galera Super + Fusilade forte – 4.10 t ha^{-1}. After the combine usage of Modaon 4 F + Stratos Ultra the obtained yields (2.26 t ha^{-1}) were very close to the yields of the variant treated only with Modaon 4 F (2.33 t ha^{-1}).

REFERENCES

Berry P., Cook S., Ellis S., Gladders P., Roques S., 2014. HGCA Oilseed rape guide. 32 pp.

Delchev Gr., 2014. Efficacy and selectivity of herbicides and herbicide combinations at winter oilseed canola grown by conventional and Clearfield technologies. Agricultural Science and Technology, Vol. 6, No 3, pp 315-320.

Dimitrova M., Zhalnov I., Stoychev D., 2014. Efficacy and selectivity of some herbicides on winter oilseed rape. Agricultural Science and Technology, Vol. 6, No 3, pp 297 – 299.

Drobny H., Schlang N., 2012. SALSA® (Ethametsulfuron-Methyl 75% WG): Ein neuartiges selektives Rapsherbizid fur Europa. Deutsche Arbeitsbesprechung über Fragen der Unkrautbiologie und–bekämpfung, 13.-15. Braunschweig. 540-543.

Fetvadzieva N., Zhelev A, Dechkov Z., Pavlov P., Dimov A., Spasov V., Topalov V., Kondarev R., 1991. Herbology. Publisher “Zemizdat” Sofia. (In Bulgarian)

Hanzlik K., Gerowitt B., 2011. The importance of climate, site and management on weed vegetation in oilseed rape in Germany. Agr Ecosyst Environ Agriculture, 141: 323-331.

Klaus M, 1992. Integrated weed control illustrated in the case of winter rape. Gesunde Pflanzen, 44, 251-254.

Mitkov A., Yanev M., Tonev T., 2015. Chewing's fescue - problematic weed in rapeseed fields. Dobiv Plus, 4, p. 30-31. (In Bulgarian)

Ogg A., Parker R, 2000. Control of volunteer crop plants. Washington State University Cooperative Extension. p. 1-4

Pacanoski Z., 2014. Application time and herbicide rate effects on weeds in oilseed rape (*Brassica napus* var. *oleifera*) Herbologia, Vol. 14, No. 1. Pp. 33-45.

Pavlović D., Mitrović P., Marisavljević D., Marjanović-Jeromela A., Anđelković A., 2015. The Effect of Weeds on the Yield and Quality Parameters of Rapeseed. Proceedings of Sixth International Scientific Agricultural Symposium „Agrosym 2015“, p. 914-918.

Roshdy A., Shams El-Din, M., Mekki B., Elewa, T. A. A., 2008. Effect of weed control on yield and yield components of some canola varieties (*Brassica napus* L.), American-Eurasian Journal of Agricultural & Environmental Sciences, 4, 23-29.

Spasov V., 1995. Habilitation for the academic title „Professor”. (In Bulgarian)

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UNEXPLOITED AND UNDERUTILIZED WILD EDIBLE FRUITS OF WESTERN GHATS IN SOUTHERN INDIA

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Abstract

Fruits play predominant role in the diet. Several health based statistical reports highlight the importance of consumption of fruits as they tend to contain broad-spectrum essential nutrients including phenolic antioxidants that impart protective role against several diseases. Western Ghats, one among eight "hottest hot-spots" of biodiversity in world harbor many wild, unexploited and minor fruits which are edible and unfamiliar to large proportion of the global population. Wild edible fruits are important source of food and income for rural communities. Wild fruits are therapeutic in nature and used to treat wide array of diseases including chronic diseases. In the last three decades, increased urbanization and deforestation for agricultural land use has led to destruction of valuable plant species including fruit yielding plants. As a result, substantial decrease in the consumption and utilization of wild edible fruits has been noticed. The present article describes 45 fruits that are edible and prominent in the Western Ghats region of Southern India. Detailed information on nutrient composition of these minor fruits is provided, as consumed by tribal and rural communities.

Key words*: minerals, nutritional composition, South India, Western Ghats, Wild edible fruits*.

INTRODUCTION

India is one of the mega diversity tropical countries that comprise rich vegetation and biodiversity. The Western Ghats is one such hotspot which is home to many wild, unutilized, underutilized and minor fruits that are rarely eaten and still many are unfamiliar to the major population. Since, these wild edible fruits comprise broad-spectrum essential nutrients, vitamins and secondary metabolites they can be considered for cultivation, consumption and utilization. However, these wild fruits may not taste good unlike cultivated tropical fruits but they hold good proportions of antioxidants, essential nutrients and bioactive molecules. Moreover, many wild fruits serve as possible future source of income for local communities in rural areas of several developing and poorly developed nations. Over the past few years, the information related to wild fruits is endangered. Due to lack of suitable and efficient processing techniques and increased deforestation has resulted in extinction of many of these fruit bearing wild plants from their natural vegetation. Furthermore, deprived knowledge about wild fruit identification to utilization and from harvesting to processing is another major hurdle to overcome. Also, studies on nutritional attributes of these wild fruits are not properly documented. Hence, cultivation, promotion and conservation of these wild edible fruits are very crucial for nutritional, medicinal and economic purposes. Though these crops grow in wild and have been neglected, they have their own unique properties, such as nutritional and therapeutic values. Hence, there is enormous scope to these fruits by creating awareness among the locals and popularization of value added products from these fruits. Wild fruits are available in plenty in their natural habitats; still it is relatively essential to have their germplasm conserved. Subsequently, this may help in tackling the problems arising due to urbanization and geographical variations.

BIODIVERSITY AND BIORESOURCES OF WESTERN GHATS

During the past few decades several studies have indicated that the Western Ghats harbor several important plants. The availability of rich bioresources is now being utilized in producing several important value added products that are commercially exploited in food, agriculture, medicine and cosmetic industries. Moreover, several wild edible fruits tend to be nutritious and medicinal. It is remarkable to mention that in a year, not less than six to eight plant species will be in fruiting in each month and majority of these wild edible fruits belong to *Anacardiaceae*, *Apocynaceae*, *Euphorbiaceae*, *Moraceae* and *Sapotaceae* families (Uthaiah, 1994). There are more than 60 wild edible fruits available in entire Western Ghats region. More recently, Jadhav et al. (2015) reported 159 wild edible plants from the Northern Western Ghats of Maharashtra, of which 77 fruit bearing plant species are edible and most fruits are consumed during January-July. According to Kumar and Shiddamallayya (2016), forest region of Hassan district of Southern Western Ghats has 75 wild edible fruit species belonging to 40 families and 60 genera. Nazarudeen (2010) studied the nutritional composition of wild fruits such as *Alangium salvifolium*, *Antidesma ghaesembilla*, *Baccaurea courtallensis*, *Debregeasia longifolia*, *Palaquium ellipticum* and *Tamilnadia uliginosa*. Several ethnobotanical studies indicated that though these fruits are not so tasty and desirable unlike cultivated fruits, nevertheless, these wild edible fruits are rich in nutritional content with respect to protein, fat and iron content. Among the wide range of available edible wild plant species, wild fruits are foremost provider of subsidiary nutrition to the rural communities. Generally, native plants determine the dietary habits of ethnic communities, though they are not nutrition specific in most occasions. Therefore, it can be concluded that the wild edible fruits are more superior to cultivated fruits when nutrition is taken in to account (Valvi et al., 2011). However, it is essential to mention that due to increased urbanization and deforestation several plant species are endangered and are under the threat of extinction. Recent studies reveal that during 1920 to 2013 as much as 35.3% of forest cover in the Western Ghats has been changed or disturbed (Reddy et al., 2016). Hence, as a foremost priority, the bioresources including wild edible fruits of Western Ghats has to be preserved and conserved (Deshmukh and Shinde, 2010; Hebbar et al., 2010; Narayanan et al., 2011; Harisha and Padmavathy, 2013).

WILD EDIBLE FRUITS OF WESTERN GHATS

The present article describes some of the important wild fruits of the Western Ghats, particularly in Southern India. A list of 45 fruits has been listed out that are edible, but the list is by no means complete. Information is provided for the rare fruits that are consumed by the tribal and rural communities. Although people consume these fruits freshly, in certain occasions the juice is taken out from the rind, rind is sundried and used as a souring agent as spice for the preparation of beverages and typical south Indian cuisines. Seeds of some *Clusiaceae* members such as *Garcinia indica* and *Garcinia gummi-gutta* yield high oil, which is known to comprise potential therapeutic properties. Commercially, butter extracted from these fruits are used for producing cosmetics and functional foods, however, traditionally these fruits are utilized for esculent, medicinal and cosmetic purposes.

FLOWERING/FRUITING PHENOLOGY AND NUTRITIONAL POTENTIAL OF WILD EDIBLE FRUITS

Aporosa cardiosperma (Gaertn.) Merr. is a valuable medicinal tree endemic to Sri Lanka, often several parts of plant such as leaves, roots and stems are utilized as a ethnomedicine against several health ailments including fever, skin diseases, diabetes, infertility and hepatic diseases.

Fruit description: Fruits globose or ovoid, pointed with the persistent style, 10-14 mm across, thin-walled, smooth, fruiting pedicels 5-6 mm long; suborbicular seeds, the edible part is yellow transparent arils comprising the seeds of around 2-4. Capsules are opened and then arils are eaten, usually seeds are often spat; the fruit tastes little sweet and sour.

Flowering and fruiting: February – July

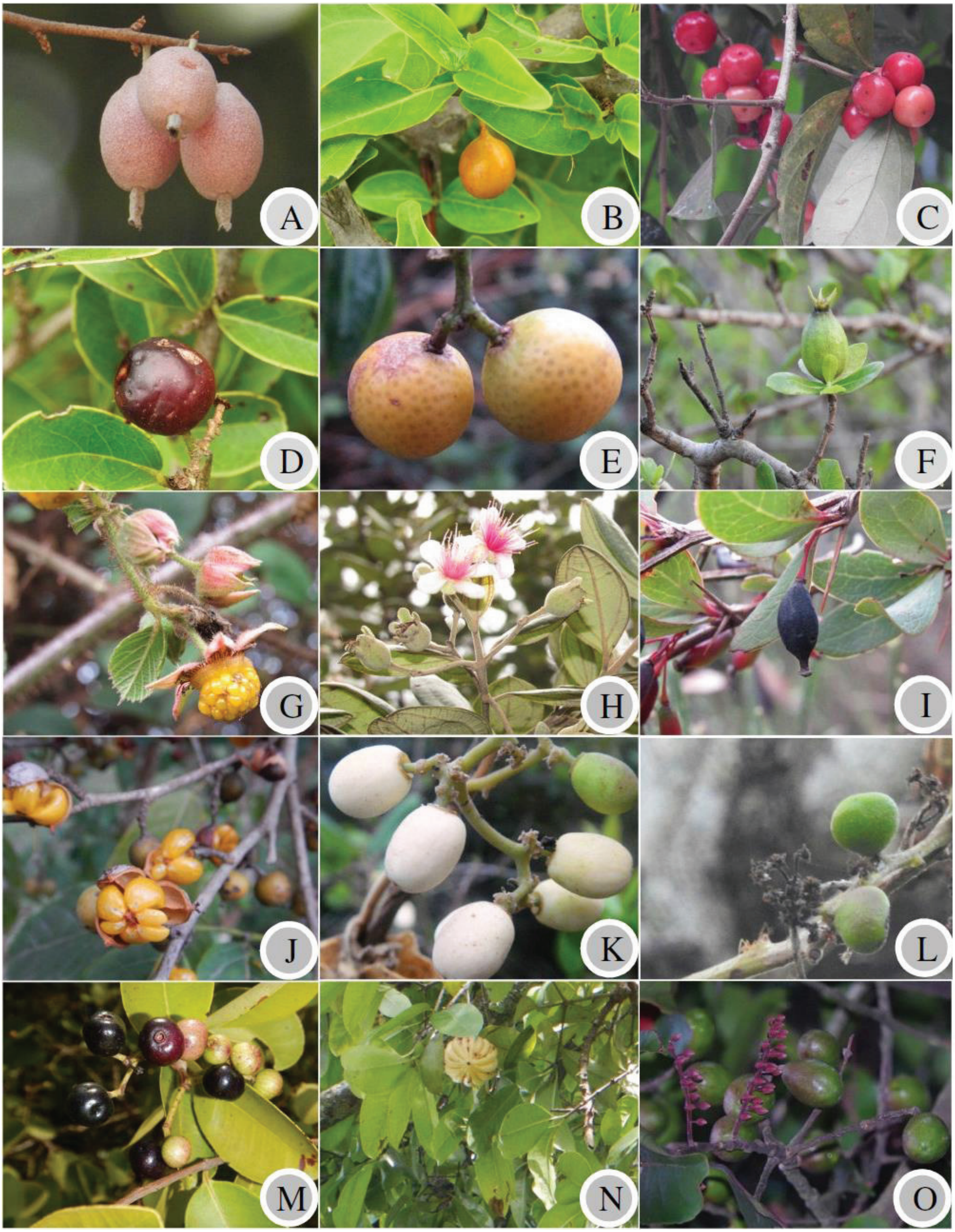

Figure 1. Selected wild, minor and edible fruits of Western Ghats in Southern India: (A) *Elaeagnus conferta*; (B) *Canthium coromandelicum*; (C) *Flacourtia Montana*; (D) *Flacourtia indica*; (E) *Toddalia asiatica*; (F) *Gardenia gummifera*; (G) *Rubus ellipticus*; (H) *Rhodomyrtus tomentosa*; (I) *Berberis tinctoria*; (J) *Aporosa cardiosperma*; (K) *Ziziphus rugosa*; (L) *Buchanania cochinchinensis*; (M) *Syzygium caryophyllatum*; (N) *Garcinia gummi-gutta*; (O) *Elaeocarpus tectorius*

Nutritional value: Moisture content (%): 92.43, protein (%): 0.02, fat (%): 1.16, reducing sugars (%): 4.91, non-reducing sugars (%): 1.06, total sugars (%): 5.98, vitamin C: traces, iron (mg/100g): 3.71, sodium (mg/100g): 11.6, potassium (mg/100g): 346.09 (Nazarudeen, 2010).

Artocarpus gomezianus Wall. ex Trecul. is an underutilized fruit tree found in the central Western Ghats.

Fruit description: Fruit is sorosis, subglobose, green turns yellow when ripe, weight (g): 52.59-245.50, length (cm): 40.80-70.90 and width (cm): 20.90-60.00), many seeded.

Flowering and fruiting: January – June.

Nutritive value: Ash (%): 5.33, moisture (%): 87.78, fat (%): 15.00, fibre (%): 8.43, protein (%): 0.36, carbohydrates (%): 8.62, zinc (ppm): 24.92, copper (ppm): 12.84, manganese (ppm): 103.49, iron (ppm): 802.01, sodium (%): 0.68, potassium (%): 1.47, phosphorus (%): 0.26, calcium (%): 0.26, magnesium (%): 0.18, nitrogen (%): 23.48, copper (ppm): 12.84. Whereas, the phenol and flavonoid content of fruits varied from 0.98-1.13 % and 0.41-0.73 % respectively. The fruits are consumed raw and also processed in to several value added products. Moreover, it is also used as spice in cooking south Indian dishes (Krishnamurthy and Sarala, 2013; Sarala and Krishnamurthy, 2014).

Berberis tinctoria Lesch. is a shrub endemic to Nilgiris – a part of UNESCO World Network of Biosphere Reserves.

Fruit description: Fruits are many seeded berries, obovoid-oblong, glabrous, shining, bluish black when ripe, with a size, length (cm): 1.2-1.5, diameter (cm): 0.5-0.7 and weight (g): 0.1-0.2.

Flowering and fruiting: March – July.

Nutritive value: The fruit has not been evaluated until now; however fruit extract has been evaluated for its total phenolics (410±0.02 mg/100g gallic acid equivalents (GAE), flavonoids (320±0.120 mg/100g quercetin equivalents) and antioxidant scavenging activity against various free radicals such as DPPH, $O2^{-}$, NO, $OH^{\cdot}$ and ABTS including anti-hemolytic activity. Tribal communities use various parts of this plant against liver related disorders and several chronic diseases including cancer. Furthermore, berberine, an alkaloid compound has been reported from this plant, wherein, this compound is used as drug by many pharmaceutical industries (Sasikumar et al., 2007; Singh et al., 2009; Sasikumar et al., 2012).

Buchanania cochinchinensis (Lour.) M.R. Almeida is a tree found in the deciduous forests of Western Ghats, native to tropical and subtropical India.

Fruit description: Fruit is drupe, black, stone hard, two valved, one seeded. Length (cm): 1.1-1.2, breadth (cm): 1.1-1.3. The ripe fruit is delicious and most often consumed raw; in several occasions, the seeds are roasted and served. Moreover, seeds are widely utilized as the kernel yields good amount of essential oil that finds several applications.

Flowering and fruiting: January – June.

Nutritive value: The seed comprises following proximate attributes: ash (%): 2.20, moisture (%): 3.60, crude fat (%): 38.00, total protein (%): 43.24, total carbohydrate (%): 12.96, total crude fibre (%): 18.50, phosphorus (mg/100 g): 593, zinc (mg/100 g) 3.32, aluminium (mg/100 g): 0.3, boron (mg/100 g): 0.6, calcium (mg/100 g): 70.00, copper (mg/100 g): 1.15, iron (mg/100 g): 4.80, magnesium (mg/100 g): 275.00, manganese (mg/100 g): 1.60. The kernel is known to be potential source of protein; oil from kernel is used as a substitute for almond oil and used extensively in cosmetic and nutraceutical applications (Munde et al., 2003; Singh et al., 2010; Kumar et al., 2012; Khatoon et al., 2015).

Carissa spinarum L. is an indigenous shrub, commonly found as hedge and a drought tolerant plant.

Fruit description: Fruit, an ovoid berry, 8-9 mm in length, 5-6 mm in diameter. Seeds 4-6, lanceolate, black in color with the weight (g), length (cm) and breadth (cm) of 2.56, 1.55 and 1.67 respectively. Fruit tastes sweet to astringent in flavor, and the fruit is known for its iron and ascorbic acid content. Several value added products are prepared.

Flowering and fruiting: February – June.

Table 1. List of selected potential wild, minor and edible fruits of Western Ghats in Southern India

Family	Botanical Name	Vernacular Name*	Habit	Mode of consumption and utilization	References
Anacardium occidentale L.	Anacardiaceae	Kan: Geru hannu, Godambe Tam: Munthiri, Andima Mal: Kasu mavu	Tree	Jam, jelly, vinegar, pectin, nonalcoholic and alcoholic beverages	Chakraborty et al., 1977; Mohanty et al., 2006
Buchanania cochinchinensis (Lour.) M.R. Almeida	Anacardiaceae	Kan: Nurukalu hannu Tam: Charam Mar: Charoli, Nuramaram	Tree	Consumed fresh, seeds- raw or cooked, oil is extracted from the seeds	Kumar et al., 2012
Semecarpus anacardium Blanco	Anacardiaceae	Kan: Gerr hannu Marathi: Bhilava, Bibba Mal: Sambiri	Tree	Dried fruits are consumed	Jadhav et al., 2015
Spondias dulcis Parkinson	Anacardiaceae	Kan: Sihi amate Hin: Ambarella	Tree	Consumed fresh, pickles	Bhat and Rajanna, 2016
Annona muricata L.	Annonaceae	Kan: Mullu ram phala Tam: Mullu sitha pazham	Tree	Ripe fruit consumed, fermented beverage	Minh, 2015
Carissa spinarum L.	Apocynaceae	Kan: Kouli hannu Mar: Karvand Hin: Jungli Karonda Tam: Kilakkay, Sirukilaa Mal: Kirkarmanji	Shrub	Consumed fresh, pickles, and jams are prepared	Fatima et al., 2013; Chauvan et al., 2015
Phoenix sylvestris (L.) Roxb.	Arecaceae	Kan: Kadu karjura hannu Tam: Kattinchu Mal: Niilanthent	Tree	Consumed fresh Dried fruits consumed	Jadhav et al., 2015
Berberis tinctoria Lesch.	Berberidaceae	Eng: Nilgiri barberry Tamil: Oosi kala	Shrub	Consumed fresh	Nayagam et al., 1993
Cordia dichotoma G. Forst.	Boraginaceae	Kan: Challe hannu Tam: Viricu Mal: Naruveeli Mar: Bhokar	Tree	Consumed fresh, pickled	Valvi and Rathod, 2011
Opuntia dillenii (Ker Gawl.) Haw.	Cactaceae	Kan: Papaskalli Tam: Sapathkalli	Shrub	Consumed fresh	Nayagam et al., 1993
Garcinia gummi-gutta (Linn.) Robson	Clusiaceae	Kan: Mantulli Tam: Kottukkappuli Mal: Kodampuli, Pinampuli	Tree	Fruit and juice are used as souring agent and butter from rind is prepared	Naveen and Krishnakumar, 2012; Namera et al., 2014
Gardenia gummifera L.f.	Rubiaceae	Kan: Bikke, Adavibikke Mal: Kambimaram Tam: Kambil	Small tree	Consumed fresh	Sivakamasundari et al., 2015
Garcinia indica (Thouars) Choisy	Clusiaceae	Kan: Murugalu, Kake mara Tam: Murgal Mal: Kotte pan, Kokumbrindeo Mar: Kokum	Tree	Consumed fresh, Juice and wine	Bafna, 2012; Naveen and Krishnakumar, 2013; Swami et al., 2014
Garcinia xanthochymous Hook	Clusiaceae	Kan: Devajarige Tam: Paccilai Mal: Beenakepuli	Tree	Consumed fresh, Wine	Rai et al., 2010; Mahesh et al., 2016
Dillenia pentagyna Roxb.	Dilleniaceae	Kan: Kaltega Mar: Karmal	Tree	Consumed fresh	Sundarapandian and Swamy, 1999
Elaeagnus conferta Roxb.	Elaeagnaceae	Kan: Halige hannu, Kerahuli Tam: Kulari Mal: Tholiar pan, Kattumunnthiringa Mar: Ambgul Eng: Wild olive	Shrub	Consumed fresh	Valvi and Rathod, 2011; Patil et al., 2012

Family	Botanical Name	Vernacular Name*	Habit	Mode of consumption and utilization	References
Elaeocarpus tectorius (Lour.) Poir.	Elaeocarpaceae	Tam: Bikki palzam	Tree	Consumed fresh	Nayagam et al., 1993
Artocarpus hirsutus Lam.	Moraceae	Kan: Hebbalasu, Kadu halsu Tam: Anjili Mal: Ayani	Tree	Consumed fresh and pickled	Vinay et al., 2014
Artocarpus gomezianus Wall. ex Trecul.	Moraceae	Kan: Vatte huli Tam: Ottipila Mal: Arampulli, Pulichakka Eng: Monkey jack	Tree	Consumed fresh and juice, used as spice	Krishnamurthy and Sarala, 2013; Sarala and Krishnamurthy, 2014
Rhodomyrtus tomentosa (Alton) Hassk.	Myrtaceae	Tam: Thavutu pazham Mal: Kirattan, Thavattukoyya	Shrub	Consumed fresh	Nayagam et al., 1993
Syzygium caryophyllatum (L.) Alston	Myrtaceae	Kan: Kuntu nerle Mal: Shenjarel	Tree	Consumed fresh and wine	Shilpa and Krishnakumar, 2015
Syzygium jambos (L.)	Myrtaceae	Kan: Pannerale, Jammu nerale Tam: Champai Mal: Malakkacampa Eng: Roseapple	Tree	Consumed as fresh juice and wine	Dhanabalan et al., 2014
Syzygium zylanicum Altson	Myrtaceae	Kan: Bilinerale Mal: Pula	Tree	Consumed fresh and wine	Shilpa and Krishnakumar, 2015
Averrhoa bilimbi L.	Oxalidaceae	Kan: Bimbuli Tam: Pulima Mal: Vilumpi	Tree	Cooked and pickled	Bhat and Rajanna, 2016
Averrhoa carambola L.	Oxalidaceae	Kan: Karabalu Tam: Tamarattai Mal: Caturappuli	Tree	Consumed fresh, juice and wine	Napahde et al., 2010; Bhat et al., 2011; Dasgupta et al., 2013; Paul and Sahu, 2014; Bhat and Rajanna, 2016
Passiflora edulis Sims.	Passifloraceae	Eng: Passion fruit Kan: Sharbath balli Tam: Odey annu	Shrub	Consumed fresh, juice is prepared	Pruthi and Girdhari, 1955
Aporosa cardiosperma (Gaertn) Merr.	Phyllanthaceae	Kan: Salle mara Tam: Vittil Mal: Vetti	Tree	Ripe fruits consumed	Bhat and Rajanna, 2016
Phyllanthus emblica L.	Phyllanthaceae	Eng: Indian gooseberries Kan: Kadu nelli, Bettad nellikayi Tam: Nelli Mal: Nellikka	Tree	Consumed fresh, jam, juice and wine are prepared	Nambiar et al., 2016; Peerajan et al., 2016
Ziziphus oenopolia (L.) Mill.	Rhamnaceae	Kan: Pargi hannu Tam: Pulichi	Shrub	Consumed fresh	Jadhav et al., 2015
Ziziphus jujube Mill.	Rhamnaceae	Kan: Bore hannu, Bari hannu Mar: Bor	Tree	Consumed fresh	Jadhav et al., 2015
Ziziphus rugosa Lamk.	Rhamnaceae	Kan: Mullu hannu Mar: Burgi, Yeruni Mal: Kotte pan	Shrub	Consumed fresh, juice and dosa are prepared	Krishnamurthy and Sarala, 2011
Rubus ellipticus Smith	Rosaceae	Kan: Kadumulli hannu Tam: Mullu pazham, Thuppa mulli	Shrub	Consumed fresh	Nayagam et al., 1993
Rubus racemosus Roxb.	Rosaceae	Tam: Mullu pazham, Yemmemulli	Shrub	Consumed fresh	Nayagam et al., 1993
Rubus rugosus Smith.	Rosaceae	Tam: Mullu pazham	Shrub	Consumed fresh	Nayagam et al., 1993
Canthium coromandelicum (Burm. f.) Alston	Rubiaceae	Kan: Kare hannu Tam: Kaaraichedi Mal: Kare pan	Shrub	Consumed fresh	Sambandan and Dhatchanamoorthy, 2012
Ixora coccinea L.	Rubiaceae	Kan: Hole daswala, Kusumaale hannu Mal: Thetti, Chethi,	Shrub	Consumed fresh	Jadhav et al., 2015

Family	Botanical Name	Vernacular Name*	Habit	Mode of consumption and utilization	References
		Thechi			
Aegle marmelos (L.) Correa	Rutaceae	Kan: Bilvapatre Tam: Vilvam Mal: Mavilavu	Tree	Juice and wine	Pandaa et al., 2014
Glycosmis pentaphylla (Retz.) DC.	Rutaceae	Kan: Bakkina kannu Tam: Kula pannai Mal: Panchi Mar: Maenaki, Kirmira	Shrub	Consumed fresh	Valvi and Rathod, 2011
Toddalia asiatica (L.) Lam.	Rutaceae	Kan: Kadu manasu Tam: Kattu milaku, Siru-kindu Mullu annu	Woody liana	Consumed fresh	Nayagam et al., 1993
Flacourtia montana J. Grahm.	Salicaceae	Kan : Sampige hannu Mar: Champari, Ataki Mal: Male kakkade	Tree	Consumed fresh	Abhishek and Thangadurai, 2015
Flacourtia indica (Burm. f.) Merr.	Salicaceae	Kan: Karimullu hannu Tam: Cottaikkalaa Mal: Kurumuli Mar: Karai, Galguggar, Bhenkal	Shrub	Consumed fresh	Valvi and Rathod, 2011; Jadhav et al., 2015
Schleichera oleosa (Lour.)	Sapindaceae	Kan: Cakota Tam: Kumbadiri, Poovahti Mar: Kosab, Koshimb, Kusum	Tree	Consumed fresh, shoots as vegetable	Valvi and Rathod, 2011
Mimusops elengi L.	Sapotaceae	Kan: Renjalu hannu Mal: Elengi Hin: Bakul	Tree	Consumed fresh	Valvi et al., 2011
Lantana camara L.	Verbenaceae	Kan; Chadurangi, Simesime Tam: Uni Mar: Ghaneri, Tantani	Shrub	Consumed fresh	Venkatachalam et al., 2011a

*Eng: English, Hin: Hindi, Kan: Kannada, Mal: Malayalam, Mar: Marathi, Tel: Telegu, Tam: Tamil

Nutritive value: Moisture: 81.05 %, proteins: 2.07 %, fat: 1.30 %, carbohydrates: 18.66 %, calcium: 29 mg/100g, phosphorus: 32.1 mg/100g, iron: 3.45 mg/100g, total phenolics: 5.31 mg TAE/g, total flavonoids: 0.44 mg QE/100 g (Chauvan et al., 2015).

Elaeagnus conferta Roxb. is a thorny climber shrub, native to tropical and subtropical regions, found across evergreen to semi-evergreen forests.

Fruit description: The fruit is elliptical in shape, color is light pink with white coloured micro spots, single seeded, weight (g): 4.21, length (cm): 3.19, breadth (cm): 1.54. The fruit is usually consumed fresh, highly perishable.

Flowering and fruiting: November – March.

Nutritive value: Moisture content (%) 77.00, titrable acidity (g/100g): 2.37, total sugars (mg/100mg): 39.00, reducing sugars (mg/100mg): 35.00, non-reducing sugars (mg/100mg): 4.00, ash (%): 22.02, copper (mg/kg): 0.049, manganese (mg/kg): 0.145, iron (mg/kg): 0.628, zinc (mg/kg): 0.411, calcium (mg/kg): 17.06, magnesium (mg/kg): 1358.00, phenolics (mg/100mg): 6.08, flavonoids (mg/100mg): 11.68, ascorbic acid (mg/100g): 8.20. The fruits are used as medicine for the treatment of indigestion (Patil et al., 2012; Valvi et al., 2014b; Khilari and Sharma, 2016).

Elaeocarpus tectorius (Lour.) Poir. is a tall tree up to 40 meters, found in the higher altitude of the Nilgiris.

Fruit description: Green fruits are sweet to taste, single seeded, weight (g): 5-8, diameter (cm): 1.8-2.1 and length (cm): 2.8-3.2.

Flowering and fruiting: March – August.

Nutritive value: Moisture (%): 59.30, proteins (mg/100g): 1.4, fibre (mg/100g): 1.6, calcium (mg/100g): 37.00, phosphorous (mg/100g): 26.00, iron (mg/100g): 3.10, carotenes (mg/100g): 190.00, thiamine (mg/100g): 0.02, riboflavin (mg/100g): 0.06, niacin (mg/100g): 0.30. Traditionally, tribal communities utilize the fruits to treat various microbial infections and diseases including rheumatism and piles (Nayagam et al., 1993; Ragunathan and Senthamarai, 2014; Sharvani and Devaki, 2014).

Flacourtia indica (Burm. f.) Merr. is a small shrub found in the deciduous forest of Western Ghats region.
Fruit description: Fruit is globular in shape, reddish to reddish black when ripe, fleshy, up to 4-10 seeded, tastes sweet to acidic, generally consumed raw, length (cm): 1.0-1.2, breadth (cm): 1.2-1.6.
Flowering and fruiting: January – October
Nutritive value: Moisture (%): 74.4, ash (%): 2.57, total sugar (%): 14.74, phenol (mg/g): 1.63, ascorbic acid (mg/100g): 53.44, crude fibre (%): 6.01, fat (%): 0.17, potassium (mg/100g): 1184.3, calcium (mg/100g): 434.8, sodium (mg/100g): 146.3, iron (mg/100g): 15.23, manganese (mg/100g): 10.37, copper (mg/100g): 7.6. It is used in making jams, jellies and unripe fruits are astringent in flavor and usually pickled (Rathod and Valvi, 2011).
Flacourtia montana J. Grahm. being named on the type of vegetation it grows in montane forests is endemic to Western Ghats and grows to a height of 8-10 m. It is a small-medium sized tree often armed with heavy thorns and branches with spines.
Fruit description: Fruits are globous, red when ripe and taste sweet with astringent flavor, 4-6 seeds present, weight (g): 0.5-0.8, length (cm): 1.2-1.5, breadth (cm): 0.7-1.1.
Flowering and fruiting: September – March.
Nutritive value: Moisture (%): 77.10, titrable acidity (%): 0.25, total sugars (mg/100mg): 64, reducing sugars (mg/100mg): 9.88, non-reducing sugars (mg/100mg): 54.11, ash (%): 8.43, calcium (%): 0.30, magnesium (%): 0.60, potassium (%): 0.89, sodium (mg/100g): 57.10, phenolics (mg/100mg): 1.63, flavonoids (mg/100mg): 0.66, ascorbic acid (mg/100g): 23.30. The methanolic fruit extract exhibits antioxidant activity against various free radicals (Abhishek and Thangadurai, 2015).
Garcinia gummi-gutta (L.) Roxb. is widely distributed along the lower altitude of Western Ghats (coastal region). The plant is native to Indonesia and tree grows up to 10-16 meters in length.
Fruit description: The unripe fruit is green in color, ripe fruit will be yellow to pale yellow, 6 to 8 seeds present, looks similar to tiny pumpkin in shape, weight (g): 70-80, diameter (cm): 5-6, length (cm): 7-9.
Flowering and fruiting: January – June.
Nutritive value: Moisture (%): 86.91, total sugars (mg/100mg): 8.6, reducing sugars (mg/100mg): 5.92, non-reducing sugars (mg/100mg): 2.67, proteins (%): 0.61, fibre (%): 3.1, sodium (%): 2.1, potassium (%): 169.7. Fruit juice exhibits anti-scorbutic, anthelmintic and cardiotonic properties. Moreover, fruit rind and seeds are potential source of bioactive compounds such as lipids, fatty acids and nutraceuticals. The fruit is commercially exploited for its weight loss properties (Nazarudeen, 2010; Naveen and Krishnakumar, 2012; Naveen and Krishnakumar, 2013; Parthasarathy and Nandakishore, 2014; Mahesh et al., 2016).
Garcinia indica (Thouars) Choisy., a tree commonly found along the coastal area of the Western Ghats. The tree grows up to 10-18 meters with drooping branches.
Fruit description: The ripe fruit is red or dark purple colored containing 3-8 large seeds. The fruit is spherical, diameter (cm): 2.5 to 3.0, weight (g): 15-30.
Flowering and fruiting: November – May.
Nutritive value: Fresh rind of Kokum has moisture (%): 80, protein (%): 2, tannin (%): 2.8, pectin (%): 5, fibre (%): 14, total sugars (%): 4.1, fat (%): 1.4, ascorbic acid (%): 0.06. Garcinia comprises several potential bioactive constituents, majority proportions of them being garcinol and hydroxycitric acid (HCA). The pulp of the fruit is acidic that tastes sour. Generally, the rind of the fruit is commercially exploited as it is considered to be potentially therapeutic; it is used as souring agent in most of south Indian coastal cuisines. Moreover, the butter extracted from rind finds application in nutraceutical and cosmetic industries. Furthermore, is used to prepare several kinds of beverages and functional foods (Krishnamurthy et al., 1982; Krishnamurthy, 1996; Krishnamurthy and Sampathu, 1988; Bhat et al., 2005; Baliga et al., 2011; Swami et al., 2014; Jagtap et al., 2015).
Garcinia xanthochymus Hook. F. T. Anderson. is a tree native to India and Myanmar, distributed in the mid altitudes of Western Ghats region; tree grows up 80-100 meters.
Fruit description: Fruit is yellow in color, subglobose in shape, tastes sour, 1-4 seeded, weight (g): 57-65, diameter (cm): 5-9, length (cm): 5.0-6.5.

Flowering and fruiting: March – August.
Nutritive value: Moisture (%): 80.96, fat (%): 7.57, ash (%): 1.65, fibre (%): 2.73, protein (%): 5.01, phenolics (mg/g): 31.31, flavonoids (mg/g): 5.313, ascorbic acid (%): 0.14, calcium (mg/kg): 134.87.
Fruits are utilized to prepare fermented beverages comprising rich nutritional compositions. The fruit is rich in hydroxycitric acid, a compound known for its potential anti-obesity and fruits are used to prepare several food products including jams, vinegar and preservatives. Beverage made out of dried fruit is used against constipation and excessive flatulence. Furthermore, fruit possess potential bioactive compounds that are antioxidant, anti-inflammatory and anticancer in nature (Konoshima et al., 1970; Baslas and Kumar, 1979; Singh et al., 1991; Facciola, 1998; Chanmahasathien et al., 2003; Baggett et al., 2005; Chen et al., 2010; Rai et al., 2010; Lim, 2012; Parthasarathy and Nandakishore, 2014; Sharma et al., 2015).
Ixora coccinea L. is a small evergreen shrub found in lower altitude of Western Ghats, the plant is native to India and Sri Lanka.
Fruit description: A red to crimson coloured globose berry, tastes sweet, two seeded.
Flowering and fruiting: March – July.
Nutritive value: Moisture content (%): 82.9, total sugars (mg/100mg): 16.2, reducing sugars (mg/100mg): 10.15, non-reducing sugars (mg/100mg): 6.05, proteins (%): 0.28, fibre (%): 0.9; sodium (%): 9.88, potassium (%): 197.69. Traditionally tribal communities use various parts such as leaf, flower and roots to treat several diseases, and especially the flower decoction is used to treat against several diseases including dysentery, hypertension and menstrual irregularities (John, 1984; Batugal, 2004; Kirtikar and Basu, 2005; Saha et al., 2008; Nazarudeen, 2010; Bose et al., 2011; Baliga and Kurian, 2012).
Lantana camara L. is an exotic shrub widely distributed in the Western Ghats.
Fruit description: The fruit is a drupaceous, green-black in colour, diameter (cm): 0.5-0.6.
Flowering and fruiting: Throughout the year
Nutritive value: Moisture (%): 8.49, ash (%): 2.75, proteins (%): 17.11, fat (%): 4.29, fibre (%): 12.76, carbohydrates (%): 45.7, calcium (ppm): 1061.84, magnesium (ppm): 869.22, potassium (ppm): 889.92, sodium (ppm): 679.42, copper (ppm): 1.98, iron (ppm): 95.14, phosphorous (ppm): 875.16, zinc (ppm): 784.93. Methanolic extract of fruits exhibits anti-diabetic activity by significantly reducing blood glucose levels in streptozotocin-induced diabetic rats (Ojo et al., 2010; Venkatachalam et al., 2011a; Venkatachalam et al., 2011b; Ajiboye et al., 2014).
Opuntia dillenii (Ker Gawl.) Haw. is native to Central America and widely distributed in the Western Ghats.
Fruit description: A berry, ovoid, glochidiate, purple when ripe, many seeds present. The fruits are occasionally eaten, length (cm): 5-6, breadth (cm): 2.5-3.5.
Flowering and fruiting: February – July.
Nutritive value: Potassium (mg/100g): 876.3, calcium (mg/100g): 17.6, magnesium (mg/100g): 9.51, sodium (mg/100g): 124.3, phosphorous (mg/100g): 29.2, iron (mg/100g): 5.16, zinc (mg/100g): 0.884, manganese (mg/100g): 1.285, aluminum (mg/100g): 1.16, barium (mg/100g): 1.27; fruits are often consumed raw. Pulp is utilized to make into syrup, jam or jelly, a rich source of betalins (Kalegowda et al., 2015; Pooja and Vidyasagar, 2016).
Rhodomyrtus tomentosa (Altson) Hassk. is native to China, it is distributed on the higher altitudes of the Western Ghat region.
Fruit description: Fruit is an ellipsoid berry, diameter (cm): 1–1.5 with a persistent calyx, purplish black in colour, soft and sweet and several seeded.
Flowering and fruiting: March – July.
Nutritive value: Moisture (%): 83, titrable acidity (g CAE/100g): 0.43, protein (g/100g): 4.0, lipids (g/100g): 4.19, sugars (g/100g): 19.96, total dietary fibre (g/100g): 66.56, ascorbic acid (mg/100g): 15.29, calcium (mg/100g): 200.24, phosphorous (mg/100g): 57.85, iron (mg/100g): 4.20, potassium (mg/100g): 602.93, sodium (mg/100g): 113.64, magnesium (mg/100g): 66.51, copper (mg/100g): 1.10, manganese (mg/100g): 8.79, zinc (mg/100g): 1.65, total phenolics (mg GAE/g DW): 49.21. Fruit extracts significantly exhibits antioxidant activity (Nayagam et al, 1993; Lai et al., 2015).

Rubus ellipticus Smith. is a thorny shrub found across higher altitude of Western Ghats region; the plant grows up to 3-4 meters in height.
Fruit description: Yellow spherical berries looks similar to raspberry, diameter (cm): 0.9-1.0 and weight (g): 0.2-0.4; fruit is consumed fresh, tastes very sweet.
Flowering and fruiting: February – June.
Nutrition value: Moisture (%): 80.60, total soluble solids (%): 6.60, total sugars (%): 8.50, carbohydrate (%): 72.70, fat (%): 7.10, fibre (%): 7.90, protein (%): 4, ascorbic acid (%): 0.011, total phenols (mg GAE/100g): 6100±0.082, total flavonoids (mg QE/100g): 320±0.120 (Jeeva, 2009; Karuppusamy et al., 2011).
Schleichera oleosa (Lour.) Oken. is a tree found in deciduous forest of Western Ghats region.
Fruit description: The ripe fruit is eaten raw, a drupe ellipsoid to sub-globular in shape, taste acidic, length (cm): 1.5-2.5, breadth (cm): 1-2.
Flowering and fruiting: March – July.
Nutritive value: Moisture (%): 77.4, carotenoid (%): 3.1, reducing sugar (%): 11.7, starch (%): 9.2, total sugar (%): 7.23, phosphorus (%): 0.453, potassium (%): 1.167, ascorbic acid (mg/g): 1.05, phenol (mg/g): 4.50, crude fibre (%): 4.53. Usually, unripe fruits are pickled (Valvi and Rathod, 2011; Valvi et al., 2014a).
Syzygium caryophyllatum (L.) Alston. is an evergreen small tree up 2-3 meters distributed in lower altitude of Western Ghats, endemic to Sri Lanka. It is an endangered plant, categorized in Red List by International Union for Conservation of Nature and Natural Resources (IUCN).
Fruit description: It is a purple small sized berry, oval in shape, weight (mg): 300-500, length (cm): 0.4-0.6, breadth (cm): 0.5-0.8.
Flowering and fruiting: January – July.
Nutritive value: Moisture content (%) 63.17, titrable acidity (g/100g): 0.770 g of acids, total sugars (mg/100mg): 37.70, reducing sugars (mg/100mg): 30.40, non-reducing sugars (mg/100mg): 7.30, vitamin C (mg/100g): 50, proteins (mg/100mg): 3.37, total anthocyanin content: 240.36 mg/l. Methanolic extract and aqueous extract of fruit had 75.16 and 33.55 mg/g phenolics, respectively. The flavonoid content of methanol and aqueous extract of fruit had 27.2 and 8.25 mg/g respectively. Fruit has antibacterial potential and leaf extract exhibits antimicrobial, antioxidant and anticancer activity (Gayathri et al., 2012; Shilpa and Krishnakumar, 2015).
Ziziphus rugosa Lamk. is a large straggling armed shrub, grown widely in the dry deciduous forest of central Western Ghats.
Fruit description: Drupe to 1.3 cm, globose, white or pale yellow, glabrous, maximum weight (g) 1-2, length (cm): 0.9-1.5, width (cm): 1.1-1.5.
Flowering and fruiting: November – May.
Nutritive value: Ash (%): 50, moisture (%): 62.2, fat (%): 5, fibre (%): 40, protein (%): 11, carbohydrates (%): 26, zinc (ppm): 3.074, copper (ppm): 62.4, manganese (ppm): 609.1, iron (ppm): 916.728, sodium (%): 18.5, potassium (%): 168, phosphorus (%): 16.5, calcium (%): 17.1, magnesium (%): 22, nitrogen (%): 19.4. Fruits are used in treatment of throat irritations (Pandey et al., 1985; Acharya et al., 1988; Pandey et al., 1988; Krishnamurthy and Sarala, 2011; Kaennakam et al., 2013).

CONCLUSIONS

Fruits listed above have to be considered as horticultural crops at a foremost priority, likewise suitable mass propagation techniques have to be adapted in order to conserve these prominent fruits for the present and future generations that are under the threat of extinction. In the recent past, researchers have made considerable attempts in listing the nutritional composition and in developing techniques of mass propagation for some of these wild fruits. The government and semi-government organizations have to come forward and undertake necessary steps/policies in conserving these medicinal, wild, and minor fruit plant species. Moreover, in recent past several underutilized fruits are gaining prominence and have been successfully utilized for preparation of value added products and functional foods, thus creating its own niche in the food industry and nutraceuticals. This substantial increase in sustainable utilization of bioresources has made a tremendous impact on the livelihoods of tribal and rural communities, creating wide array of job opportunities and as a source of income and awareness among major populations.

Nevertheless, over the past few decades several scientific studies have been undertaken to understand phytochemicals present in various plant parts such as the leaves, barks and root. However, comparatively only few or rather rare studies have been conducted on fruits. Hence, it is quite significant to carry more intensive scientific studies on these wild edible fruits. It is believed that regular consumption of these fruits will aid in preventing several diseases and disorders including obesity, diabetes and chronic diseases. Since fruits are thought to be rich in nutrients, polyphenols (flavonoids and stilbenes) and carotenes, in recent past, several reports have successfully demonstrated that these bioactive compounds are directly attributed to antioxidant properties against various free radicals. Anti-nutritional factors have to be evaluated before their utilization and consumption. However, recent statistics shows that consumption and utilization of fruits and fruit products is declining. Hence, more scientific studies is required in elucidating the structure and properties of important bioactive compounds present in these minor wild edible fruits, so that more awareness is created among the consumers, which will subsequently benefit to fight several nutrition related problems.

REFERENCES

Abhishek M., Thangadurai D., 2015. Proximate composition, nutritive value and antioxidant activity of *Flacourtia montana* J. Graham. (Salicaceae). *Vegetos*, 28, 181-187.

Acharya S.B., Tripathi S.K., Tripathi Y.C., Pandey V.B., 1988. Some pharmacological studies on *Zizyphus rugosa* saponins. *Ind J Pharm*, 20, 200-202.

Ajiboye A.A., Oyedara O.O., Agboola D.A., Familola O.T., 2014. Evaluation of antibacterial effects and phytochemical analysis of *Lantana camara* Linn leaf and berry extracts. *Euro J Med Plants*, 4, 332-341.

Bafna P.G., 2012. Optimization of process parameters for extraction of Kokum (*Garcinia indica*) fruit pulp using response surface methodology (RSM). *Int J Sci Eng Res*, 3, 1-7.

Baggett S., Protiva P., Mazzola E.P., Yang H., Ressler E.T., Basile M.J., Bernard W., Edward J.K., 2005. Bioactive benzophenones from *Garcinia xanthochymus* fruits. *J Nat Prod*, 68, 354-360.

Baliga M.S., Bhat H.P., Pai R.J., Boloor R., Palatty P.L., 2011. The chemistry and medicinal uses of the underutilized Indian fruit tree *Garcinia indica* Choisy (kokum): a review. *Food Res Int*, 44, 1790-1799.

Baliga M.S., Kurian P.J., 2012. *Ixora coccinea* Linn.: traditional uses, phytochemistry and pharmacology. *Chin J Integrative Med*, 8, 72-79.

Baslas R.K., Kumar P., 1979. Chemical examination of the fruits of *Garcinia xanthochymus*. *Curr Sci*, 48, 814-815.

Batugal P.A., 2004. Inventory and documentation of medicinal plants in 14 Asia Pacific countries. In *Medicinal plants research in Asia: the framework and project work plans*, Batugal PA, Jayashree K, Lee SY, Jeffrey TO (eds), International Plant Genetic Resources Institute - Regional Office for Asia, the Pacific and Oceania, Serdang, 3-6.

Bhat D.J., Kamat N., Shirodkar A., 2005. Proceedings of 2nd National Seminar on Kokum (*Garcinia indica* Choicy), Goa University, Goa.

Bhat R., Ameran S.B., Voon H.C., Karim A.A., Tze L.M., 2011. Quality attributes of star fruit (*Averrhoa carambola* L.) juice treated with ultraviolet radiation. *Food Chem*, 127, 641-644.

Bhat S., Bhandary M.J., Rajanna L., 2014. Plant diversity in the homegardens of Karwar, Karnataka, India. *Biodiversitas*, 15, 229-235.

Bhat S.S., Rajanna L., 2016. Plant diversity studies and role of Halakki community in agroforestry homegardens of Uttara Kannada district, Karnataka, India. *Int J Life Sci*, 5, 54-62.

Bose S., Maji S., Chakraborty P., 2011. Comparative study of *in vitro* and *in vivo* antioxidant property of different *Ixora* species. *J Adv Pharma Educ Res*, 2, 90-103.

Chakraborty R.N., Sastry L.V.L., Pruthi J.S., 1977. Study on chemical composition and recovery of pectin from cashew apple waste (residue). *J Inst Chem*, 49, 145-151.

Chanmahasathien W., Li Y.S., Satake M., Oshima Y., Ruangrungsi N., Ohizumi Y., 2003. Prenylated xanthones with NGF-potentiating activity from *Garcinia xanthochymus*. *Phytochem*, 64, 981-986.

Chauhan A., Tanwar B., Arneja I., 2015. Influence of processing on physiochemical, nutritional and phytochemical composition of *Carissa spinarum* (karonda) fruit. *Asian J Pharm Clin Res*, 8, 254-259.

Chen Y., Fan H., Yang G.Z., Jiang Y., Zhong F.F., He H.W., 2010. Prenylated xanthones from the bark of *Garcinia xanthochymus* and their 1,1-Diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activities. *Molecules*, 15, 7438-7449.

Dasgupta P., Chakraborty P., Bala N.N., 2013. *Averrhoa carambola*: an updated review. *Int J Pharma Res Rev*, 2, 54-63.

Deshmukh B.S., Shinde V., 2010. Fruits in the wilderness: a potential of local food resource. *Int J Pharma Bio Sci*, 1, 1-5.

Dhanabalan R., Palaniswamy M., Devakumar J., 2014. Total polyphenol and flavonoid content of *Syzygium jambos* (L.) Alston leaf extracts and its *in vitro* DPPH radical scavenging activity. *J Pharm Res*, 8, 593-596.

Facciola S., 1988. *Cornucopia II: a source book of edible plants*. Kampong Publications, California, pp. 1-79.

Fatima A., Singh P.P., Agarwal P., Irchhaiya R., Alok S., Verma A., 2013. Treatment of various diseases by

Carissa spinarum L. – a promising shrub. *Int J Pharm Sci Res*, 4, 2489-2495.

Gayathri A., Benish Rose P.M., Saranya J., Eganathan P., Sujanapal P., Ajay K.P., 2012. Antimicrobial, antioxidant, anticancer activities of *Syzygium caryophyllatum* (L.) Alston. *International Journal of Green Pharmacy*, 6, 285-288.

Harisha R.P., Padmavathy S., 2013. Knowledge and uses of wild edible plants in two communities in Malai Madeshwara Hills, South India. *Int J Bot*, 9, 64-72.

Hebbar S.S., Hedge G.M., Hedge G.R., 2010. Less known wild edible fruits and seeds of Uttar Kannada district of Karnataka. *The Indian Forester*, 136, 1218-1222.

Jadhav R., Datar M.N., Upadhye A.S., 2015. Forest foods of Northern Western Ghats: mode of consumption, nutrition, and availability. *Asian Agri-Hist*, 19, 293-316.

Jagtap P., Bhise K., Prakya V., 2015. A phytopharmacological review on *Garcinia indica*. *Int J Herbal Med*, 3, 2-7.

Jeeva S., 2009. Horticultural potential of wild edible fruits used by the Khasi tribes of Meghalaya. *J Hort Forestry*, 1, 182-192.

John D., 1984. One hundred useful raw drugs of Kani tribe of India. *Int J Crude Drug Res*, 22, 17-39.

Kaennakam S., Sichaem J., Siripong P., Tip-Pyang S., 2013. Chemical constituents of the roots of *Zizyphus rugosa*. *Chem Nat Compd*, 49, 767-768.

Kalegowda P., Haware D.J., Rajarathnam S., Shashirekha M.N., 2015. Minerals of cactus (*Opuntia dillenii*): cladode and fruit. *Curr Sci*, 109, 2295-2298.

Karuppusamy S., Muthuraja G., Rajasekaran K.M., 2011. Antioxidant activity of selected lesser known edible fruits from Western Ghats of India. *Indian J Nat Prod Resources*, 2, 174-178.

Khatoon N., Gupta R.K., Tyagi Y.K., 2015. Nutraceutical potential and phytochemical screening of *Buchanania lanzan,* an underutilized exotic Indian nut and its use as a source of functional food. *J Pharm Phytochem*, 4, 87-94.

Khilari V.J., Sharma P.P., 2016. Studies on ascorbic acid content of some wild edible fruits from Ahmednagar District, Maharashtra (India). *Int J Adv Res*, 4, 583-590.

Kirtikar K.R., Basu B.D., 2005. Indian medicinal plants, Vol. 2, International Book Publisher, Dehradun, pp. 1288-1289.

Konoshima M., Ikeshiro Y., Miyahara S., Yen K.Y., 1970. The constitution of biflavonoids from *Garcinia* plants. *Tetrahedron Lett*, 48, 4203-4206.

Krishnamurthy K., 1996. Indian functional foods: role in prevention of cancer. *Nutri Rev*, 54, 5127-5131.

Krishnamurthy N., Lewis Y.S., Ravindranath B., 1982. Chemical constituents of Kokum fruit rind. *J Food Sci Technol*, 19, 97-100.

Krishnamurthy N., Sampathu S.R., 1988. Antioxidant principals of kokum rind. *J Food Sci Technol*, 25, 44-45.

Krishnamurthy S.R., Sarala P., 2011. Determination of nutritive value of *Ziziphus rugosa* Lamk.: a famine edible fruit and medicinal plant of Western Ghats. *Indian J Nat Prod Resources*, 3, 20-27.

Krishnamurthy S.R., Sarala P., 2013. Phytochemical studies of *Artocarpus gomezianus* Wall. ex Trecul. var. *lakoocha* Roxb. fruits collected from various altitudes of central Western Ghats. *Indian J Nat Prod Resources*, 4, 398-411.

Kumar G.M.P., Shiddamallayya N., 2016. Survey of wild edible fruits in Hassan forest division, Karnataka, India. *J Biodiversity Environ Sci*, 8, 57-66.

Kumar J., Vengaiah P.C., Srivastava P.P., Bhowmick P.K., 2012. Chironji nut (*Buchanania lanzan*) processing, present practices and scope. *Indian Journal of Traditional Knowledge*, 11, 202-204.

Lai T.N.H., André C., Rogez H., Mignolet E., Nguyen T.B.T., Larondelle Y., 2015. Nutritional composition and antioxidant properties of the sim fruit (*Rhodomyrtus tomentosa*). *Food Chem*, 168, 410-416.

Lim T.K., 2012. *Garcinia xanthochymus*. In *Edible Medicinal and Non-Medicinal Plants, Vol. 1, Fruits*, Lim TK (ed), Springer: Dordrecht, The Netherlands, pp. 128-133.

Mahesh M.P., Muhammed Ali M., Anu-Appaiah K.A., 2016. Lipids and fatty acid profiling of major Indian Garcinia fruits: a comparative study and its nutritional impact. *J Am Oil Chem Soc*, 93, 823-836.

Minh N.P., 2015. Production of fermented beverage from Soursop fruit. *Int J Pure App Biosci*, 33, 231-236.

Mohanty S., Ray P., Swain M.R., Ray R.C., 2006. Fermentation of cashew (*Anacardium occidentale* L.) "apple" into wine. *J Food Process Preservation*, 30, 314-322.

Munde V.M., Shinde G.S., Sajindranath A.K., Prabu T., Machewad P.M., 3003. Correlation and path analysis studies in charoli (*Buchanania lanzan* Spreng). *South Indian Horticulture*, 50, 517-521.

Nambiar S.S., Venugopal K.S., Shetty N.P., Anu Appaiah K.A., 2016. Fermentation induced changes in bioactive properties of wine from *Phyllanthus* with respect to atherosclerosis. *J Food Sci Technol*, 53, 2361-2371.

Namera K.C., Vaast P., Kushalappa C.G., 2014. Bioinventory and documentation of traditional ecological knowledge of wild edible fruits of Kodagu - Western Ghats, India. *J Forestry Res*, 25(3), 717-721.

Napahde S., Durve A., Bharati D., Chandra N., 2010. Wine production from carambola (*Averrhoa carambola*) juice using *Saccharomyces cerevisiae. Asian J Exp Biol Sci*, S, 20-23.

Narayanan M.K.R., Anilkumar N., Balakrishnan V., Sivadasan M., Ahmed Alfarhan H., Alatar A.A., 2011. Wild edible plants used by the Kattunaikka, Paniya and Kuruma tribes of Wayanad District, Kerala, India. *J Med Plants Res*, 5, 3520-3529.

Naveen G.P.A.N., Krishnakumar G., 2012. Biochemical analysis and seed oil characterizations of *Garcinia indica*, *G. xanthochymus* and *G. gummi-gutta* for nutritional qualities. *Indian J Sci*, 1, 71-73.

Naveen G.P.A.N, Krishnakumar G., 2013. Traditional and medicinal uses of *Garcinia gummi-gutta* fruit – a review. *Species*, 4, 4-5.

Nayagam M.C., Pushparaj M.S., Rajan S., 1993. Less known edible fruit yielding plants of Nilgiris. *Ancient Science of Life*, 12, 363-376.

Nazarudeen A., 2010. Nutritional composition of some lesser-known fruits used by ethnic communities and local folks of Kerela. *Indian Journal of Traditional Knowledge*, 9, 398-402.

Ojo O.O., Anibijuwon I.I., Ojo O.O., 2010. Studies on extracts of three medicinal plants of South-Western Nigeria: *Hoslundia opposita*, *Lantana camara* and *Cymbopogon citratus*. *Adv Nat Appl Sci*, 4, 93-98.

Panda S.K., Sahu U.C., Behera S.K., Ray R.C., 2014. Bio-processing of bael (*Aegle marmelos* L.) fruits into wine with antioxidants. *Food Biosci*, 5, 34-41.

Pandey V.B., Singh J.P., Khosa R.L., Singh J.P., 1985. Chemical studies on *Zizyphus rugosa* Lam. *J Chem Soc Pak*, 7, 33-35.

Pandey V.B., Tripathi Y.C., Devi S., Singh J.P., Shah A.H., 1988. A cyclopeptide alkaloid from the bark of *Zizyphus rugosa*. *Phytochemistry*, 27, 1915-1918.

Parthasarathy U., Nandakishore O.P., 2014. Morphological characterization of some important Indian Garcinia species. *Dataset Papers in Science*, 823705, http://dx.doi.org/10.1155/2014/823705

Patil R.P., Pai S.R., Pawar N.V., Shimpale V.B., Patil A.M., Nimbalkar M.S., 2012. Chemical characterization, mineral analysis, and antioxidant potential of two underutilized berries (*Carissa carandus* and *Eleagnus conferta*) from the Western Ghats of India. *Crit Rev Food Sci Nutr*, 52, 312-320.

Paul S.K., Sahu J.K., 2014. Process optimization and quality analysis of Carambola (*Averrhoa carambola* L.) wine. *Int J Food Eng*, 10, 457-465.

Peerajan S., Chaiyasut C., Sirilun S., Chaiyasut K., Kesika P., Sivamaruthi B.S., 2016. Enrichment of nutritional value of *Phyllanthus emblica* fruit juice using the probiotic bacterium, *Lactobacillus paracasei* HII01 mediated fermentation. *Food Sci Technol*, 36, 116-123.

Philip J.K.M., Arif A.M., Hemant V., Shylaja G., Mythili S., Sathiavelu A., 2015. Evaluation of antibacterial and antioxidant activity of *Garcinia gummigutta*. *Int J Drug Development Res*, 7, 57-59.

Pooja S., Vidyasagar G.M., 2016. Phytochemical screening for secondary metabolites of *Opuntia dillenii* Haw. *Journal of Medicinal Plants Studies*, 4, 39-43.

Pruthi J.S., Girdhari L., 1955. Passion fruit processing, a new promising line in fruit technology. *Indian Food Packer*, 9, 13-18.

Ragunathan M., Senthamarai R.B., 2014. Pharmacognostical studies on the fruit of *Elaeocarpus oblongus* Gaertn. *Phcog J*, 6, 72-78.

Rai A.K., Prakash M., Anu Appaiah K.A., 2010. Production of Garcinia wine: changes in biochemical parameters, organic acids and free sugars during fermentation of Garcinia must. *Int J Food Sci Technol*, 45, 1330-1336.

Rathod V.S., Valvi S.R., 2011. Anti-nutritional factors of some wild edible fruits from Kolhapur district. *Recent Res Sci Technol*, 3, 68-72.

Reddy C.S., Jha C.S., Dadhwal V.K., 2016. Assessment and monitoring of long-term forest cover changes (1920–2013) in Western Ghats biodiversity hotspot. *J Earth Syst Sci*, 125, 103-114.

Reddy K.N., Pattanaik C., Reddy C.S., Raju V.S., 2007. Traditional knowledge on wild plants in Andhra Pradesh. *Indian Journal of Traditional Knowledge*, 6, 223-229.

Saha M.R., Alam M.A., Akter R., Jahangir R., 2008. *In vitro* free radical scavenging activity of *Ixora coccinea* L. *Bang J Pharmacol*, 3, 90-96.

Sambandan K., Dhatchanamoorthy N., 2012. Studies on the phytodiversity of a sacred grove and its traditional uses in Karaikal District, U.T. Puducherry. *J Phytol*, 4, 16-21.

Sarala P., Krishnamurthy S., 2014. Monkey jack: underutilized edible medicinal plant, nutritional attributes and traditional foods of Western Ghats, Karnataka, India. *Indian Journal of Traditional Knowledge*, 13, 508-518.

Sasikumar J.M., Maheshu V., Smilin A.G., Gincy M.M., Joji C., 2012. Antioxidant and antihemolytic activities of common Nilgiri barberry (*Berberis tinctoria* Lesch.) from south India. *Int Food Res J*, 19, 1601-1607.

Sasikumar J.M., Thayumanavan T.H.A., Subashkumar R., Janardhanan K., Lakshmanaperumalsamy P., 2007. Antibacterial activity of some ethnomedicinal plants from the Nilgiris, Tamil Nadu, India. *Nat Prod Radiance*, 6, 34-39.

Shaheel S.K., Swami D.V., Prasanna Kumar B., Uma Krishna K., 2015. Effect of blending of Karonda (*Carissa carandas* L.) juice with guava, papaya and pineapple juices on its quality and organoleptic evaluation. *Plant Archives*, 15, 187-192.

Sharma P.B., Handique P.J., Sunitibala Devi H., 2015. Antioxidant properties, physico-chemical characteristics and proximate composition of five wild fruits of Manipur, India. *J Food Sci Technol*, 52, 894-902.

Sharvani K.A., Devaki N.S., 2014. Distinct characters of *Elaeocarpus*, a conservation dependent endemic genus of Western Ghats. *Acta Biologica Indica*, 3, 663-667.

Shilpa K.J., Krishnakumar G., 2015. Nutritional, fermentation and pharmacological studies of *Syzygium caryophyllatum* (L.) Alston and *Syzygium zeylanicum* (L.) DC fruits. *Cogent Food Agri*, 1, 1018694.

Singh M., Srivastava S., Rawat A.K.S., 2009. Antimicrobial activity of stem of different *Berberis* species. *Nat Prod Sci*, 2, 60-65.

Singh M.P., Parveen N., Khan N., Achari B., Dutta P., 1991. Constituents of *Garcinia xanthochymus*. *Fitoterapia*, 62, 286-289.

Singh S., Singh A.K., Bagle B.G., More T.A., 2010. Chironji, a potential dry fruit for dry lands. Central Institute for Arid Horticulture, Bikaner,, pp. 1-2.

Sivakamasundari, Karuppusamy S., Parthipan R., 2015. Survey on the RET-listed medicinal plants in Thadagamalai range of Kanyakumari District, Tamilnadu. *J Biodivers Endanger Species*, 3, 1-4.

Sundarapandian S.M., Swamy P.S. Litter production and leaf-litter decomposition of selected tree species in tropical forests at Kodayar in the Western Ghats, Swami S.B., Thakor N.J., Patil S.C., 2014. Kokum (*Garcinia indica*) and its many functional components as related to the human health: a review. *J Food Res Technol*, 2, 130-142.

Uthaiah B.C., 1994. Wild edible fruits of Western Ghats – a survey. In: *Higher plants of Indian subcontinent (Additional Series of Indian Journal of Forestry), Volume 3,* Bishen Singh Mahendra Pal Singh, Dehra Dun, India, pp. 87-98.

Valvi S.R., Gadekar S.S., Jadhav V.D., 2014a. Phytochemical assessment of five wild edible fruits. *Int J Life Sci*, 2, 168-172.

Valvi S.R., Jadhav V.D., Gadekar S.S., Yesane D.P., 2014b. Assessment of bioactive compounds from five wild edible fruits, *Ficus racemosa*, *Elaegnus conferta*, *Grewia tillifolia*, *Scleichera oleosa* and *Antidesma ghasembilla. Acta Biologica Indica*, 3, 549-555.

Valvi S.R., Rathod V.S., Yesane D.P., 2011. Screening of three wild edible fruits for their antioxidant potential. *Curr Bot*, 2, 48-52.

Valvi S.R., Rathod V.S., 2011. Mineral composition of some wild edible fruits from Kolhapur district. *Int J Appl Biol Pharm Technol*, 2, 392-396.

Venkatachalam T., Kishor Kumar V., Kalai Selvi P., Avinash O.M., Anbarasan V., Siva Kumar P., 2011a. Antidiabetic activity of *Lantana camara* Linn. fruits in normal and streptozotocin-induced diabetic rats. *J Pharm Res*, 4, 1550-1552.

Venkatachalam T., Kishor Kumar V., Kalai Selvi P., Avinash O.M., Senthil Kumar N., 2011b. Physicochemical and preliminary phytochemical studies on the *Lantana camara* (L.) fruits. *Int J Pharm Pharm Sci*, 3, 52-54.

Vinay S.M.N., Venkatachalapathy R., Hanumanthappa M.K., Ramesh B.S., 2014. Phytochemical analysis and antimicrobial activity of *Artocarpus hirsutus*: an *in-vitro* study. *Int J Pharm Bio Sci*, 5, 98-104.

Wani R.A., Prasad V.M., Hakeem S.A., Sheema S., Angchuk S., Dixit A., 2013. Shelf life of Karonda jams (*Carissa carandas* L.) under ambient temperature. *Afr J Agric Res*, 8, 2447-2449.

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PROXIMATE ANALYSIS AND MINERAL COMPOSITION OF POTENTIAL MINOR FRUITS OF WESTERN GHATS OF INDIA

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Abstract

A study on fifteen minor fruits belonging to eleven families was undertaken. The fruits were harvested from different geographic locations of Western Ghats, viz., Uttar Kannada, Dharwad and Ooty. Ethnobotanically, various parts of these plants are utilized for treatment of wide array of health disorders such as jaundice, diabetes and dysentery. Fruits were screened for their proximate composition and mineral content. Further the relationship and variation between different attributes analyzed was investigated using two different statistical approaches such as principal component analysis and agglomerative hierarchical clustering. Phenological characters among the studied fruits varied greatly indicating that the fruits occur at different seasons of a year. In the present study, proximate and mineral composition analysis of the fruits indicated that these minor fruits are rich source of nutrients and minerals. Study indicated that fruits such as Carissa spinarum, Opuntia dillenii, Flacourtia indica, Syzygium caryophyllatum, Ixora coccinea, Buchanania cochinchinensis and Phoenix sylvestris contained adequate quantity of nutrients. PCA analysis revealed variability of 53.97% as contributed by the first two components. Cluster analysis classified the fruits into four major groups. Therefore, these underutilized fruits act as potential source of essential nutrients and minerals to the rural communities and can find application in the nutraceutical and food industries.

***Key words**: agglomerative hierarchical clustering, minerals, proximate composition, principal component analysis, underutilized fruits.*

INTRODUCTION

Fruits are essential part of human diet. They comprise good amount of antioxidants and essential nutrients such as polyphenols, flavonoids, minerals and vitamins (WHO, 2003). Inadequate consumption of fruits has resulted in several serious disorders. Regular intake of fruits and their products has shown lower incidence of cardiovascular diseases and cancer (Grivetti and Ogle, 2000; Anand et al., 2008; Hall et al., 2009). In addition, they have also been attributed to increase the immunity against various infections (Veer et al., 2000; Bernstein et al., 2002; Seeram, 2008). Minor fruits such as wild, unutilized and under utilized serve as alternative for food during food deficit and are considered as most valuable nutritional supplements for diet. It is pertinent to mention that a tropical country like India has more than 150 species of edible minor fruit species (Mazumdar, 2004; Mitra et al., 2008; Giampieri et al., 2012). In addition, these fruits act as source of income for rural communities. Small fruits are utilized and consumed more in rural areas in comparable to that of urban areas. Some of the small are rich source of nutrients and known to be beneficial for health. However, due to insufficient knowledge and increased urbanization, consumption and utilization of these fruits are declining and in most cases neglected. Previous reports suggests that these fruits comprise fair amount of essential nutrients and minerals which may not be found in cultivated fruits (Stadlmayr et al., 2013; Rahman and Rahman, 2014).

Minerals play a predominant role in maintaining good health (Maughan et al., 1999). Essential minerals help to fight diseases and promote good health. Many previous epidemiological reports suggest that lack of essential minerals in dietary intake can result in increased incidence of diseases (Key et al., 2004). Lack of essential minerals, *viz*., iron, zinc, sodium, copper and magnesium in the body cause some chronic diseases including cardiovascular disease, diabetes and hypertension (Steyn et al., 2004; Volpe, 2013). Moreover, human body cannot synthesize these minerals sufficiently and only they can be obtained externally through the diet (Nath and Gill, 1993; Milton, 2003).

Nowadays, chemometric tools finds application in easy determination and classification of geographic origin of food products based on the complex experimental data (Alonso-Salces et al., 2006; Woodcock et al., 2007). Previous reports indicate that principal component analysis (PCA) has been successfully employed to characterize various food products based on their antioxidant capacities, phenolic content and geographical origin (Rodríguez-Delgado et al., 2002; Wesolowski and Konieczynski, 2003). For instance, PCA was used to evaluate similarities and variations among 10 different Icelandic seaweeds depending on their phenolic content and antioxidant activity (Wang et al., 2009). In another study, PCA was used to categorize pomegranate juices depending on their antioxidant profiles and thus they could observe key determinants (Cam et al., 2009). PCA acts as powerful statistical tool that allows illustration of variations and similarities between multiple factors depending on multi-dimensional experimental data. More recently, Patras et al. (2011) evaluated the application of chemometric tools, *viz*., principal component analysis and cluster analysis to distinguish between fruits and vegetables depending on their antioxidant profiles, wherein different antioxidant groups were considered for the study.

The present study was undertaken to evaluate the proximate and mineral composition of fifteen potential under utilized fruits from Western Ghats of India. Further two statistical tools such as PCA and cluster analysis were employed to characterize and distinguish the fruits based on their nutrient composition.

MATERIALS AND METHODS

Study area and fruit collections

Fifteen minor fruits were collected from different location of Western Ghats, India, whose scientific names, vernacular names and the place of collection has been shown in Table 1. All the collected fruits were determinated and herbarium was deposited at the Department of Botany, Karnatak University, Dharwad, India.

Proximate analysis and mineral composition

The fruits were washed cleanly, manually deseeded, chopped in to small pieces and oven dried at 45±5°C. Further the samples were pulverized into fine powder with the help of pestle and mortar. This was used for further analysis. Proximate composition of fruits was analyzed following methods of AOAC (2005). Briefly, nitrogen content was determined using the Kjeldahl method and protein content was calculated by multiplying nitrogen conversion factor (6.25). Moisture was determined by heating 5g of powdered sample in a hot air oven at 100±2°C until constant weight was obtained. Crude fat was determined by acid digestion which was further extracted with petroleum ether in a Soxhlet apparatus. Ash value was determined by incinerating the sample at 550±5°C for 5-6 h. Crude carbohydrate was calculated using the formula: 100 – (moisture – protein – fibre – fat – ash). Calorific value was calculated with Atwater conversion factor (4 for protein and carbohydrate and 9 for total fat). Minerals such as phosphorus (P), potassium (K), copper (Cu), iron (Fe), magnesium (Mg), zinc (Zn), calcium (Ca) and sodium (Na) of the fruits were determined following the methods of AOAC (2005) using atomic absorption spectrophotometer.

Statistical analysis

Triplicate analysis was carried out and values are represented as mean of three assays on a dry weight basis. XLSTAT software (2014.5.03, Addinsoft, NY) was used for principal component analysis (PCA) and agglomerative hierarchical clustering (AHC).

RESULTS AND DISCUSSIONS

The selected minor fruits used in the presented study are depicted in Figure 1 and the results of proximate composition and mineral content is represented in Table 2 and Table 3, respectively. Based on the calorific values, the fruits can be ranked in descending order as *P. dulce* > *B. cochinchinensis* > *S. caryophyllatum*

> *P. sylvestris* > *E. tectorius* > *S. pinnata* > *P. loureirii* > *F. indica* > *C. spinarum* > *I. coccinea* > *Z. oenopolia* > *S. anacardium* > *O. dillenii* > *S. jambos* > *A. cardiosperma*. The ash content of the fruits denotes the overall availability of minerals. The ash value varied from 3.36-0.24% from highest to lowest. Fats are essential as they are rich source of energy, further they help in absorption and transportation of fat-soluble vitamins especially A, D, and E. Generally, fruits comprise very low amount of fat (Lichtenstein and Van Horn, 1998). However, in the present study the fruits showed considerable variations in the fat content. *P. sylvestris*, *P. loureirii*, *B. cochinchinensis* and *E. tectorius* showed higher content of fat in comparable to rest of fruits. Among the minerals, iron is considered as an essential as it provides energy and supplies oxygen. Iron deficiency may lead to anaemia (Cook, 2005). Magnesium deficiency may lead to severe disorders such as diarrhoea, hypertension and cardiovascular diseases (Swaminathan, 2003). Nevertheless, it helps to tackle muscle cramping. Calcium accounts for most predominant element in the body and is essential in regulating muscle contractions and formation of bones (Soetan et al., 2010). Zinc is associated with cell growth and testosterone production, further it aids in metabolism of vitamins A and E. It is reported that its deficiency may cause several severe disorders including poor appetite and night blindness (Evans, 1986). In the present study, among the analyzed fruits, *P. sylvestris*, *P. loureirii*, *B. cochinchinensis* and *E. tectorius* exhibited a higher value of minerals when compared to other fruits.

Table 1. Botanical description of minor fruits collected and used in the present study

Scientific name	Local name	Family name	Place of collection	Abbreviation
Aporosa cardiosperma (Gaertn) Merr.	Salle mara	Phyllanthaceae	Uttar Kannada	AC
Buchanania cochinchinensis (Lour.) M.R.Almeida	Nurukalu hannu	Anacardiaceae	Uttar Kannada	BC
Carissa spinarum L.	Kouli hannu	Apocynaceae	Uttar Kannada	CS
Elaeocarpus tectorius (Lour.) Poir	Bikki palzam	Elaeocarpaceae	Ooty	ET
Flacourtia indica (Burm.f.) Merr.	Karimullu hannu	Salicaceae	Uttar Kannada	FI
Ixora coccinea L.	Hole daswala	Rubiaceae	Uttar Kannada	IC
Opuntia dillenii (Ker Gawl.) Haw.	Papaskalli	Cactaceae	Dharwad	OD
Phoenix loureiroi var. *pedunculata* (Griff.) Govaerts	Tale karjura	Arecaceae	Dharwad	PL
Phoenix sylvestris (L.) Roxb.	Kadu karjura	Arecaceae	Dharwad	PS
Pithecellobium dulce (Roxb.) Benth.	Seeme hunase	Leguminosae	Dharwad	PD
Semecarpus anacardium Blanco	Gerr hannu	Anacardiaceae	Dharwad	SA
Spondias pinnata (L. f.) Kurz	Huli amate	Anacardiaceae	Uttar Kannada	SP
Syzygium caryophyllatum (L.) Alston	Kuntu nerle	Myrtaceae	Uttar Kannada	SC
Syzygium jambos (L.) Alston	Pannerale	Myrtaceae	Uttar Kannada	SJ
Ziziphus oenopolia (L.) Mill.	Pargi hannu	Rhamnaceae	Uttar Kannada	ZO

PCA employed in the present study reduced the data dimensionally and represented the experimental data in a simpler way. Principal components (PC) 1 and 2 explained 54% of total variance of data. The biplot for PC1 vs PC2 is depicted in Figure 2. Figure 2a clearly indicates the scatterplot of distinction between different fruits. It is apparent from these biplots that fruits can be easily categorized depending on their nutrient contents. Figure 2b explains the location of minor fruits in the quadrants based on the factor loadings, *viz*., proximate composition and mineral components. The minor fruits such as *O. dillenii*, *S. anacardium* and *C. spinarum* contained a significant amount of fibre, potassium and sodium. Further *P. sylvestris*, *P. loureirii*, *B. cochinchinensis* and *E. tectorius* were found to contain fair amount of ash, fat, phosphorus, iron, zinc and magnesium; whereas, *P. dulce*, *S. caryophyllatum* and *S. pinnata* fruits were rich in carbohydrates, protein and calcium. Nevertheless, fruits such as *S. jambos*, *A. cardiosperma*, *F. indica*, *I. coccinea* and *Z. oenopolia* expressed high content of moisture. Copper was found in moderate quantity in all the fruits located in the lower bottom of the components.

AHC categorized the minor fruits into four major groups based on similarities. Dendrogram has been depicted in Figure 3 which clearly distinguishes minor fruits in to four main clusters and exhibited a significant correlation with the PCA analysis. The first cluster included *A. cardiosperma*, *S. jambos*, *Z. oenopolia* and *I. coccinea* which have been clustered orderly depending on their moisture content, whereas second cluster was represented by *O. dillenii*, *S. anacardium* and *C. spinarum* based on higher content of fibre, potassium and sodium, among these three *O. dillenii* showed slight higher content that's how it formed different sub cluster. Cluster 3 had 3 fruits wherein *S. pinnata* formed a single sub cluster, *S. caryophyllatum* and *F. indica* showed similar pattern. Finally, cluster 4 comprised 5 fruits, wherein the first sub cluster represented two fruits *P. sylvestris* and *P. loureirii*, which were almost similar in nutrient composition while the second subcluster had *E. tectorius*, *P. dulce* and *B. cochinchinensis*. Further *P. dulce* and *B. cochinchinensis* showed much more similarity. Fruits observed in cluster 4 exhibited higher content of ash, fat, phosphorus, iron, zinc and magnesium.

Table 2. Proximate composition of ripened minor fruits on dry weight basis*

Scientific name	Moisture (%)	Ash (%)	Crude fat (%)	Crude Fibre (%)	Crude protein (%)	Crude carbohydrate (%)	Calorific value (Kcal/100g)
Aporosa cardiosperma (Gaertn) Merr.	91.45	0.24	0.18	1.03	1.44	5.66	30.02
Buchanania cochinchinensis (Lour.) M.R.Almeida	63.01	1.45	0.43	2.59	1.69	30.83	133.9
Carissa spinarum L.	79.86	0.49	1.82	1.95	1.31	14.57	79.90
Elaeocarpus tectorius (Lour.) Poir	72.18	2.76	1.13	2.23	3.69	18.01	96.97
Flacourtia indica (Burm. f.) Merr.	74.12	2.09	0.21	2.96	2.42	18.20	84.37
Ixora coccinea L.	78.94	0.98	0.51	1.24	1.56	16.85	78.23
Opuntia dillenii (Ker Gawl.) Haw.	81.91	0.73	1.01	5.48	0.88	8.99	48.57
Phoenix loureiroi var. *pedunculata* (Griff.) Govaerts	73.89	2.53	0.63	3.27	2.44	17.24	84.39
Phoenix sylvestris (L.) Roxb.	70.44	2.08	0.57	3.52	2.18	21.21	98.69
Pithecellobium dulce (Roxb.) Benth.	60.54	3.36	0.51	1.83	2.53	31.23	139.6
Semecarpus anacardium Blanco	78.01	1.41	1.84	4.33	3.04	11.37	74.21
Spondias pinnata (L. f.) Kurz	74.01	2.06	0.71	1.29	2.13	19.89	94.47
Syzygium caryophyllatum (L.) Alston	66.76	1.08	0.93	3.73	3.22	24.09	119.3
Syzygium jambos (L.) Alston	87.71	0.76	0.22	1.76	0.84	8.71	40.18
Ziziphus oenopolia (L.) Mill.	78.45	0.77	0.11	2.23	1.81	16.72	74.30

*Values are represented as mean of three determinations

Table 3. Mineral composition of ripened minor fruits on dry weight basis (mg/100g)*

Scientific name	P	K	Cu	Fe	Mg	Zn	Ca	Na
Aporosa cardiosperma (Gaertn) Merr.	22.2	131.8	0.40	1.78	42.52	0.25	20.11	33.98
Buchanania cochinchinensis (Lour.) M.R.Almeida	53.3	229.2	0.21	4.49	61.89	0.88	61.54	21.22
Carissa spinarum L.	16.1	217.5	0.31	7.42	75.34	0.57	31.54	33.77
Elaeocarpus tectorius (Lour.) Poir	49.2	188.3	0.65	4.16	39.36	0.88	31.56	21.81
Flacourtia indica (Burm. f.) Merr.	11.1	142.8	0.04	1.11	18.91	0.33	51.12	44.12
Ixora coccinea L.	24.5	287.5	1.01	0.81	28.39	0.67	11.54	11.87
Opuntia dillenii (Ker Gawl.) Haw.	32.6	642.8	0.02	3.22	10.73	0.95	19.54	116.5
Phoenix loureiroi var. *pedunculata* (Griff.) Govaerts	28.4	288.3	0.41	9.81	59.63	0.78	22.43	51.65
Phoenix sylvestris (L.) Roxb.	32.5	131.1	0.32	9.91	58.89	0.71	24.43	43.41
Pithecellobium dulce (Roxb.) Benth.	49.1	212.3	0.66	4.76	95.87	0.61	44.98	12.45
Semecarpus anacardium Blanco	29.7	248.6	0.48	3.97	66.51	0.16	26.11	22.67
Spondias pinnata (L. f.) Kurz	23.5	165.2	0.73	2.25	31.37	0.62	66.41	21.09
Syzygium caryophyllatum (L.) Alston	14.1	42.14	0.12	1.04	19.83	0.15	44.41	21.31
Syzygium jambos (L.) Alston	20.2	66.91	0.91	1.22	4.934	0.12	28.99	80.92
Ziziphus oenopolia (L.) Mill.	18.3	128.5	0.51	4.73	19.04	0.65	29.01	12.76

*Values are represented as mean of three determinations

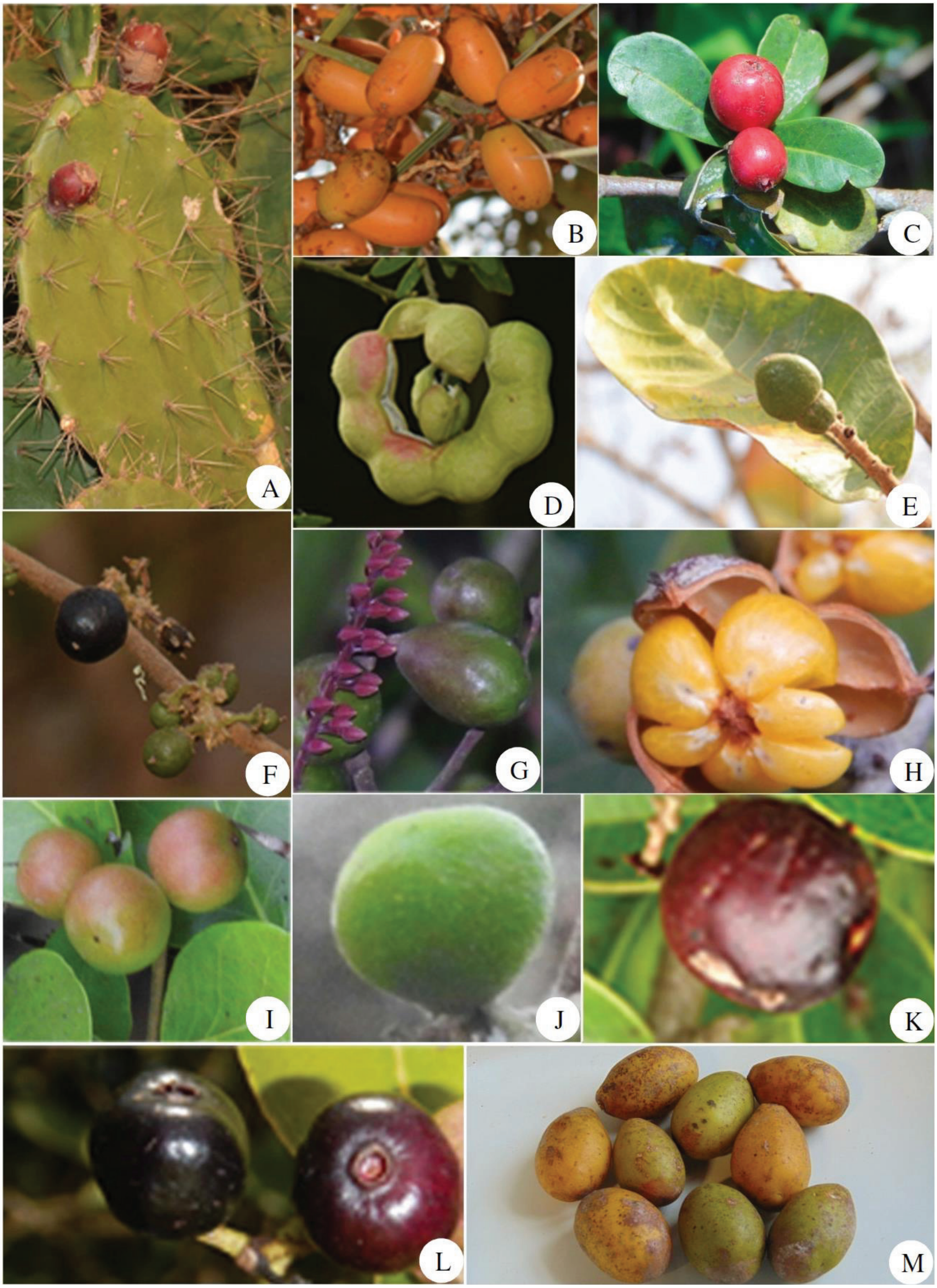

Figure 1. Minor fruits used in the present study for proximate and mineral analysis: (A) *Opuntia dillenii*; (B) *Phoenix loureirii* var. *pedunculata*; (C) *Ixora coccinea*; (D) *Pithecellobium dulce*; (E) *Semecarpus anacardium*; (F) *Ziziphus oenopolia*; (G) *Elaeocarpus tectorius*; (H) *Aporosa cardiosperma*; (I) *Carissa spinarum*; (J) *Buchanania cochinchinensis*; (K) *Flacourtia indica*; (L) *Syzygium caryophyllatum*; (M) *Spondias pinnata*

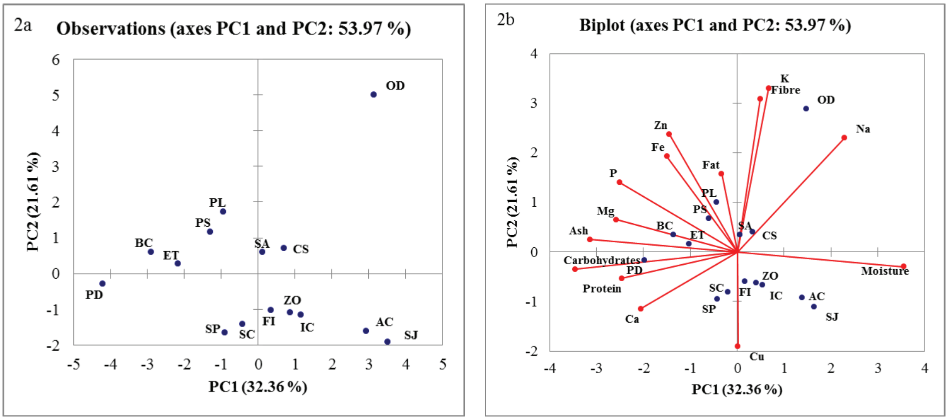

Figure 2. PC1 vs PC2 biplots indicating variability among types of fruits: 2a: biplot showing distinction between minor fruits; 2b: biplot highlighting fruits with different variables, *viz*., proximate composition and mineral content

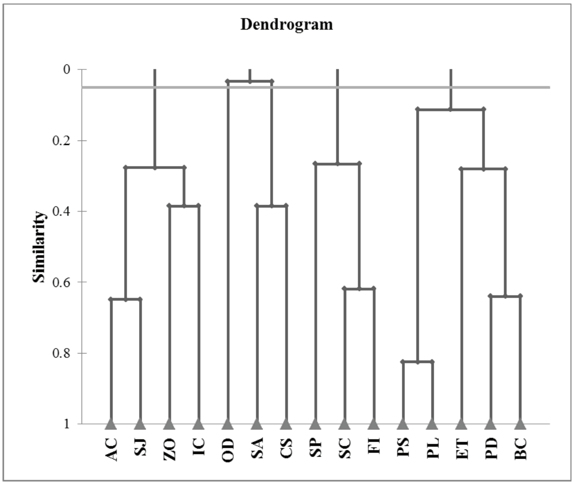

Figure 3. Dendrogram depicting agglomerative hierarchical clustering of minor fruits

CONCLUSIONS

Considerable variations were observed between fruits in terms of nutrient composition. The study thus provided deeper insights on the nutrient composition of the fifteen types of fruits. Moreover, the present study endorses the potential use of these fruits in the near future by food and nutraceutical industries through commercialization by domestication. Further, utilizing these bioresources which are available in plenty during the glut season, can offer local employment and can improve the economy of rural communities.

REFERENCES

Alonso-Salces R.M., Herrero C., Barranco A., Lopez-Marquez D.M., Berrueta L.A., Gallo B., 2006. Polyphenolic compositions of Basque natural ciders: a chemometric study. Food Chem., 97(3):438-446.

Anand P., Kunnumakara A.B., Sundaram C., Harikumar K.B., Tharakan S.T., Lai O.S., Sung B., Aggarwal B.B., 2008. Cancer is a preventable disease that requires major lifestyle changes. Pharm Res., 25:2097-2118.

AOAC, 2005. Official Methods of Analysis of Association of Official Analytical Chemists, Washington, D.C., 777-784.

Bernstein M.A., Nelson M.E., Tucker K.L., Layne J., Johnson E., Neurenberger A., Castaneda C., Judge J.O., Buchner D., Singh M.F., 2002. Home-based nutrition intervention to increase consumption of fruits, vegetables and calcium-rich foods in community dwelling elders. Journal of the American Dietetic Association, 102:1421-1427.

Cam M., Yasar H., Durmaz G., 2009. Classification of eight pomegranate juices based on antioxidant activity measured by four methods. Food Chem., 112:721-726.

Cook J.D., 2005. Diagnosis and management of iron-deficiency anaemia. Best Pract Res Clin Haematol., 18:319-332.

Evans G.W., 1986. Zinc and its deficiency diseases. Clin Physiol Biochem., 4(1):94-98.

Giampieri F., Tulipani S., Alvarez-Suarez J.M., Quiles J.L., Mezzetti B., Battino M., 2012. The strawberry: composition, nutritional quality, and impact on human health. Nutrition, 28:9-19.

Grivetti L.E., Ogle B.M., 2000. Value of traditional foods in meeting macro- and micronutrient needs: the wild plant connection. Nutrition Research, 13:31-46.

Hall J.N., Moore S., Harper S.B., Lynch J.W., 2009. Global variability in fruit and vegetable consumption. American Journal of Preventive Medicine, 36(5):402-409.

Key T.J., Schatzkin A., Willett W.C., Allen N.E., Spencer E.A., Travis R.C., 2004. Diet, nutrition and the prevention of cancer. Public Health Nutrition, 7(1A):187-200.

Lichtenstein A.H., Van Horn L., 1998. Very low fat diets. Circulation, 98:935-939.

Maughan R.J., 1999. Role of micronutrients in sport and physical activity. Br Med Bull., 55(3):683-690.

Mazumdar B.C., 2004. Minor Fruit Crops in India, Daya Publishing House, New Delhi, 1-109.

Milton K., 2003. Micronutrient intakes of wild primates: are humans different? Comparative Biochemistry and Physiology, 136:47-59.

Mitra S.K., Pathak P.K., Chakraborty I., 2008. Potential use of underutilized crops for nutritional and medicinal properties. In: Smith J., Haq N. (Eds.), New crops and uses, their role in rapidly changing world, Southamption University, UK, 1-357.

Nath R., Gill K.D., 1993. Health and disease: role of magnesium and trace minerals. APH Publishing, New Delhi, 1-188.

Patras A., Brunton N.P., Downey G., Rawson A., Warriner K., Gernigon G., 2011. Application of principal component and hierarchical cluster analysis to classify fruits and vegetables commonly consumed in Ireland based on *in vitro* antioxidant activity. Journal of Food Composition and Analysis, 24:250-256.

Rahman M., Rahman J., 2014. Medicinal value and nutrient status of indigenous fruits in Bangladesh. Nova Journal of Medical and Biological Sciences, 3(4):1-9.

Rodríguez-Delgado M.A., González-Hernández G., Conde-González J.E., Pérez-Trujillo J.P., 2002. Principal component analysis of the polyphenol content in young red wines. Food Chemistry, 78(4):523-532.

Seeram N.P., 2008. Berry fruits: compositional elements, biochemical activities, and the impact of their intake on human health, performance, and disease. J. Agric. Food Chem., 56(3):627-629.

Soetan KO., Olaiya CO., Oyewole OE., 2010. The importance of mineral elements for humans, domestic animals and plants: a review. African Journal of Food Science, 4(5):200-222.

Stadlmayr B., Charrondière UR., Eisenwagen S., Jamnadass R., Kehlenbeck K., 2013. Nutrient composition of selected indigenous fruits from sub-Saharan Africa. J Sci Food Agric., 93(11):2627-2636.

Steyn N.P., Mann J., Bennett P.H., Temple N., Zimmet P., Tuomilehto J., Lindstrőm J., Louheranta A., 2004. Diet, nutrition and the prevention of type 2 diabetes. Public Health Nutrition, 7(1A):147-165.

Swaminathan R., 2003. Magnesium metabolism and its disorders. The Clinical Biochemist Reviews, 24(2):47-66.

Veer P.V., Jansen M.C., Klerk M., Kok F.J., 2000. Fruits and vegetables in the prevention of cancer and cardiovascular disease. Public Health Nutrition, 3(1):103-107.

Volpe S.L., 2013. Magnesium in disease prevention and overall health. Adv Nutr. 4:378S-383S.

Wang T., Jonsdottir R., Olafsdottir G., 2009. Total phenolic compounds, radical scavenging and metal chelation of extracts from Icelandic seaweeds. Food Chem., 116:240-248.

Wesolowski M., Konieczynski P., 2003. Thermoanalytical, chemical and principal component analysis of plant drugs. International Journal of Pharmaceutics, 262:29-37.

WHO, 2003. Chronic disease: key risk factors include high cholesterol, high blood pressure, low fruit and vegetable intake. World Health Organization, Geneva, Switzerland.

Woodcock T., Downey G., Kelly J.D., O'Donnell C., 2007. Geographical classification of honey samples by near infrared spectroscopy: a feasibility study. Journal of Agricultural and Food Chemistry, 55:9128-9134.

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MODERN METHODS IN CEREALS AUTHENTICATION

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Abstract

Common and durum wheat are widelly used for many purposes and the prices are significantly different for each wheat type, thus efficient methods for detection of accidental or intentional admixtures of common wheat to durum wheat products, and vice-versa, are required. The aim of this study is to identify some characteristics of the Triticum aestivum genetic material witch will be useful in developing methods for determination of the quality and authenticity of this species. Melting, DNA methylation and RAPD analysis can be used to discriminate between wheat species/varieties.

***Key words**: Triticum aestivum, authentication, food safety, Romania.*

INTRODUCTION

Wheat is the world's most prevalent plant due to various industrial use.
Romania has approximately 10 million hectares of cultivated arable land (more than 2 million hectares are cultivated with wheat). Main production area is the Danube plain in the south of the country. Other important wheat growing areas are Transylvania, the northern part of Moldova in north-eastern Romania and the Banat region in the South West. According to data preserved by Ministry of Agriculture and Rural Development, wheat has the largest acreage in Romania (2043.0 thousand hectares in 2015), recording a continuously growing production (in 2015 3842 kg/ha) (http://www.madr.ro/culturi-de-camp/cereale/grau.html).
At present, a large number of wheat varieties were obtained by genomic selection or genetic engineering (Bhalla et al., 2006).
From those, *Triticum aestivum* L. (also named *Triticum vulgare*, *Triticum aestivum* subp. *aestivum*) and *Triticum turgidum* ssp. *durum* (includes durum and red durum) are the most cultivated species of wheat. *Triticum aestivum* L. (common wheat) is a hexaploid species of wheat. (www.ogtr.gov.au/internet/ogtr/publishing.nsf/Content/wheat-3/$FILE/biologywheat08.pdf).
It is almost completely processed into flour and the rest is used in different types of food.
Triticum turgidum ssp. *durum* is mainly used for the production of pasta and macaroni, but as well for the production of bread.
Determination of the quality and authenticity of *Triticum* wheat is important for industry, food safety and consumer protection (Knodler et al., 2010). The investigation field is broad (Korzun et al., 1997; Pegels et al., 2015; Prandi et al., 2012) due to growing wheat variety, the large number of industrial processing steps and also to merchandising diversity of bakery and pastry products.
Several methods that can identify varieties that are genuine from forged products (substitution of wheat varieties with other grains species of wheat or mixtures in different proportions) are described in the literature (Arlorio et al., 2003). Some of these methods are based on molecular biology techniques (e.g. particularly the analysis of specific protein fractions and DNA analysis of wheat varieties) (Osborne, 1996). Peculiarities of wheat varieties, degree of maturation, ecological conditions, soil processing techniques, physico-chemical

composition and technological peculiarities make the standardization of these methods and identification of wheat species/varieties even more difficult.

The aim of this study was to identify some characteristics of the *Triticum aestivum* L. genetic material which will be useful for developing methods for determination of the quality and authenticity of wheat species.

MATERIALS AND METHODS

The analysed wheat samples were: *Triticum aestivum* Glosa variety, *Triticum aestivum* Excelsior variety, *Triticum durum* Condurum variety, *Triticum durum* Grandur variety, *Triticale* Haiduc variety (all of them are originated from National Agricultural Research and Development Institute Fundulea experimental plots, Calarasi county). The samples were collected in 2014. Each sample consisted of approximately 500 g of wheat. The samples were selected after harvesting.

The characteristics of these samples were analysed by molecular methods based on the Random Amplified Polymorphic DNA (RAPD) technique, thermal denaturation profile of DNA molecules and DNA methylation analysis.

DNA was extracted from the selected probes with SureFood® PREP Plant X (R-Biopharm, Germany) according to manufacturer's instructions. The quality of the DNA extract was verified by electrophoretic and spectrophotometric methods (Beckman DU170 spectrophotometer). Every DNA sample was considered as an average of two measurements and it was accepted if the acceptance range for DNA quality value was between 1.7 and 2.

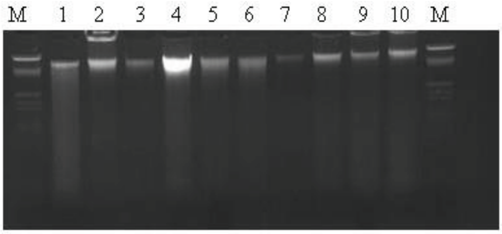

Figure 1. Agarose gel electrophoresis from wheat genomic DNA. Lines: 1,2-*Triticum aestivum* Glosa variety; 3,4-*Tritcum aestivum* Excelsior variety; 5,6-*Triticum durum* Condurum variety; 7,8-*Triticum durum* Grandur variety; 9,10-*Triticale*; M marker Lambda DNA/EcoRI + Hind III

1. Analysis of thermic denaturation curves in the presence of fluorophore- Melting Analysis

Initially an incubation of mixture at 35ºC/2 minutes was used to settle the basal fluorescence of samples. Denaturation curve of DNA samples was recorded, based on a series of fluorescence readings every minute, with a 5 seconds incubation at constant temperature before every reading (to allow fluorescence stabilization of the DNA denaturation equilibrium at every step).

Denaturation curves and data analysis were performed with HRM or melting analysis on a Corbett RotorGene 6000 (HRM module) device.

2. DNA Methylation analysis

The methylation profiles of DNA were analysed with izoschizomere enzymes Msp and Hpa. Reaction mixture contained: DNA (20 µl), restriction endonuclease (10 U), restriction buffer (2.5µl), H_2Odd till final volume of 30µl. Reaction mixture was incubated for 3 hours at 37ºC, in continuous stirring water bath. Restriction reaction was stopped by adding loading buffer. The restriction products were resolved by electrophoresis (agarose gel 0.8%).

3. RAPD analysis

Hexanucleotide OPA primers were used for RAPD technique. The composition of the mixture used for amplification was: PCR buffer 1.2 µl, dNTP 0.4 µl, Taq polimerase 0.4 µl, OPA primers 0.25 µl, double-distilled H_2O 8.75 µl, DNA 1 µl. The amplification products were separated in 2% agarose gel (stained with ethidium bromide whereas the small fragments were separated in PAGE 8%).

RESULTS AND DISCUSSIONS

1. Profile analysis of thermal distortion in the presence of fluorophore - Melting Analysis

Denaturation curves analysis can be used to characterize the genome composition in nitrogenous bases and for DNA molecules discrimination. An improvement of the technique was made by introducing fluorescent dyes. These methods allow the accurate recording of fluorescence changes at temperature variations of at least 0.1°C.

The denaturation curves profile for all DNA samples were heterogeneous and, regardless of fluorophore used (e.g. SYBR Green or Eva Green), the results of analysis were difficult to interpret. One possible explanation of these results was the different distribution of AT or GC base pairs in different regions of genome of the analysed species. The optimization method was performed by changing the amount of DNA (10-25 µl), the range of temperature used for denaturation (55-98ºC), the frequency of fluorescence readings (1 fluorescence reading at every 0.1ºC, 0.5ºC or 1ºC sample warming) and the fluorophore used.

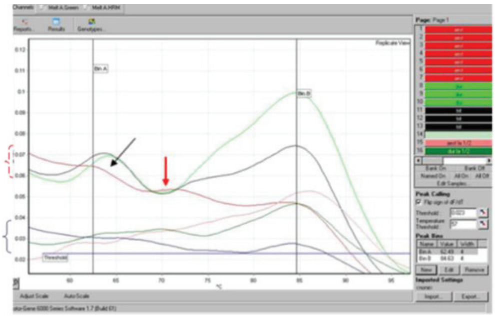

Figure 2. Denaturation profiles for *Triticum durum* Condurum variety; *Triticale* Haiduc variety and *Triticum aestivum* Glosa variety (melting analysis)

In Figure 2 the upper curve was obtained from an amount of 2.5 times higher than bottom one (SYBR Green 1x; denaturation range 55 to 95ºC, 1 reading at 0.5ºC, replicate view).

The effect of the amount of DNA used for each determination is revealed in the Figure 2. Our results indicated that at low concentrations of DNA certain peaks in the distortion curve are difficult to be identified. Thus, our results regarding the effect of the amount of DNA on the denaturation curves are consistent with previously published data in other scientifical papers. The best results were obtained for reading of 25 µl DNA, recording of fluorescence with a frequency of 1 reading at every 1°C increase of sample temperature, with a heavy digital filter for fluorescence noise and in replication analysis module.

Repeating the experiment showed similar patterns of bands, with similar differences (replicated view).

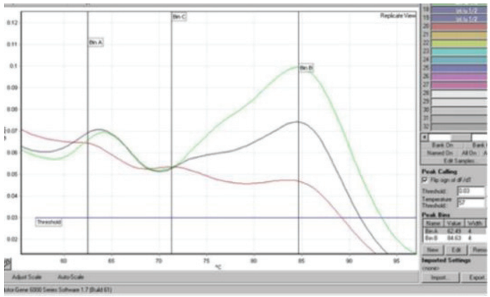

Figure 3. Analysis of melting curves showed some variation features of fluorescence between the analysed species of wheat. The most evident differences were recorded when the fluorescence was read at every 1°C increase of sample temperature (replication results, heavy digital filter). *Legend:* red – denaturation curve for *Triticum aestivum*, green- denaturation curve for *Triticum durum,* black -denaturation curve for *Triticale*

Melting analysis may reveal significant differences between *Triticum aestivum*, *Triticum durum* and *Triticale*. The differences between melting curves obtained for *Triticum aestivum*, *Triticum durum* and *Triticale* was most evident for 60-68°C and 83-92°C temperature interval. These differences may reflect the percent of AT and GC in these region. In the range of 60-68°C the pattern of denaturation curves obtained for *Triticum durum* and *Triticale* samples differs significantly from that produced by *Triticum aestivum*. These regions may be used in development of molecular methods useful for identification of species of wheat.

2. DNA Methylation analysis

DNA methylation occurs in both animals and plants. The first applied model was the plant *Arabidopsis thaliana* (Cokus et al., 2008) and, since then, has been applied to many plant species. Genomic DNA methylation in plants can occur symmetrical or non-symmetrical. Investigation of DNA methylation may provide new data about factors which may involve in gene transcription and phenotypic variation in booth plants and animals. Our results are in agreement with the data reported in the literature (Gardiner et al., 2015).

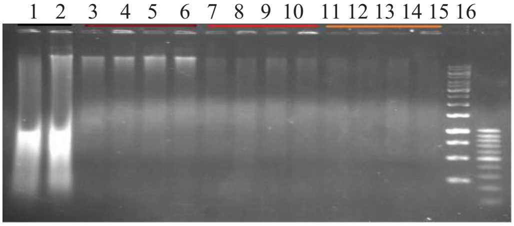

Figure 4. Agarose gel electrophoresis from wheat genomic DNA.
Legend: Lines: 1-2 DNA mammal verification; 3-6 Triticale; 7-8: *Triticum durum* Grandur variety; 9-10: *Triticum durum* Condurum variety; 11-12: *Triticum aestivum* Excelsior variety; 13-14: *Triticum aestivum* Glosa variety; 15: 1kb GeneRuler DNA Leadde (Fermentas); 16: 100 bp GeneRuler DNA Leadde (Fermentas), (0.8% agarose gel).

3. RAPD analysis

Random Amplified Polymorphic DNA analysis is a technique which does not require any specific knowledge of the DNA sequence of the target organism. RAPD analysis showed that a low number of genetic markers for drought tolerance in wheat are polymorphic (18.6%) (Deshmukh et al., 2012).

We determined 4-12 electrophoretic bands/ sample of DNA, according to the primers used and the concentration of the genomic DNA extract from *Triticum aestivum* Glossa variety and *Triticum durum* Condurum variety. Most of the bands resulted were not polymorphic (polymorphic bands are indicated in the brace and the arrows indicate monomorphic bands). However, the bands number and pattern is insufficient to determine efficiently the wheat species.

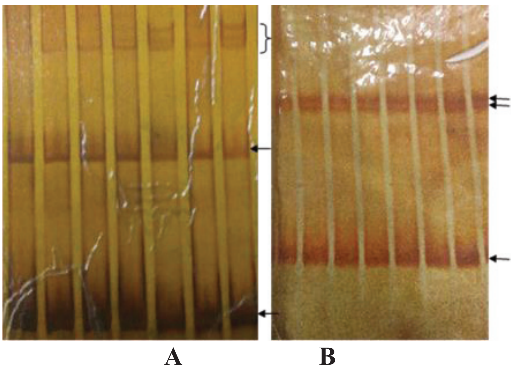

Figure 5. The image of an acrylamide gel, where there were separated amplification products with different random hexamer primers type OPA (A, B)

CONCLUSIONS

Based on the results obtained in this study we can formulate the following conclusions:

Melting analysis may reveal differences between *Triticum aestivum*, *Triticum durum* and *Triticale*.

The mehtylation profile presented the biggest differences in *Triticale* comparativ to *Triticum aestivum* and *Triticum durum,* and the smallest differences in *Triticum aestivum* and *Triticum durum.* The mehtylation profile was similar within the samples from the same species.

The RAPD analysis showed the existence of 4-12 bands that can be used to determine wheat species. The results can be influenced by the amount and purity of the genetic material used in the reaction.

The varieties/species of wheat can also be determined with the help of molecular analysis, but they need some special conditions, related to the amount and the quality of the genetic material needed for analysis.

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REFERENCES

Arlorio M., Coisson J. D., Cereti E., Travaglia F., Capasso M., Martelli A., 2003. Polymerase chain reaction (PCR) of puroindoline b and ribosomal/puroindoline b multiplex PCR for the detection of common wheat (*Triticum aestivum*) in Italian pasta. Eur Food Res Technol, 216:253–258.

Bhalla P., Ottenhof H.H., Singh M.B., 2006. Wheat transformation - an update of recent progress. Euphytica, 149:353-366.

Cokus S.J., Feng S., Zhang X., Chen Z., Merriman B., Haudenschild C.D., Pradhan S., Nelson S.F., Pellegrini M., Jacobsen S.E., 2008. Shotgun bisulphite sequencing of the *Arabidopsis* genome reveals DNA methylation patterning. Nature, 452: 215–219.

Deshmukh R., Tomar N.S., Tripathi N., Tiwari S., 2012. Identification of RAPD and ISSR markers for drought tolerance in wheat (*Triticum aestivum* L.). Physiology and molecular biology of plants: an international journal of functional plant biology.

Gardiner L.J., Quinton-Tulloch M., Olohan L., Price J., Hall N., Hall A., 2015. A genome-wide survey of

DNA methylation in hexaploid wheat. Genome Biology, 16:273.
Knodler M., Most M., Schieber A., Carle R., 2010. A novel approach to authenticity control of whole grain durum wheat (*Triticum durum* Desf.) flour and pasta, based on analysis of alkylresorcinol composition. Food Chemistry, 118:177–181.
Korzun V., Borner A., Worland A.J., Law C.N., Roder M.S., 1997. Application of microsatellite markers to distinguish inter-varietal chromosome substitution lines of wheat (*Triticum aestivum* L.). Kluwer Academic Publishers, Euphytica, 95: 149–155.
Osborne B. G., 1996. Food Authentication. Springer US, Chap. Authenticity of cereals, 171-197.
Pegels N., Gonzalez I., Garcia T., Martín R., 2015. Authenticity testing of wheat, barley, rye and oats in food and feed market samples by real-time PCR assays. LWT - Food Science and Technology, 60: 867-875.
Prandi B., Bencivenni M., Tedeschi T., Marchelli R., Dossena A., Galaverna G., Sforza S., 2012. Common wheat determination in durum wheat samples through LC/MS analysis of gluten peptides. Anal Bioanal Chem, 403:2909–2914.
http://www.madr.ro/culturi-de-camp/cereale/grau.html.
http://www.ogtr.gov.au/internet/ogtr/publishing.nsf/Content/wheat-3/$FILE/biologywheat08.pdf

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SOME MECHANICAL PROPERTIES OF SOYBEAN (*Glycine max*) STEMS AND SEEDS

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Abstract

Harvesting is the most important operation in soybean production. To develop a new harvesting machine with any cutting system, we have to exactly know cutting properties of stems and seeds. Firstly, the design of the machine was based on cutting properties.
This study was carried out to evaluate the stem cutting properties and mechanical behavior under compression load of soybean grains (Glycine max L.). This research was conducted at the Department of Agricultural Machinery and Technologies Engineering, University of Dicle, Diyarbakır, Turkey. The soybean cultivar, SA-88, used for this study. It was obtained from the local a commercial farm in Diyarbakir Province, Turkey.
In this research, Cutting force (CF), cutting strength and cutting energy (CE) for stems and seeds were measured by considering cross sectional area at during the harvesting season in year 2016.
Cutting properties of soybean stems and compression properties of seeds were measured by The Lloyd LRX plus materials testing machine.
The highest pod cracking force was observed as 13.43 N at vertical orientation, while the least value of cracking force was determined as 4.59 N at horizontal position. According to Tukey's multiple range tests, the internodes effects were not found significant effect on seed force and energy. The average cracking force and energy were obtained as 146. 62 N and 10.05 N.cm, respectively. Cutting force values increased linearly with the increase in stem diameters.

***Key words**: soybean, cutting properties, pod detachment, energy.*

INTRODUCTION

Harvesting and threshing are the most important operations in soybean production. Knowledge of the physical and mechanical properties of soybean stem and seeds are therefore particularly important for the optimization of harvesting, threshing, drying and storing processes, as it translates into minimization of losses and mechanical damage (Kuźniar et al., 2016). Soybean usually is harvested in the autumn season with high air relative humidity and possibility of rainfall. In this condition, the moisture content of soybean pods and stems are high, so during the harvesting and threshing operations, some problems can be occurred and conventional combine harvester can`t harvest of stem, thresh and separate the bean from its pod properly. Determination of mechanical properties of soybean pod is needed for designing and fabrication of pre-threshing dryer on combine harvester (Azadbakht et al., 2012). Pod distribution along the plants and the operational characteristics of existing combines require the entire crop to be cut before being threshed, separated and cleaned (Mesquita and Hanna., 1993; Sessiz, 2003). The threshing cylinder of a combine requires about 40% of the combine engine power. The cylinder is high because the cylinder processes the stem in addition to the pods. The amount of energy necessary to shatter soybean decreases as the moisture content of the soybeans decreases. A small amount of energy is necessary to open soybean pods at impact velocities similar to those imported by the reel and cutter-bar of a combine. The energy required to shatter soybean pod is significantly correlated with moisture content and impact velocity (Mesquita and Hanna., 1995; Sessiz, 2003). More information on the physical and mechanical properties of soybean is necessary for the efficient use of energy in harvesting and threshing of soybean. Specially designed equipment was developed to reduce harvesting losses, mainly due to pod shattering. Header components were modified to reduce impact on

soybean pods and to reduce the cutting height (Mesquita and Hanna., 1995). Shear force and shear strength of stems are important data in design of harvesting and threshing machine (Sessiz, 2003).
The objective of this study was to determine the relationship between soybean stem cutting properties and seed cracking force and energy at during the harvesting time depend on internodes along whole plant, to determine relationship between cutting properties, seed cracking and pod detachment force along ascendant nodes of the whole plant stems.

MATERIALS AND METHODS

The study was performed with SA-88 soybean variety. The samples were obtained from a commercial farm in Diyarbakır province, which is located in the southeastern part of Turkey. The cutting tests were carried out during the harvesting season in September 2016, soybean plants which have between three internodes that it is has different diameter were randomly harvested by hand from field. Harvested and collected soybean plants which have different internode were transported to laboratory of Department of Agricultural Machinery and Technologies Engineering, University of Dicle.
This study was conducted in two phases. The first phase consist of the determination of stem cutting force were measured. In the second phase, seed cracking force was determined under compressive load.
The initial moisture content of the stems and seeds were determined using ASABE standard involving the oven-drying method. In order to determine the initial moisture content of soybean stems, three samples of 30 g were weighed and dried in an oven of 105 ^{o}C for 24 hours (ASABE, 2006; Taghijarah et al., 2011; Sessiz et al., 2013; Sessiz et al., 2015), after oven drying, samples were removed from oven. Then samples reweighed to obtain the final moisture content using the gravimetrical method. The weights were measured using electronic scales with a capacity of 1.2 kg and with a precision of 0.01 g. The moisture content of stem was determined at 28.34% w.b.
The soybean stem cutting was determined along whole plant (stem and leaves) from first internode to three internodes during the harvesting time. Prior to the tests, the soybean stem was cutted into three different groups. The first group stems were selected between 0-20 mm plant heights; the second groups were selected between at 40-60 cm plan height. The third groups were selected between at 80-100 cm plant height. The average whole plant length and the first pod height was observed as 100.5 cm and 15.5 cm, respectively.
The cutting tests were performed by Lloyd LRX Plus Materials Testing Machine (Figure 1). In cutting tests, the test samples were placed on the machine loading table in its flat position. Loading was applied vertical direction. The cutting knife was steel, 50 mm width, 6 mm thickness and the blade angle of 17^{o}. Cutting measurement were performed at 100 mm/min fixed loading speed for all tests (Sessiz et al., 2013; Sessiz et al., 2015). Cracking force is one of the parameters in the mechanical properties (Putri et al., 2015).

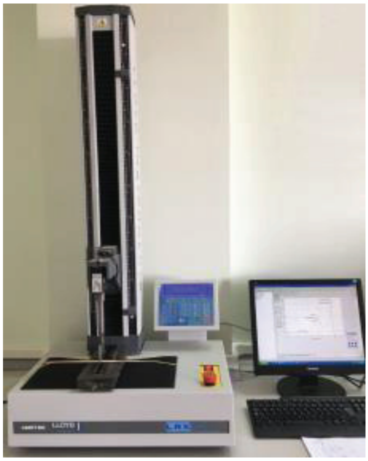

Figure 1. The Lloyd LRX Plus Materials Testing Machine

The cutting energy was calculated by measuring the surface area under the force-deformation curve (Chen et al., 2004; Heidari and Chegini, 2011; Sessiz at al., 2015; Nowakowski, 2016). The cutting energy and displacement was calculated by material testing machine. A computer data acquisition system recorded all the force-displacement curves during the cutting process.
Soybean grain cracking forces were determined by Lloyd LRX Plus Materials Testing Machine.

For each treatment, 20 soybean grains were randomly selected to measure the cracking force and pod cracking force in horizontal and vertical orientation under compressive load by the testing machine. Also, pod detachment force from stem of plant were measured by using a pull digital force gauge (Model FG-20, Lutron Instrument) (Figure 2).

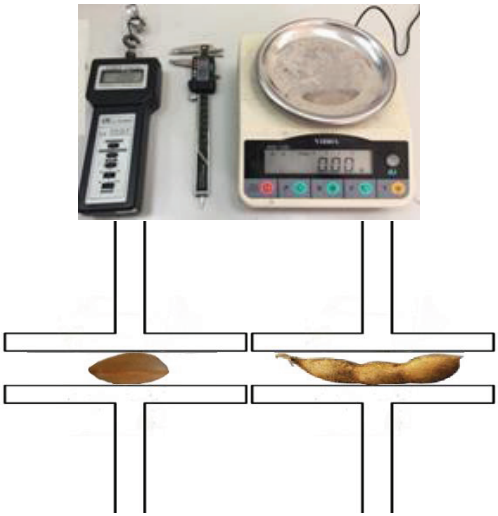

Figure 2. Force gauge and loading directions

The experiment was planned as a completed randomized plot design, and data were analyzed using The General Linear Model (GLM). Mean separations were made for significant effects with LSD and the means were compared at the 1% and 5% levels of significance using the Tukey multiple range tests in JMP software, version 11.

RESULTS AND DISCUSSIONS

The mean values of the pod cracking force and pod detachment force at different nodes are presented in Table 1. As shown in Table 1, the variance analysis of the obtained data indicated that the effect of internode diameter and plant height point on pod cracking force both horizontal and vertical orientation under compressive, and pod detachment force from stem was significant at 5 % possibility level. There was no significant difference between force levels vertical and horizontal oriental. There were not found differences between the second and third internodes results ($p>0.05$). But, there was found significant differences between the first internodes values and other internodes ($P<0.05$). This may be explain that at the first internode exactly was pod not opened. However, there was no differences among the nodes along the plant length in terms of pod detachment force ($p>0.05$). This results similar was found by Sessiz (2003) and Mesquita and Hanna (1995). Detachment force for each per pod was observed approximately 6.5 N by Sessiz (2003). The highest pod cracking force was observed as 13.43 N at vertical orientation, while the least value of cracking force was determined as 4.59 N at horizontal position. The forces required to detach pods from stems were not correlated with pod location along ascendant nodes for the SA-88 cultivar.

Table 1. The pod cracking and pod detachment force depending on along plant stem height

Internode (cm)	Vertical Force (N)	Horizontal Force (N)	Mean Force (N)	Pod Detachment Force (N)
N1[2] (20-40)	13.44^{a1}	8.19^{a}	10.81^{a}	4.55^{ns}
N2(40-60)	8.94^{b}	5.52^{b}	7.23^{b}	4.37^{ns}
N3 (80-100)	8.77^{b}	4.45^{b}	6.68^{b}	4.06^{ns}
LSD	0.1226	0.1226	0.119	0.122
Mean	10.38^{a}	6.10^{b}	8.24	4.33^{ns}

[1]means followed by the same letter in each column are not significantly different by Tukey's multiple range test at the 5 % level.
[2]IN1, IN2 and IN3: first, second and third internodes, respectively

The mean values of seed cracking force and cracking energy at different internodes are shown in Table 2. According to Tukey's multiple range tests, the internodes effects was not found significant effect on seed cracking force and energy under load. The seed cracking force was changed between 143.78 N and 149.45 N. The average values of cracking force and energy were obtained as 146.62 N and 10.05 N.cm, respectively (Table 2).

Table 2. The average values of seed cracking force and energy

Height (cm)	Cracking Force (N)	Cracking Energy (N.cm)
N1 (20-40)	149.45	10.17
N2 (40-60)	146.65	8.16
N3 (80-100)	143.78	11.83
Mean	146.62	10.05

The average results of cutting force and cutting energy are shown in Table 3. According to Tukey's tests result, cutting force values increased with an increase in the stem internodes depend on plant height. But, there were no significant differences between the cutting forces along internodes (Table 3). However, the cutting energy requirement increased depends on internodes. There were found significant differences between internodes ($p<0.05$). At top internode, the cutting energy value is lower than the other internodes (Table 3). The lowest cutting forces were determined at top internode of whole plant.

Table 3. The average values of cutting force and cutting energy depend on cut height

Height (cm)	Maximum Cutting Force (N)	Cutting Energy (N.cm)
N1 (20-40)	303[a]	211.99[a]
N2 (40-60)	230[a]	146.48[ab]
N3 (80-100)	218[a]	116.48[b]
LSD	0.1214	0.1214
Mean	250.63	158.31

CONCLUSIONS

The highest pod cracking force was observed as 13.43 N at vertical orientation, while the least value of cracking force was determined as 4.59 N at horizontal position. The forces required to detach pods from stems were not correlated with pod location along ascendant nodes for the SA-88 cultivar.

According to Tukey's multiple range tests, the internodes effects were not found significant effect on seed force and energy. The average cracking force and energy were obtained as 146. 62 N and 10.05 N.cm, respectively.

Cutting force values increased linearly with the increase in stem diameters. But, there were no significant differences between the cutting forces along internodes (Table 3). However, the cutting energy requirement increased depends on internodes. There were found significant differences between internodes ($p<0.05$). At top internode, the cutting energy value is lower than the other internodes (Table 3).

REFERENCES

ASABE Standards, 2006. S358.2: 1:1 Measurement – Forages. 52nd edn. American Society of Agricultural Engineers, St Joseph MI.

Azadbakht M., Khoshtaghaza M.H., Gobadian B., Minaei S., 2012. Mechanical properties of soybean pod as a function of moisture content and energy. Journal of Agricultural Technology, 8(4), 1217-1228.

Chen Y., Gratton J.L., Liu J. 2004. Power requirements of hemp cutting and conditioning. Biosystems Engineering, 87(4), 417–424.

Heidari A., Chegini G.R. 2011. Determining the shear strength and picking force of rose flower. Agricultural Engineering. Ejpau, 14(2), 13.

Kuźniar P., Szpunar-Krok E., Findura P., Buczek J., Bobrecka-Jamro D., 2016. Physical and chemical properties of soybean seeds determine their susceptibility to mechanical damage. Zemdirbyste-Agriculture, 103(2), 183–192.

Mesquita C.M., Hanna M.A., 1995. Physical and mechanical properties of soybean crops. Transaction of the ASAE, 38(6), 1655-1658.

Nowakowski T., 2016. Empirical model of unit energy requirements for cutting giant miscanthus stalks depending on grinding process parameters. Annals of Warsaw University of Life Sciences – SGGW, Agriculture No 67 (Agricultural and Forest Engineering) 63–70.

Putri R.E., Yahya A., Adam N.M., Aziz S.A., 2015. Correlation of moisture content to selected mechanical properties of rice grain samples. International Journal on Advanced Science Engineering Information Technology, 5(5), 264-267.

Sessiz A., 2003. Physical and mechanical properties of soybean crops and their relationship. Indian Journal of Agricultural Engineering, 40(2), 30-38.

Sessiz A., Eliçin A.K., Esgici R., Özdemir G., Nozdrovický L., 2013. Cutting properties of olive sucker. Acta Technologica Agriculturae. The Scientific Journal for Agricultural Engineering, The Journal of Slovak University of Agriculture in Nitra, 16(3), 80–84.

Sessiz A., Esgici R., Özdemir G., Eliçin A.K., Pekitkan F.G., 2015. Cutting properties of different grape varieties. Agriculture & Forestry, 61(1) 211-216.

Taghijarah H., Ahmadi H., Ghahderijani M., Tavakoli M., 2011. Shearing characteristics of sugar cane (*Saccharum officinarum* L.) stalks as a function of the rate of the applied force. AJCS, 5(6), 630-634.

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GRAIN QUALITY OF DURUM WHEAT AS AFFECTED BY PHOSPHORUS AND COMBINED NITROGEN-PHOSPHORUS FERTILIZATION

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Abstract

The influence of phosphorus and combined N-P fertilization on durum wheat grain quality under conditions of long term fertilizing experiment in cotton-durum wheat crop-rotation during the period 2011-2013 was studied. The treatments were: N_0P_0; N_0P_{80}; N_0P_{120}; N_0P_{160}; $N_{120}P_{80}$; $N_{120}P_{120}$; $N_{120}P_{160}$. The experimental design was the method of Latin square with trial plot size 50 m^2 in four replications. The test weight and 1000 kernel weight of durum wheat variety. Progress slightly depended on phosphorus fertilization at rates of P_{80-160}. Average for the period, the largest grain of 59.96 g was obtained after the high phosphorus rate of 160 kg.ha^{-1} and in years with favorable conditions during vegetation. With contents of mineral nitrogen in soil below 40 mg.kg^{-1}soil and phosphorus fertilization at rates P_{80-160} was obtained total vitreousness in the range of 49.20 - 53.0% and crude protein concentration within 12.37 - 12.60%. When N_{120} was added, vitreousness of grain increased to 79.38 - 84.52% and the protein concentration in the grain increased significantly to 14.95%. Combined fertilization $N_{120}P_{80}$ was the optimal system, wherein grain was obtained with the highest content of wet (34.07%) and dry (13.10%) gluten, while the combination of nitrogen rate N_{120} and higher than P_{80} tended to decrease the gluten content. Drought at the end of durum wheat vegetation in June led to grain with higher vitreousness and content of the wet and dry gluten.

***Key words**: durum wheat, gluten, grain quality, phosphorus, protein.*

INTRODUCTION

The productivity and quality of durum wheat varies to a wide range in dependence of a number of factors: agroecological conditions, genetic potential of the cultivar, crop-rotation, soil fertility, applied fertilization, cultivation technology, etc. (Delchev, 2009; Delchev and Panayotova, 2010; Delchev and Petrova, 2012; Gerdzhikova et al., 2013; Lalev et al., 2000; Moral, 2003; Panayotova, 2001; Panayotova and Kostadinova, 2011; Petrova, 2009). Weather conditions in the years and applied fertilizers exert great influence on the grain yield and quality of durum wheat (Abad et al., 2004; Ammes et al., 2003; Koleva-Lizama and Panayotova, 2002; Panayotova and Dechev, 1997).

Optimizing the mineral nutrition is one of the most important conventions for a favorable growth, production and quality of the plants, for ensuring their need of nutrient elements, for increasing the soil fertility. The fertilization of durum wheat grown after cotton should be complied with the fact that a significant part of the nitrogen for cotton is not utilized by it, but remains in soil. The two crops are successfully developed in crop-rotation and when fertilized actively participate in the nutrient utilization (Panayotova, 1999). A number of studies (Pacucci et al., 2004; Panayotova and Yanev, 2001) establish fertilization efficiency for varieties with different genetic endowments in different soil fertility. Panayotova (2001) appoints a genotype specific in relation with grain yield depending on the nutrition level. It is generally acknowledged that the varieties vary in their responsiveness to nitrogen accumulation in the vegetative parts. In breeding rarely takes into account the specifics of output forms in terms of mineral nutrition and are predicted possible results. So in recent years, agrochemical assessment of varieties and hybrids are emerging as a component in modern selection (Johnson, 2004; Sylvester-Bradley and Kindred, 2009). Grain quality is the most important criterion in the breeding of durum wheat to produce high quality pasta.

Experimental data indicate that the new genotypes combine high productivity with good quality. The problems for genetically transmitted and improved grain quality under different varieties of durum wheat are the subject of extensive scientific work (Mariani, 1995; May et al., 2008; Panayotova and Gorbanov, 1999; Panayotova and Valkova, 2010; Rharrabti et al., 2003; Uppal et al., 2002). Many studies have been conducted to examine the effects of N fertilizers and pre-crop on cereal grain yield. Some authors (Bauer et al., 1987; Carcea, 2003; Kostadinova, 2000) reported that the increasing N rate and rich soil fertility enhanced the content of grain protein and N in the straw. The responsiveness of different cultivars to N accumulated in the vegetative plant parts was established (May et al., 2008; Panayotova, 2010).
The aim of this study was to investigate the influence of the long-term phosphorus fertilization and combined nitrogen-phosphorus fertilization on grain quality of durum wheat.

MATERIALS AND METHODS

The investigation was studied under conditions of long term fertilizing experiment. The standard variety Progress, selected in Institute of field crops - Chirpan, Bulgaria was grown in two field crops rotation cotton-durum wheat under rainfed conditions for the period of three growing seasons including years 2011 – 2013. The experimental design was the method of Latin square with trial plot size 50 m^2 in four replications. The treatments were as follows: N_0P_0; N_0P_{80}; N_0P_{120}; N_0P_{160}; $N_{120}P_{80}$; $N_{120}P_{120}$; $N_{120}P_{160}$. The phosphorus fertilization was applied before sowing as a triple superphosphate. The nitrogen as ammonium nitrate (34% N) for durum wheat was applied by hand two times: one third - at sowing, and the rest as a top dressing at the end of wheat tillering stage (Feekes stage 4-5). The seeds were sown on October 25-30 in a sowing rate of 450 germinated seeds per m^2. Weeds were controlled between the tillering and shoot elongation stages with herbicides. There were no pathogens and pests above the threshold of harm during the durum wheat vegetation period in the three growing years and chemicals praying was not carried out. The harvest with plot combine was occurred on July10-15.
The main quality parameters of grain were studied: test weight ($kg.hl^{-1}$) - determined with libra; 1000 kernel weight (g) – by weighting two samples with 500 kernels; total vitreousness (%) - by cutting with pharinotom of Heinsdorf; the content of crude protein – by Kjeldahl standard method after combustion with sulfuric acid and derived according to: Protein, %= N (% DM) x 5.7; and wet and dry gluten (%) - with Gluten washing apparatus and by drying.
In regard with the meteorological conditions on grain quality unfavorable influence had the high temperatures during the period April to June in the three years and heavy precipitation in May-June in 2012 and 2013. During the winter period were not counted critical negative temperatures and no frost bite of crop (Figures 1 and 2).

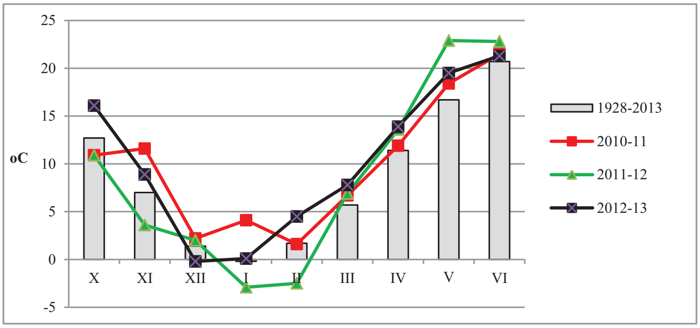

Figure 1. The average air temperatures during the vegetation period of durum wheat, 2011-2013

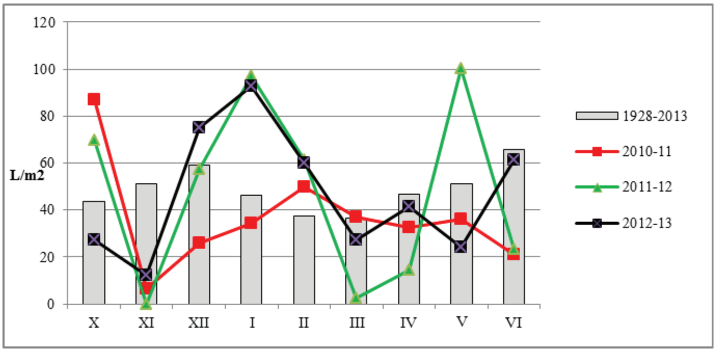

Figure 2. Sum of rainfall during the vegetation of durum wheat, 2011-2013

The soil in the field was *Pellic Vertisols* (FAO). It characterized with high humidity capacity and small water-permeability, defined by the sand-clay composition. The test field was with bulk weight of the plough soil layer 1.2 g/m^3 and specific gravity - 2.45. The sorbcium capacity was 35-50 mequ/100 g soil. The soil was of slightly acid soil reaction pH 6.2. The effect of different fertilizing systems on the contents of mineral nitrogen and the available forms of phosphorus and potassium in the soil is presented in Table 1.

Table 1. Content of mineral nitrogen and available phosphorus and potassium in the soil depends on fertilization

Fertilization	Depth, cm	N_{min}, mg.kg^{-1}	P_2O_5, mg.100g^{-1}	K_2O, mg.100g^{-1}
N_0P_0	0-20	19.63	3.3	17.9
	20-40	14.24	1.95	16.4
N_0P_{80}	0-20	20.02	18.6	18.2
	20-40	16.94	16.2	16.4
N_0P_{120}	0-20	19.74	19.7	18.4
	20-40	16.18	18.0	16.8
N_0P_{160}	0-20	21.56	21.6	18.6
	20-40	16.56	19.6	17.3
$N_{120}P_{80}$	0-20	43.12	19.9	20.1
	20-40	28.49	17.9	17.6
$N_{120}P_{120}$	0-20	43.82	19.8	19.4
	20-40	33.11	18.0	18.8
$N_{120}P_{160}$	0-20	44.34	21.2	19.2
	20-40	27.52	20.2	18.6

The content of mineral nitrogen as sum of NH_4-N and NO_3-N in the arable layer and in the 30-60 cm layer was 19.63-44.34 mg.kg^{-1} and 14.24 - 33.11 mg.kg^{-1}soil respectively, and the higher values were observed with nitrogen-phosphorus fertilization. Phosphorus fertilization led to enrichment with mobile phosphates. The soil in the plowing layer from low (3.3 mg/100 g soil at the unfertilized control) reached well-supplied with available phosphate (21.65 mg/100 g at P_{160}). The analyzes showed that the *Pellic Vertisols* was well supplied with mobile potassium - 17.95-20.1 mg/100 g soil in the plowing layer and 16.40-18.80 mg/100 g soil in layer 30-60 cm. Enrichment of plowing layer with phosphorus and potassium was more intense compared to that in 30-60 cm layer. Phosphorus fertilization enriched the subsoil with mobile phosphates - from 1.95 mg/100 g at P_0 to 18.02 mg at P_{120}, and to 19.65 mg/100 g at P_{160}. This is the result of long-term fertilization with phosphorus under a 50-years stationary fertilization trial.

RESULTS AND DISCUSSIONS

The test weight of grain during the period 2011-2013 had good values - more than 80.50 kg and conformity with the quality standard (Table 2). Different fertilizing systems influenced the test weight, and the differences were proven during the three analized years, despite their very close values. Average for the period, the highest proven test weight was reported as a result of natural soil fertility - 80.98 kg, and the lowest after phosphorous fertilization P_{120} - 80.50 kg (Table 2). In 2011, combined fertilization $N_{120}P_{160}$ formed a proven highest test weight of 81.15 kg, while the lowest was after fertilization with P_{120} - 80.05 kg. The highest values proven to exceed all systems of fertilization were reported in 2012 at unfertilized control - 81.20 kg, and were lowest at the high phosphorous rate of 160 kg P_2O_5.ha^{-1} and a background of N_{120} - 80.40 kg. In 2013, just like the previous year, a check had the highest values of the index, whereas the lowest value of 80.45 kg was reported to the combined nitrogen-phosphorous fertilization at a rate of $N_{120}P_{80}$.

The test weight in 2011 increased by raising the level of combined fertilization, and in 2012 and 2013 had lower values as compared to control, which was associated with different precipitation and temperature supply at the end of the vegetation period when the qualitative parameters were being formed. In the different years, average for all fertilizing systems, the test weight was within very narrow limits and the differences were not proven mathematically (Table 2).

Average for the three analized statistically years, despite the proven differences between some of the variants, the 1000 kernel weight in variety Progress had similar values and was not strongly dependant on the system of fertilization (Table 3). The largest grain average for the period of study was established at the highest level of combined fertilization $N_{120}P_{160}$ - 55.52 g, which was 4 % more than the lowest 1000 kernel weight at high phosphorus fertilization P_{160} - 53.46 g. In 2011, the largest grain (similar to the average values for the whole period of study) was reported at the high phosphorus level of P_{160} and background of N_{120}- 59.96 g, which was proven to exceed all the other systems. The lowest values were at phosphorus fertilization P_{160}– 7% less than $N_{120}P_{160}$. In 2012, the 1000 kernel weight was highest compared to the other systems at $N_{120}P_{80}$ - 57.40 g, and it was lowest for the control - 55.00 g. In the last year of study, the strongest effect on size formation for wheat grain was observed with the combination $N_{120}P_{120}$ - 52.04 g, whereas the weakest was at N_0P_{160} - 48.38 g. The obtained higher values after combined NP fertilization could be explained by both manifested synergy between nitrogen and phosphorus in terms of assimilation by the wheat plants and increase in grain yield, and by their influence on the 1000 kernel weight. The average weight of 1000 kernels showed its highest values in 2011 - 57.34 g, which was more with 1.28 g than in 2012. The smallest grain was formed during the hot and dry year of 2013, which was characterized by insufficient rainfall during the ear formation – flowering period, which was an average of 14 % less than in 2011 (Table 3). Bozhanova et al. (2006) also reported a decreasing 1000 kernel weight in years of drought, and Abdullah (2009) found that the weight of grain was negatively affected by high temperatures and water deficit during filling and maturity of grain.

Average for the period, the total vitreousness after phosphorous fertilization on durum wheat was not high - 49.20-53.0%. According to some researchers, phosphorus fertilization decreased grain vitreousness, according to others – there was no effect on this parameter, and according to still others – it had positive effect. In the present study the increase of level of phosphorus fertilization from 80 to 160 $kg.ha^{-1}$ found that vitreousness increased with 2.53 to 6.33 points compared to the unfertilized check but it did not comply with the quality standard (Table 4). The values were proven higher after including nitrogen in the fertilization system, where vitreousness was 79.38 - 84.52% on average for the period and grain complied with the quality requirements. The differences were proven between all fertilization systems as average for the whole period.

In 2011, vitreousness for systems without nitrogen was low, whereas after combined fertilization the values significantly increased (72.35 - 75.35%). Higher grain vitreousness was obtained in 2012 for systems without nitrogen, where values reached 60.60 - 63.80% in dry conditions at the end of vegetation (June) and 88.60 - 90.0% after combined NP fertilization. In 2013, systems without nitrogen reached values of 45.60 - 50.80%, whereas adding nitrogen increased significantly the values (76.40 - 89.60%). Average for all systems of fertilization, vitreousness had proven and significantly higher values in 2012 - 73.87% due to drought at the end of the growing season (June), (respectively 17 and 36% more) compared to the values of this parameter in 2013 - 63.31% and in 2011 - 54.46% (Table 4).

The concentration of protein in durum wheat grain manifested slight changes after phosphorus fertilization. Average for the period of experiments, the lowest concentration of grain protein was established in check and after fertilization with P_{160} - 12.37%, and proven the highest was after combined phosphorous rate

P_{120} with 120 kg $N.ha^{-1}$ (Table 5). The percentage of protein in the grain increased significantly after including nitrogen in the fertilization system, and the differences were proven against phosphorus fertilization. The highest proven values of the index were recorded for fertilization system $N_{120}P_{120}$ in each of the three years, and the lowest for unfertilized in 2011 and 2012 and at phosphorous fertilization P_{160} in 2013.

The year did not affect significantly the percentage of crude protein and average in all systems of fertilization, the values were very close – 13.12 to 13.58% and not cover statistically (Table 5).

Without nitrogen fertilization cannot be obtained durum wheat grain complying to the quality requirements for content of wet and dry gluten (Tables 6 and 7). The durum wheat requires nitrogen fertilization to obtain grain of good quality gluten. The annual nitrogen-phosphorous fertilization $N_{120}P_{80}$ on variety Progress and its cotton pre-crop was optimal out of the studied fertilizing systems, where grain was yield with the highest content of wet (34.07 %) and dry (13.10 %) gluten.

Table 2. Test weight of the wheat grain depends on fertilization (kg), 2011-2013

Factors	2011	2012	2013	Average	
				kg	%
A. Fertilization					
N_0P_0	80.80 c	81.20 a	80.95 a	80.98 a	100.0
N_0P_{80}	80.20 d	80.55 bc	80.90 a	80.55 cd	99.5
N_0P_{120}	80.05 e	80.75 b	80.70 b	80.50 d	99.4
N_0P_{160}	80.25 d	80.75 b	80.70 b	80.57 cd	99.5
$N_{120}P_{80}$	81.00 b	80.55 bc	80.45 c	80.67 bc	99.6
$N_{120}P_{120}$	80.95 b	80.45 bc	80.65 b	80.68 bc	99.6
$N_{120}P_{160}$	81.15 a	80.40 c	80.60 b	80.72 b	99.7
B. Year	80.63 ns	80.66	80.71		

Table 3. Weight of 1000 grains (g) in the wheat grain depends on fertilization, 2011-2013

Factors	2011	2012	2013	Average	
				g	%
A. Fertilization					
N_0P_0	56.68 bc	55.00 c	49.56 cd	53.75 cd	100.0
N_0P_{80}	57.32 b	55.80 bc	50.40 bc	54.51 bc	101.4
N_0P_{120}	56.84 bc	55.60 bc	49.53 cd	53.99 cd	100.4
N_0P_{160}	55.80 c	56.20 b	48.38 d	53.46 d	99.5
$N_{120}P_{80}$	57.28 b	57.40 a	51.24 ab	55.31 ab	102.9
$N_{120}P_{120}$	57.52 b	56.40 b	52.04 a	55.32 ab	102.9
$N_{120}P_{160}$	59.96 a	56.00 bc	50.61 abc	55.52 a	103.3
B. Year	57.34 a	56.06 b	50.25 c		

Table 4. Vitreousness (%) of durum wheat grain depends on fertilization, 2011-2013

Factors	2011	2012	2013	Average	
				%	% to N_0P_0
A. Fertilization					
N_0P_0	33.80 e	60.60 b	45.60 f	46.67 g	100.0
N_0P_{80}	40.00 d	61.00 b	46.60 ef	49.20 f	105.4
N_0P_{120}	41.20 d	63.70 b	48.20 e	51.03 e	109.3
N_0P_{160}	44.40 c	63.80 b	50.80 d	53.00 d	113.6
$N_{120}P_{80}$	72.35 b	89.40 a	76.40 c	79.38 c	170.1
$N_{120}P_{120}$	74.10 ab	90.00 a	86.00 b	83.37 b	178.6
$N_{120}P_{160}$	75.35 a	88.60 a	89.60 a	84.52 a	181.1
B. Year	54.46 b	73.87 a	63.31 b		

Table 5. Content of crude protein (%) in the grain of durum wheat depends on fertilization, 2011-2013

Factors	2011	2012	2013	Average	
				%	% to N_0P_0
A. Fertilization					
N_0P_0	12.51 e	12.20 f	12.39 de	12.37 f	100.0
N_0P_{80}	12.64 de	12.39 de	12.52 cd	12.52 e	101.2
N_0P_{120}	12.69 d	12.49 d	12.61 c	12.60 d	101.9
N_0P_{160}	12.52 e	12.26 ef	12.34 e	12.37 f	100.0
$N_{120}P_{80}$	14.86 b	14.07 b	14.44 b	14.46 b	116.9
$N_{120}P_{120}$	15.25 a	14.58 a	15.01 a	14.95 a	120.9
$N_{120}P_{160}$	14.62 c	13.87 c	14.30 b	14.26 c	115.3
B. Year	13.58 ns	13.12	13.37		

The combination of nitrogen rate N_{120} with higher than P_{80} showed a tendency to decrease the content of dry and wet gluten average for the period (Tables 6 and 7). In 2011 and 2012, the highest proven content of wet and dry gluten was reported after phosphorus rate of 80 kg.ha^{-1} + N_{120} and the lowest after phosphorus fertilization P_{160}. In 2013 the highest content of gluten was for $N_{120}P_{160}$ (wet - 32.60% and dry - 12.00%) and lowest - for the unfertilized. Average for the period for all fertilization systems the gluten content was highest in 2012 due to high temperatures in the period May-June, reaching 33.81% for wet and 13.33% for dry gluten. Gluten content was lowest in 2013 due to precipitation during the grain filling (June) (Tables 6 and 7).

Table 6. Concentration of wet gluten (%) in the grain of durum wheat depends on fertilization, 2011-2013

Factors	2011	2012	2013	Average	
				%	% to N_0P_0
A. Fertilization					
N_0P_0	26.40 d	31.00 f	12.60 f	23.33 f	100
N_0P_{80}	24.20 e	31.50 e	16.60 e	24.10 e	103.3
N_0P_{120}	24.00 f	31.80 d	16.80 d	24.20 d	103.7
N_0P_{160}	22.60 g	29.90 g	16.80 d	23.10 g	99.0
$N_{120}P_{80}$	33.50 a	37.80 a	30.90 c	34.07 a	146.0
$N_{120}P_{120}$	31.40 b	37.00 c	32.00 b	33.47 c	143.5
$N_{120}P_{160}$	31.20 c	37.70 b	32.60 a	33.83 b	145.0
B. Year	27.61 b	33.81 a	22.61 c		

Table 7. Concentration of dry gluten (%) in the grain of durum wheat depends on fertilization, 2011-2013

Factors	2011	2012	2013	Average	
				%	% to N_0P_0
A. Fertilization					
N_0P_0	9.60 d	12.60 d	4.20 g	8.80 f	100
N_0P_{80}	8.70 e	12.80 c	5.70 f	9.07 e	103.1
N_0P_{120}	8.60 f	12.80 c	5.90 d	9.10 d	103.4
N_0P_{160}	8.00 g	10.60 e	5.80 e	8.13 g	92.4
$N_{120}P_{80}$	13.20 a	14.90 a	11.20 c	13.10 a	148.9
$N_{120}P_{120}$	11.40 b	14.80 b	11.70 b	12.63 c	143.5
$N_{120}P_{160}$	11.20 c	14.80 b	12.00 a	12.67 b	144.0
B. Year	10.10 b	13.33 a	8.07 c		

CONCLUSIONS

The test weight and 1000 kernel weight of durum wheat variety Progress slightly depended on phosphorus fertilization at rates of 80-160 kg P_2O_5.ha^{-1}. Average for the studied period, the largest grain of 59.96 g was obtained after the high phosphorus fertilizer rate of 160 kg.ha^{-1} against background of N_{120} and in years with favorable hydrothermal conditions during the vegetation of durum wheat. With contents of mineral nitrogen in soil below 40 mg.kg^{-1}soil and phosphorus fertilization at rates 80-160 kg P_2O_5.ha^{-1} was obtained total grain vitreousness in the range of 49.20 - 53.0% and crude protein content within 12.37 - 12.60%.

When N_{120} was added, vitreousness of grain increased to 79.38 - 84.52% and the protein concentration in the grain increased significantly to 14.95%. To obtain grain with good quality gluten, durum wheat requires nitrogen fertilization. Combined fertilization $N_{120}P_{80}$ was the optimal system, wherein grain was obtained with the highest content of wet (34.07%) and dry (13.10%) gluten, while the combination of nitrogen rate N_{120} and higher than P_{80} tended to decrease the gluten content. Drought at the end of durum wheat vegetation in June led to grain with higher vitreousness and content of the wet and dry gluten.

REFERENCES

Abad A., Lloveras J., Michelena A., 2004. Nitrogen fertilization and foliar urea effects on durum wheat yield and quality and on residual soil nitrate in irrigated Mediterranean conditions. Field Crops Research. VL, 87, 257-269.

Abdullah J.A., 2009. Modeling Biomass Allocation and Grain Yield in Bread and Durum Wheat under Abiotic Stress. Australian Journal of Crop Science, Vol. 3, No. 5, 237-248.

Ammes N.P., Clark J.M, Dexter J.E., Woods J., Schols F., Marchylo B., 2003. Effects of nitrogen fertilizer on protein quantity and gluten streng parameters in durum wheat (*Triticum turgidum* L. var. *durum*) cultivars of variable gluten strength. Cereal Chemistry, 80, 203-211.

Bauer A., Frank A., Black A., 1987. Aerial parts of hard red spring wheat. II. Nitrogen and phosphorus concentration and content by plant development stage, Agronomy Journal, 79, 852-858.

Bozhanova, V., Dechev D., Yanev Sh., 2006. Study on drought tolerance in durum wheat. Soil science, Agrochemistry and Ecology, 30 (4), 40-46.

Carcea, M. 2003. The quality of durum wheat in Italy. Sementi Elette. VL, 49, 14-15.

Delchev, Gr., 2009. Effect of some complex and organic fertilizers on the productive capacity of durum wheat. Soil Science, Agrochemistry and Ecology, 43 (3), 49-54.

Delchev G. and Panayotova G., 2010. Application of some agrotechnical factors for increasing grain yield and quality of durum wheat in Bulgaria. Сборник научных докладов XIII Международной конференции "Аграрная наука – сельскохозяйственному производству Монголии, Казахстана и Сибири", Улаанбаатар, 6-7 июня 2010 г. Рос. акад. с.-х. наук. Сиб. регион. отд-ние – Новосибирск, 222-227.

Delchev Gr., Petrova I., 2012.Changes in productivity of two durum wheat cultivars by influence of some stimulators. Safe food, Novi Sad, 193-199.

Gerdzhikova M., Pavlov D., Zhelyazkova Ts., Plescuta L., 2013. Dray Matter Weight, Crop Growth Rate, Relative Growth Rateof Triticale Grown with the Increasing Nitrogen Fertilizer Rates and After Different Predecessors. Journal of Mountain Agriculture on the Balkans, 16, 5, 1133-1157.

Johnson A., 2004. Agricultural nutrients and climate change, Crop nutrients and the environment, Progress Knowledge, Canada, 202-211.

Kostadinova S., 2000. Response of winter common wheat (Triticum aestivum L.) to the level of nitrogen nutrition, Ph.D. Thesis, Sofia.

Lalev Tsh., Delchev Gr., Panayotova G., Nikolov G., Saldzhiev I., Yanev Sh., Deneva M., 2000. Achievements of the scientific research on the durum wheat's agrotechnology and technology of growing. Plant Science, 37, 682-687.

Mariani B.M., 1995. Durum wheat quality evaluation, influence of genotype and environment. Cereal Chemistry, 72,194-197.

May W., Fernandez M., Holzapfel Chr. and Lafond G., 2008. Influence of Phosphorus, Nitrogen, and Potassium Chloride Placement and Rate on Durum Wheat Yield and Quality, Agron. J, 100, 1173–1179.

Moral L., 2003. Durum wheat quality in Mediterranean environments: II. Influence of climatic variables and relationships between quality parameters. Field Crops Research, Vol. 80, Issue 2, 133-140.

Pacucci G., Troccoli C., Leoni B., 2004. Response of durum wheat genotypes to previous crop and N fertilization under Mediterranean conditions. Proc. 4th Intern. Crop Science Congress, Brisbane, Australia, 26 Sep-1 Oct 2004.

Panayotova G., 1999. Nutrition of durum wheat (*Tr. durum* Desf.) cultivated with cotton in crop rotation, Ph.D. Thesis, Sofia.

Panayotova G., 2001. Response of Durum Wheat Genotypes to Nitrogenous Fertilizers. Plant Science, 5-6, 203-207.

Panayotova G., 2010. Effect of Soil Fertility and Direct Nitrogen Fertilization on the Durum Wheat Varieties in the Conditions of Central Southern Bulgaria. 12th International Symposium Materials, Methods & Technologies (MMT), June 11-15, 2010, Sunny Beach, Bulgaria, vol. 4, part 1, 281- 293.

Panayotova G., Dechev D., 1997. Stability of the 1000 kernel weight of durum wheat at different nitrogenous fertilization rates and agrometeorological conditions. Soil Science, Agrochemistry and Ecology, 6, 38-40

Panayotova G., Gorbanov S., 1999. Influence of the fertilization on the properties of durum wheat grain and pasta products. Bulgarian Journal of Agricultural Science, 5, 425-430.

Panayotova G., Kostadinova S., 2011. Response of new durum wheat varieties to the level of nitrogen nutrition. II.Quality parameters of grain. Field Crops Studies, Volume VII-2, 363-376.

Panayotova G., Valkova N., 2010. Effect of previous and direct nitrogen fertilization on some grain properties of durum wheat varieties. Proceedings 14th International Eco-Conference® SAFE FOOD, 22nd-25th September 2010, Novi Sad, Serbia, 131-138.

Panayotova G., Yanev Sh., 2001. Response of Durum

Wheat Genotypes to Nitrogen Fertilization. Animal Science, 6, 109-111.
Petrova I., 2009. Criteria and indices for durum wheat technological quality, Agricultural Science, No. 3, p. 23-32.
Rharrabti Y., Villegasb D., Royo C., Martos-Núñeza V., García del Moral LF, 2003**.** Durum wheat quality in Mediterranean environments: II. Influence of climatic variables and relationships between quality parameters, Field Crops Research, Vol. 80, Issue 2, 20, 133-140.
Sylvester-Bradley R., Kindred D., 2009. Analysing nitrogen responses of cereals to prioritize routes to the improvement of nitrogen use efficiency. J Exp Bot, 60,1939-1951.
Uppal R., Singh R., Jagrup S., 2002. Effect of nitrogen levels and time of application on quality of durum wheat. Crop Improvement, VL, 29, 58-64.

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A RESEARCH ON DETERMINATION OF ONTOGENETIC AND DIURNAL VARIATION OF ESSENTIAL OIL CONTENT AND COMPOSITION IN *Hypericum kazdaghensis* GROWING WILD IN IDA

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Abstract

The research carries out the determination in Hypericum kazdaghensis types of components essential oil content for growing season in Mount Ida (Turkey-Balikesir-Edremit) in 2012. Moreover the diurnal and ontogenetic variations were investigated.
In this paper we determine that change in essential oils of whole plant within a day during the course of ontogenetic did not follow the same trend in H. kazdaghensis. Essential oils in whole plant increased during flower ontogenesis and reached their highest level at full flowering. Then it decreased at the fresh fruiting stage. The highest level at full flowering 0.26% and the lowest level fresh stage is 0.02%. We obtained the six-four components from aerial parts of H. kazdaghensis at the vegetative, full flowering and fresh stage. In addition, we determined that the oils consisted of mainly calamene (29.4%), germacrene-D (20.1%), gurjunene-gama (14.8%), tau-muurool (9.0%); cubenol (6.0%) and δ -cadinol (6.0%). at the vegetative stage. Finally we determined that the oils consisted calamene (16.5%), gurjunene-gama (12.8%), germacrene-D (10.9%) and α-cadinene (7.9%) at the fresh fruiting stage.

Key words: *Hypericum kazdaghensis, essential oil content, calamine, germacrene-D.*

INTRODUCTION

Hypericum L. (*Hypericaceae*) is a large genus of herbs or shrubs, which grown in temperate regions of the world (Campbell and Delfosse, 1984). The genus *Hypericum* contains 469 species that have been classified into 36 taxonomic sections by the most recent count (Crockett, 2010). *Hypericum* species are also used as sedatives, antiseptics and antispasmodics in Turkish folk medicine (Baytop, 1999). Turkey is an important place for *Hypericum* species. The *Hypericum* genus, a member of the *Hypericaceae* family is represented in Turkey by 96 species of which 43 are endemic (Cirak et al., 2006; Aslan, 2012).
Morphologically, *Hypericum* species are characterized by the presence of different kinds of secretory tissues including light glands, dark glands and secretary canals. These secretory structures are sites of synthesis and accumulation of biologically active substances and their localizations are different depending on plant tissue (Cicracelli et al., 2001). Therefore, organ-dependence of phenolic compounds has an important role to understand the underlying sources of variation in phenolic contents of *Hypericum* species (Ayan et al., 2007).
The research carries out the determination in *Hypericum kazdaghensis* types of components essential oil content for growing season in Mount Ida (Turkey-Balikesir-Edremit) in 2012. Moreover, the diurnal and ontogenetic variations were investigated.

MATERIALS AND METHODS

Hypericum kazdaghensis was collected at different stages of plant development from Edremit district of Balikesir province, Turkey between April and August of 2012. The soil of the trial area was sandy, pH value (6.9), organic matter (6.8%), sand (68%), silt (24%) and clay (8%). On the place where the trial was reflected mean temperature is 20.4 ºC, mean rainfall is 28.1 mm and relative humidity is 60.7 % in

2012. Collections were done three times a day (9.00 am; 12.00 am and 16.00 pm) for each development stages. Ontogenetic sampling corresponded with different date for *Hypericum kazdaghensis* shoots with leaves were harvested at the vegetative stage. At the full flowering stage, only shoots with fully opened flowers were harvested. At the fresh fruiting stage, the shoots which had green capsules were harvested. The plant materials were dried at room temperature (20ºC). Dried plant materials (50 g each *Hypericum kazdaghensis*) was subjected to hydro distillation for 6 h using a Clevenger type apparatus for determining the oil content. The oil composition was determined with GC-MS. GC-MS analyses were conducted in the TUBITAK (MAM). GC-MS conditions; helium was used as carrier gas at a constant flow rate of 1 mL/min. 1µL of sample was injected. The GC temperature program was set as follows; 50ºC hold for 5 min, ramp to 250ºC at 5ºC/min and hold for 10 min. The temperature of the MS transfer line was set at 220ºC. Using scan mode a mass range from 50 to 650 *m/z*. Used column, DB-5 30 m x 0.25 mm ID x0.25 µm. The Thermo Scientific TSQ GC-MS/MS was used in this study.

RESULTS AND DISCUSSIONS

Results of this study reveal that Diurnal and ontogenetic variations significantly affected ($p<0.01$) essential oils. The differences between that means were compared by Duncan's multiple range test (Duncan's test). They are shown Table 1.

Table 1. Diurnal collecting times and developmental stages of *Hypericum kazdaghensis*

Diurnal Collecting Times	Developmental Stages			
	Vej. Stage	Full Flow.	Fresh Fruit	Mean
09:00 am	0.19	0.23	0.02	0.15
12:00 am	0.17	**0.29**	0.02	**0.16**
16:00 pm	0.16	0.26	0.02	0.15
Mean	0.17	**0.26**	0.02	0.15

Change in essential oils of whole plant within a day during the course of ontogenetic did not follow the same trend in *Hypericum kazdaghensis*. Essential oils in whole plant increased during flower ontogenesis and reached their highest level at full flowering. Then it decreased at the full flowering stage. The highest level at full flowering 0.26% and the lowest level fresh stage is 0.02%. The difference among essential developmental stages was found significant ($p<0.01$). Diurnal fluctuation in essential oils of whole plant was also observed for *Hypericum kazdaghensis* and it was highest (0.29%) at 12:00 pm (Table 1).
Investigations of ontogenetic variation of secondary metabolites have been made over several, eg. alkaloid changes during fruit development in *Papaver somniferum* (Miriom and Pfeifer, 1959) and *Conium maculatum* (Fairbairn and Challen, 1959). Also essential oil changes during the course of ontogenesis in *Hypericum perforatum* (Schwob et al., 2004), changes of artemisinin during phonological cycle of *Artemisia annua* (Gupta et al., 2002) and foliar monoterpenoid variation in *Umbellularia californica* in seedlings, saplings and adult tree stages. Chemical concentrations vary considerably during the course of ontogenesis in a medicinal plant, not only the concentrations of plant chemicals fluctuate through the season, but they can also be short-lived and experience rapid turnover (Smith et al., 1996).
This compositional trend which is characterized by an increase of the oil complexity during the plant development suggests that numerous metabolic pathways were elicited in the *Hypericum triquetrifolium* secondary metabolism (Schwob et al., 2004). The major constituents of the oil were 3-methyl nonane (10.5-43.5%), carvacrol (0.2-7.6%), caryophyllene (10.4-32.9%), Germacrene-D (2.9-13.6%), α-pinene (2.7-17.6%) and Caryophyllene oxide (1.4-10.8%).

Table 2. Variation of essential oils content of *Hypericum kazdaghensis* within a day during the course of ontogenetic (%)

KI	RT	Compounds	Vej. Stages / 09.00 am	Vej.Stages / 12.00 am	Vej. Stages/ 16:00 pm	Full Flow./ 09:00 am	Full Flow./ 12:00 am	Full Flow./ 16:00 pm	Fresh Fruit/ 09.00 am	Fresh Fruit/ 12.00 am	Fresh Fruit/ 16.00 pm
861	11.78	2-methyl octane	3.1	3.0	2.1	-	-	-	2.3	2.2	4.8
939	14.25	α-pinene	4.0	3.1	3.0	-	-	-	6.0	5.3	1.1
971	15.41	3-methyl nonane	0.7	0.7	0.8	-	-	-	0.7	0.7	0.9
991	16.01	β-myrcene	0.6	0.4	0.4	-	-	-	0.6	0.7	0.7
1025	17.22	σ-cymene	0.8	0.5	0.4	-	-	-	0.7	0.6	0.7
1037	17.48	β- ocimene(Z)	0.7	0.8	0.9	-	-	-	0.7	0.7	0.9
1060	18.29	τ-terpinene	1.1	1.2	0.8	-	-	-	1.0	1.0	0.5
1097	19.46	β-linalool	0.9	1.4	0.9	-	-	-	0.6	1.2	0.3
1122	20.20	Fenchol, exo-	1.0	0.9	0.7	-	-	-	0.3	0.7	1.2
1141	20.96	Cis-verbenol	2.4	1.6	1.8	1.0	0.9	1.1	1.7	2.3	0.7
1177	21.98	4-terpineol	0.7	0.8	0.9	5.8	6.1	6.0	0.7	1.0	0.4
1194	22.52	Myrtenol	0.7	0.7	1.0	1.3	0.5	0.9	0.5	0.7	0.4
1253	24.13	Piperitone	0.5	0.5	0.4	4.2	3.4	3.8	0.4	0.6	0.6
1290	25.06	Thymol	0.5	0.4	0.6	3.3	2.6	2.9	0.3	0.4	0.7
1338	26.18	τ-elemene	0.7	0.9	1.0	0.9	0.4	0.9	0.7	0.7	0.8
1351	26.54	α-cubebene	0.8	0.6	0.9	0.8	0.9	0.8	0.9	0.8	0.6
1375	27.19	α-ylangene	0.9	1.2	0.8	4.0	3.8	3.5	0.6	0.6	4.0
1377	27.34	α-Copaene	5.8	2.4	4.0	1.4	0.6	1.1	5.1	4.0	2.8
1387	27.62	Dodecanal	2.4	1.6	1.9	0.8	0.5	0.5	3.4	2.0	0.9
1418	28.45	β-cedrene	2.0	1.3	1.4	6.0	5.8	6.0	1.8	1.1	0.2
		β-caryophyllene	1.8	2.1	1.5	4.0	3.1	3.5	0.7	0.4	0.7
1430	28.73	β-copaene	1.2	1.1	1.0	18.6	16.7	17.4	1.2	1.5	2.2
1441	29.01	Aromadendrene	1.4	1.5	1.3	4.9	2.8	3.2	4.3	2.9	2.8
1455	29.40	α-humulene	2.4	1.7	1.4	4.0	2.6	3.0	4.3	2.4	3.2
1477	29.53	Gurjunene-gama	14.8	10.0	16.0	0.9	0.3	0.8	12.8	7.3	8.2
1480	29.81	τ-muurolene	6.1	3.8	5.0	1.8	2.9	2.5	3.8	2.8	1.2
1485	29.90	Amorphene	0.9	0.9	0.9	4.1	4.2	4.0	0.9	0.6	3.0
1485	30.05	Germacrene D	20.1	12.1	17.1	16.0	16.4	15.7	10.9	7.2	13.2
1496	30.23	gama-amorphene	4.2	3.8	4.0	0.5	0.4	0.5	3.3	2.8	3.0
1496	30.35	Valencene	1.8	1.3	1.5	0.5	0.6	0.8	3.8	3.9	3.2
1514	30.48	gama-cadinene	1.1	0.9	1.0	1.5	1.2	1.1	0.8	0.2	1.1
1523	30.74	delta-cadinene	3.2	3.0	2.4	1.4	1.3	1.3	2.6	1.5	3.2
1539	30.82	α-cadinene	7.2	6.1	6.0	4.1	4.5	4.0	7.1	5.9	7.9
1540	30.92	Calamenene	29.4	30.1	25.3	6.0	6.8	5.5	16.5	11.3	9.7

KI	RT	Compounds	Vej. Stages / 09.00 am	Vej.Stages / 12.00 am	Vej. Stages/ 16:00 pm	Full Flow./ 09:00 am	Full Flow./ 12:00 am	Full Flow./ 16:00 pm	Fresh Fruit/ 09.00 am	Fresh Fruit/ 12.00 am	Fresh Fruit/ 16.00 pm
1536	31.17	α-bisabolene	0.8	0.7	0.9	0.5	0.7	1.0	0.9	0.3	0.6
1556	31.27	Nerolidol	0.7	0.8	0.8	0.5	0.7	0.4	0.9	0.4	0.5
1567	31.69	Dodecanoic acid	0.6	0.9	1.1	1.5	1.3	1.0	0.9	0.7	0.5
1570	31.94	Cis-3-hexenyl benzoate	0.9	0.9	1.0	1.4	1.5	1.6	0.7	0.9	0.6
1576	32.11	Germacrene D-4-ol	0.8	0.8	0.7	-	-	-	0.9	0.8	0.8
1578	32.28	Spathulenol	2.3	1.6	1.3	2.4	2.8	2.2	5.2	2.8	4.0
1583	32.45	Caryophyllene oxide	2.1	0.9	2.2	-	-	-	4.0	2.5	2.3
1585	32.52	Globulol	1.0	1.3	1.0	1.3	1.5	1.1	0.8	0.4	0.7
1593	32.73	Viridiflorol	0.9	0.7	0.9	1.1	1.0	1.0	0.8	0.6	0.8
1608	32.97	Ledol	0.6	0.9	0.7	1.4	1.2	1.3	0.9	0.7	0.6
1619	33.12	Cubenol|<1,10-di-epi->	0.8	0.9	0.8	0.9	1.0	1.0	0.7	0.4	0.7
1635	33.41	Cubenol	6.0	4.3	4.1	8.0	8.9	7.8	5.0	4.0	4.0
1644	33.57	δ-cadinol	6.0	3.0	4.1	2.3	2.1	2.0	7.3	5.1	5.5
1647	33.75	tau-muurolol	9.0	8.1	6.3	4.2	3.8	3.1	9.0	7.7	7.8
1657	34.04	α-cadinol	5.1	5.0	4.0	6.1	5.8	4.7	5.3	5.3	5.3
1664	34.14	Caryophylla-3(15),7-dienol(6) I	1.1	0.9	1.1	1.8	1.7	1.4	1.4	0.9	1.6
1684	34.70	α-santalol	0.9	1.1	0.6	-	-	-	1.0	0.8	0.9
1748	35.93	Tetradecanoic acid	1.1	0.7	0.8	-	-	-	1.2	0.9	1.1
1769	36.42	Benzyl benzoate	0.5	1.4	1.3	-	-	-	0.8	0.7	0.6
1876	36.55	Hexadecanol	0.6	0.7	0.9	0.5	0.4	0.7	0.8	0.6	0.7
1910	37.72	Palustrol	0.8	0.9	0.8	0.7	0.8	0.4	1.2	0.8	0.9
1922	40.02	Hexadecanoic acid	1.0	1.2	0.9	0.9	1.1	0.4	1.0	0.9	1.0
1944	42.84	Phytol	3.8	4.1	3.4	3.4	4.0	2.7	7.0	5.1	5.0
2099	46.09	Heneicosane	1.1	0.9	1.1	0.9	1.1	0.6	2.0	1.9	2.1
2304	48.07	Tricosane	1.7	2.1	1.4	2.8	2.9	2.5	3.1	2.5	2.7
2504	49.22	Pentacosane	1.2	1.8	1.7	0.8	1.0	1.1	1.6	1.4	2.0
2706	52.18	Heptacosane	4.0	1.9	2.7	1.8	2.0	2.2	5.8	4.5	6.0
2902	56.02	Nonacosane	4.6	2.2	3.0	5.3	5.7	4.7	4.8	4.1	5.1
		α-selinene	3.0	3.8	3.4	-	-	-	0.8	0.9	0.4
		β-selinene	3.5	4.3	3.0	-	-	-	0.5	0.7	0.5

Most of them have been previously reported in the essential oil of *Hypericum triquetrifolium* (Bertoli et al., 2003; Petrakis et al., 2005; Hosni et al., 2011); *H.perforatum, H.tetrapterum, H. olympicum* (Pavlovic et al., 2006); *H. kazdaghensis; H. aucherii, H.perforatum* and *H. montbretii* (Pasa, 2013); *H. richerii* (Ferretti et al., 2005) and *H. hirsutum* (Gudzic et al., 2007).

For example, Petrokis et al. (2005) studied the essential oil of Greek specimens without specifying the phonological stage and found that 2-methyloctane, α-pinene, n-nonane, β-caryophyllene and 3-methylnonane; Hosni et al. (2011), β-caryophyllene, n-nonane, α-pinene, germacrene-D, n-octane and 2-methyloctane. Report from Italy showed that the n-nonane, β-pinene, β-caryophyllene, α-pinene, myrcene, sabinene, germacrene-D, Caryophyllene oxide were the major compounds of the leaf and flowers essential oils (Bertoli et al., 2003).

The identity, the retention index and percent composition of the essential oils content from *Hypericum kazdaghensis*. are listed Table 2. As can be seen the studied oils were resolved into 64 components at the vegetative, full flowering and fresh stage respectively.

At the vegetative stage, the oils consisted mainly of calamene (29.4%), germacrene-D (20.1%), gurjunene-gama (14.8%), tau-muurool (9.0%); cubenol (6.0%) and δ -cadinol (6.0%). At the flowering stage the oils consisted mainly of β-copaene (18.6%), germacrene-D (16.4%), cubenol (8.9%), 4-terpineol (6.1%) and calamine (4.5%). At the fresh fruiting stage flowering stage the oils consisted mainly of calamene (16.5%), gurjunene-gama (12.8%), germacrene-D (10.9%), α-cadinene (7.9%), cubenol (6.0%) and δ -cadinol (7.3%).

The effects of the diurnal variation on the essential oils composition *Hypericum kazdaghensis* have not been reported previously. Nevertheless, differences in the essentials composition of developmental stages have been described for the closely related species *H. perforatum* (Schwab et al., 2004), *H. aucherii, H.perforatum* and *H. montbretii* (Pasa, 2013), *Hypericum triquetrifolium* (Hosni et al., 2011).

CONCLUSIONS

Essential oils in whole plant increased during flower ontogenesis and reached their highest level at full flowering. Then it decreased at the fresh fruiting stage. The highest level at full flowering 0.26% and the lowest level fresh stage is 0.02%. We obtained the six-four components from aerial parts of *H. kazdaghensis* at the vegetative, full flowering and fresh stage.

In addition, we determined that the oils consisted of mainly calamene (29.4%), germacrene-D (20.1%), gurjunene-gama (14.8%), tau-muurool (9.0%); cubenol (6.0%) and δ-cadinol (6.0%). at the vegetative stage. Finally, we determined that the oils consisted calamene (16.5%), gurjunene-gama (12.8%), germacrene-D (10.9%) and α-cadinene (7.9%) at the fresh fruiting stage.

REFERENCES

Aslan S., 2012. Hypericum. Türkiye Bitkileri Listesi (Damarlı Bitkiler). Nezahat Gökyiğit Botanik Bahçesi ve Flora Araştırmaları Derneği Yayını, İstanbul.

Ayan A.K., Yanar O., Cirak C., Bilginer M., 2007. Morphogenetic and diurnal variation of total phenols in some *Hypericum* species from Turkey during their phonological cycles. Bangladesh J. Bot. 36 (1): 39-46, 2007.

Baytop T., 1999. Therapy with Medicinal plants in Turkey. Istanbul University press, Istanbul pp.66-167.

Bertolli A., Menchini F., Mazzetti M., Spinelli G., Morelli I., 2003. Volatile constituents of leaves and flowers of *Hypericum triquetrifolium* Turra. Flavour Fragrance J. 18, 91-94.

Campbell M.H., Delfosse E.S., 1984. The biology of Australian weeds 13. *Hypericum perforatum* L. J.Aust.Inst.Agr.Sci. 50, 50-63.

Ciccarelli D., Andreucci A.C., Pagni A.M., 2001. Translucent glands and secretory canals in *Hypericum perforatum* L. (Hypericaceae): morphological, anatomical and histochemical studies during the course of ontogenesis. Ann. Bot. 88, 637-644.

Cirak C., Sağlam B., Ayan A.K., Kevseroğlu K., 2006. Morphogenetic and diurnal variation of hypericin in some *Hypericum* species from Turkey during the course of ontogenesis. Biochem. Syst. Ecol. 34, 1-13.

Crockett S.L., Robson N.K.B., 2010. Taxonomy and chemotaxonomy of the genus Hypericum. Medicinal and Aromatic Plant Science and Biotechnology.

Fairbairn J.W., Challen S.B., 1959. Alkaloids of Hemlock (*Conium maculatum* L.) distribution in relation to the development of the fruit. Biochem. 72: 556-562.

Ferretti G., Maggi F., Tirillini B., 2005. Essential oil composition of *Hypecium richeri* Vil. From Italy. Flavour Frangrance J. 20, 295-298.

Gudzic B.T., Smelcerovich A., Dordevic S., Mimica-Dukic N., Ristic M., 2007. Essential oil composition of *Hypericum hirsutum* L. Flavor Frangrance J. 22, 42-43.

Gupta S.K., Singh P., Bajpai P., Ram G., Singh D., Gupta M.N., Gupta D.J., Jain S.P., Khanuja S.P., Kumar S., 2002. Morphogenetic variation for artemisinin and volatile oil in Artemisia annua. Ind. Crop Prod. 16: 217-224.

Hosni K., Msaada K., Taarit M.B., Marzouk B., 2011. Phenological variations of secondary metabolites from *Hypericum triquetrifolium* Turra. Biochemical Systematics and Ecology 39 (2011), 43-50.

Miriam R., Pfeifer S., 1994. Über die Veranderungen im Alkaloidhaushalt der Mohnpfanze warend einer Vegatationsperiode Sci Pharm. 27: 34-40.

Pasa C., 2013. Kazdağlarında yayılış gösteren bazı *Hypericum* türlerinde uçucu yağ oranı ve bileşenlerinin diurnal, ontogenetik ve morfogenetik varyasyonunun belirlenmesi üzerine bir araştırma. Namik Kemal Universitesi, Fen Bilimleri Enst., Doktora Tezi, 2013.

Pavlovic M., Tzakou O., Petrakis P.V., Couladis M., 2006. The essential oil of *Hypericum perforatum* L., *Hypericum tetrapterum* Fries and *Hypericum olympicum* L. growing in Greece. Flavour Fragrance J. 21, 84-87.

Petrakis P.V., Couladis M., Roussis V., 2005. A method for detecting the biosystematics significance of the essential oil composition: the case of five Hellenic *Hypericum* L. species. Biochem. Syst. Ecol. 33, 873-898.

Schwob L., Bessiere J.M., Masotti V., Viano J., 2004. Changes in essential oil composition in Saint John's wort (*Hypericum perforatum* L.) aerial parts during its phonological cycle. Biochem.Syst.Ecol, 32, 735-745.

Smith R., Caswell D., Carriere A., Zielke B., 1996. Variation in the ginsenoside content of American gingseng, Panax quinquefolius L. roots. Can. J. Bot. 74: 1616-1620.

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SCREENING METHODS FOR EVALUATING THE ALLELOPATHIC POTENTIAL OF WHEAT AND TRITICALE GENOTYPES

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Abstract

Of the many methods for weed management one of them is using allelopathy in weed management programs. Application of allelopathic wheat and triticale cultivars is thought a resources conservation and environmental friendly way of weed bio-control, and could promote the sustainable development of agriculture. Screening or evaluating the allelopathic potential of wheat and triticale variety is the first step. This experiment was done to develop a new simple and valid methods for allelopathy studies and facilitating the use of some physiological traits in such researchs. One method was to assessment the allelopathic potential of some winter wheat and triticale genotypes using aqueous extract from the leaves and shoot of each genotype. Evaluation of allelopathic potential of these genotypes was done by measuring the germination capacity of ryegrass seeds (Lolium rigidum). Results showed that the allelopathic activity of wheat was associated with extract concentrations and wheat/triticale cultivars. Germination percentage of ryegrass seeds ranged from 0.2 to 92 %. In average for all used concentrations, extract of Titan (triticale) reduced ryegrass germination by 61% and most suitable concentration to evidentiate allelopatic activity was 5%.
Another method consisted in incorporating in soil of the plant residues from winter wheat and triticale genotypes. Evaluation of allelopathic potential of these genotypes was done by measuring the length of root of amaranth (Amaranthus retrophlexus) and ryegrass (Lolium rigidum).
Results demonstrated that the root length of weed species were significantly reduced in the presence of some wheat cultivars. Wheat and triticale varieties differ in allelopathic potential against ryegrass and amaranth and the differences were evidentiate by both methods

Key words*: allelopathy, wheat, triticale, annual ryegrass (Lolium rigidum), amaranth (Amaranthus retrophlexus).*

INTRODUCTION

Allelopathy, an important ecological phenomenon explaining the interference among species through bio-chemical pathways, seems to be one such tool that can be manipulated to manage weeds in agro-ecosystems (Khanh et al., 2005).
The allelopathic activity of wheat has been attributed to hydroxamic acids (Wu et al., 2000) and phenolic acids (Wu et al., 2001; Andrew et al., 2015).
Wheat seedlings, straw, aqueous extracts of residues and root exudates exerted allelopathic effects on a number of agricultural weeds (Khaliq et al., 2011).
Wheat is the second crop in Romania and ryegrass (*Lolium* spp.), foxtail (*Setaria* spp.), lambsquarters (*Chenopodium album* L.), redroot amaranth (*Amaranthus retroflexus* L) and specially purslane, maybe thistle (*Cirsium arvense*) are widespread weeds in wheat field and substantially reduce the yield.
Their control has been performed by different management practices and high dose of herbicides. It is desirable to have an alternative weed control method in wheat fields.
Application of allelepathy to control weeds can avoid environmental contamination and improve crop yield.
Allelopathic control refers to the method that exploits allelochemicals from volatile, leachate, exudates of certain plant to control of weeds (Oueslati, 2003; Kashif et al., 2016).
To realise the potential of competitive crop cultivars as a tool in integrated weed management, a quick and simple-to-use protocol for assessing their competitive potential is required as it is likely that selection will not be based on a single trait, but will need to capture the

combined effect of multiple traits (Andrew et al., 2015).

In a field observation from NARDI Institute two wheat cultivars were found to be as allelopathic as the most allelopathic triticale and are now used in a conventional breeding program to improve the allelopathic proprieties of the Romanian winter wheat. Screening bioassays are essential tools in identifying crop accessions with allelopathic potential.

The objective of this study was to establish the screening methodology for determination wheat and triticale differences in allelopathic potential against some weeds.

MATERIALS AND METHODS

The wheat and triticale were considered as the donor plants and ryegrass and amaranth as acceptor or target plants.

Bioassay with aqueous extracts of wheat and triticale

Three winter wheat and two triticale genotypes provided by Agricultural Research and Development Institute from Fundulea, Romania, and ryegrass seeds (Naki cv.) were used in order to establish/find a concentration level that allows sufficient germination of ryegrass for determining allelopathic potential.

Preparation of the extract from wheat plants

The donor plants seeds were sown during autumn in wooden boxes in soil:sand mixture and grown in vegetation house for five weeks. Than the above ground plant part (leaves and shoot) of each genotype were harvested, oven-dried at 40-50°C for 72 hours and ground to obtain a powder.

Different grams of powder from each wheat and triticale genotype (1.25, 2.5, 5, 7.5 and 10 g) were extracted with 100 ml of top water in a glass jad for 24 hours at room temperature.

The pulpy mixture was filtered through two layers of cheese cloth and the resulting filtrate was centrifuged at 10,000 rpm for 15 minutes. The supernatant was stored in a freezer prior to use. Beside those extract series as control was used top water.

Seed bioassay

Fifty seeds of ryegrass (*Lolium rigidum* L.) cv. “Naki” were sterilized with 10% sodium hypochlorite for 5 min., rinsed for 15 min. with top water and sown onto 10 cm Petri dishes lined with two layer of filter paper. Five ml of each concentration were then delivered to each Petri dish. All dishes were maintained in a control conditions, in darkness at 22-23°C for 14 days. The experiment was performed in five replications for each concentration.

Germination percentage was determined by counting germinated seeds after 24 hours of sowing till 10th day.

The results are expressed as percent of sown seeds.

Pipper index (PI) was used for evaluated the dynamics of germination. PI refers to number of days needed for one seed to germinate and was calculated according to the following formula:

$$PI = x_1 s_1 + x_2 s_2 + \dots x_n s_n / s_1 + s_2 + \dots + s_n$$

$x_1, x_2, \dots x_n$ - day of germination

s – number of seeds that germinated at given day

n – last day of experiment

Bioassay with shoot residues incorporate into soil

Twenty four genotype of donor plants (wheat and triticale) were sown during autumn in plastic boxes in soil:sand mixture (20 seeds/plots and 1 kg soil:sand mixture) and grown in vegetation house up to maturity, than were cutting and shoot residues were incorporate into soil.

The same quantity of redroot amaranth seeds collected from spontan flore (approximately 0.5 g) and five ryegrass seeds were sown in each plot.

Alleopathy was studied in terms of root length inhibition. As control was used amaranth and ryegrass grows in clear soil mixture (without residues).

RESULTS AND DISCUSSIONS

Results revealed that the germination of ryegrass was inhibited by the extract of studied wheat and triticale genotypes.

The responses significantly differed depending on extract concentration.

Both the delay and the reduction in ryegrass germination are positive correlate with extract concentration, being the greatest at the highest concentration (Table 1).

Table 1. Germination of ryegrass (*Lolium rigidum* L.) (%) in water extracts of wheat and triticale

Genotype	Control (water)	Extract concentration (% DM w/v)					Average
		1.25	*2.5*	*5*	*7.5*	*10*	
Boema	91d	87cd	76 c	40 b	10 a	3.6 a	43 ab
GCO 3-22	88c	92c	84 c	51b	3 a	0.8 a	46 b
GDR 2863	88c	84 c	76 c	38 b	11 a	7.6 a	43 ab
Titan	90d	83 cd	71 c	36 b	4 a	0.8 a	39 a
Haiduc	98d	87 cd	76 c	50 b	14 a	4 a	46 b
Average	91d	87 d	76 c	43 b	8.4 a	3.3a	43

Ryegrass seeds, used in this test, were healthy having a high germinate capacity as in control conditions, ranking from 88% up to 98%

All the applied concentrations of shoot and leaves extract, except 1.25%, significantly suppressed the germination of the test weed.

The 5% concentration of shoot and leaves extracts highlights best the allelopathic potential of genotypes studied. At this concentration the germination of ryegrass seeds ranked from 36% (Titan) to 51% (GCO 3-22) In average for all used concentrations, extract of Titan (triticale) reduced ryegrass germination by 61% while of GCO 3 - 22 (wheat) by 54 % (Table 1). Our results are consistent with others that show that wheat accessions varied in their allelepathic activity in the fields, some accessions inhibited the weed growth up to 75 % (Rivzi et al., 2004).

Allelopathic effect of crop extracts was demonstrated also by changes in the dynamics of ryegrass germination. Pipper Index values ranged, on average for all studied concentrations, from 7.7 to 8.4 days (Table 2).

Table 2. Pipper Index for ryegrass (*Lolium rigidum* L.) seeds germinated in water extracts of wheat and triticale

Genotype	Control (water)	Extract concentration (% DM w/v)					Average
		1.25	2.5	5	7.5	10	
Boema	4.5a	5.9b	6.7 b	8.7 c	8.42c	8.70 c	7.7 ab
GCO 3 -22	4.5a	6.4b	7.5 bc	8.5 cd	8.6d	11.0 e	8.4c
GDR 2863	4.6a	6.4b	7.02bc	8.1 cd	8.6d	7.68 d	7.5 ab
Titan	4.6a	6.1 ab	7.8 bc	9.1 c	8.8c	9.0 c	8.1 bc
Haiduc	4.7a	6.3 ab	7.1 ab	8.64 b	8.4b	7.0 ab	7.5a
Average	4.6a	6.2b	7.2c	8.63 d	8.61d	8.68 d	7.89

Regarding the allelopathic effect of extracts from wheat the greatest delay was caused by extract from GCO3-22 genotype, as one seed to germinate, in average for all concentrations, needed 8.4 days more than in water (control).

Aqueous extract bioassays, which are conducted in Petri-dishes and seedling screening bioassays with the "equal compartment agar method"(ECAM), are two bioassay tests widely used in laboratory screening bioassays (Wu et al., 2001). Despite many advantages of these methods, there are also criticisms. For example, the release of certain salts, amino acids and nitrogen compounds, all may not be released under natural circumstances, inconsistent results due to non-uniform wetting of growth medium were mentioned as strong criticism of extract bioassays in Petri-dishes (Mardani et al., 2014). In order to determine the allelopathic potential of other 24 wheat and triticale genotypes the 5% extract concentration was used (Table 3).

Table 3. Germination and Pipper Index for ryegrass (*Lolium rigidum* L.) in water extracts of wheat and triticale

Genotype	Germination (%)	Pipper Index
Control	90	4.5
Dropia	52	6.9
Boema	38	7.3
Glosa	32	7.6
Izvor	31	7.6
00628G34-20	36	7.2
00628G34-1M01	51	6.4
00628G34-2M02	34	7.3
Titan	24	8.2
Stil	34	7.5
Gorun	53	6.7
Haiduc	42	7.0
Cascador	57	6.2
Impuls	30	7.8
Lotru	44	6.6
Migrator	46	6.9
Metropol	36	7.3
Matroz	49	6.8
00596 T1-2	61	6.0
00596 T1-101	30	8.0
114 T1-10101	34	7.9
01234T1-2	33	7.7
99574 T1-10201	33	7.7
00153 T5-12301	33	7.6
02511 T6-2	38	8.1

Our results indicated that the 5% concentration of extract was toxic enough than varietal differences in the inhibition of the germination of ryegrass could hardly be detected. At this level of concentration, the germination rate ranging from 24 (Titan) to 61% (00596 T1-2), compared to water control with a germination rate of 90%. The Pipper index ranging from 8.2 (Titan) to 6 (00596 T1-2), compared to water control with a Pipper index of 4.5 (Table 3).

Because the aqueous extract bioassays offer only information on behaviour of weed seed at allelopathic potential of wheat, screening

bioassays using plant residues have been developed. In fact the combination of several screening bioassays in sequence is therefore essential in order to establish conclusive proof of crop allelopathy on weeds (Wu et al., 2001).
The data indicated that the degree of phytotoxicity of the residues differed among varieties. Of the 24 wheat and triticale cultivar tested, three cultivars (Izvor, 00596T1-101 and Matroz) were able to inhibit length of ryegrass root on by 40 %. Migrator cultivar gaves less than 5% root length reduction in ryegrass (Figure 1).

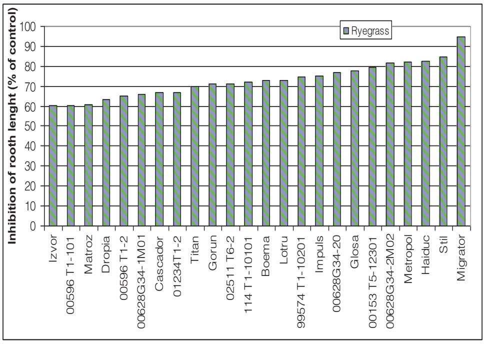

Figure 1. Effect of residues incorporate into soil on length of ryegrass root

Our results show that the degree of inhibition for root growth of ryegrass, and that the plant responses to the phytotoxic substances are genotype dependent (Figure 2).

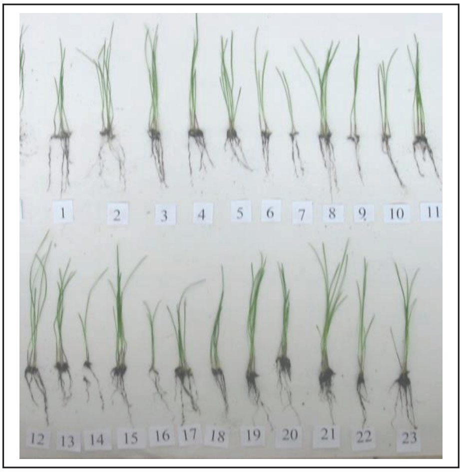

Figure 2. Effect of residues of 24 wheat and triticale and incorporate into soil on ryegrass

Of the 24 wheat and triticale cultivar tested, several cultivars have significantly reduced the amaranyh root elongation by more than 40% (02511 T6-2, Izvor, 99574T1-10201, Impuls, Titan and Glosa). Two genotypes (Boema and 00628G34-20) gave less than 5% root length reduction in amaranth (Figures 3 and 4).

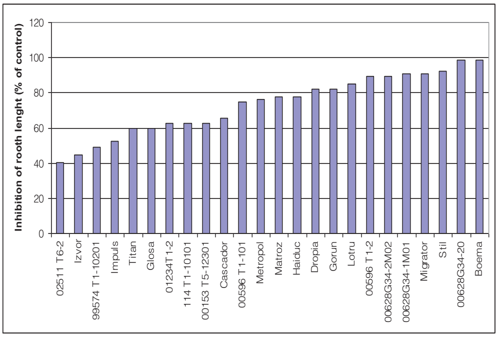

Figure 3. Effect of residues from wheat and triticale genotypes incorporate into soil on length of amaranth root

Growth of root was influenced different by the plant residues beeing genotypes which could be more toxic for ryegrass and less for amaranth (ex. Boema - Figure 3). Other researchers indicated there existed a significant difference among different bioassay methods, and the same rice line had a different allelopathic potential depending on bioassay methods employed (Lu et al., 2016).
Laboratory screening of 453 wheat genotypes showed continous variation in wheat allelopathy against annual ryegrass *(Lolim rigidum)* and among wheat genotypes studied, 63 were highly allelopathic, inhibiting root growth by more than 80% (Olasdotter and Andersen, 2004).

Figure 4. Effect of residues of several wheat genotypes incorporate into soil on amaranth

There was a positive correlation between germination response and root (r = 0.43, r = 0.67 for P 5% and 1%) (Table 4).
The positive correlation between seed germination and root growth may indicate that extracts that allowed rapid germination also allowed more time for root growth compared to extracts that delayed germination. This suggests that the reduction in root growth may have been a reflection of delayed germination rather than due to a direct effect of an allelochemical.

Table 4. The relationships between of the studied traits

Specification	Inhibition of rooth	
	Rygrass	Amaranth
Pipper index	r = - 0.43*	r = - 0.42*
Seed germination	r = 0.21 NS	r = 0.43*
Inhibition of root		r = 0.67**

This are in concordance with the recent discussion about the problems and proposal for future research directions in this field to provide a useful reference for future studies on plant allelopathy (Fang Cheng and Zhihui Cheng, 2015).

CONCLUSIONS

Compounds contained in water extracts of GCO 3-22 and GDR 2863 wheat genotypes have allelopathic activity against ryegrass comparable with triticale genotype.
These results are in concordance with Romanian breeders' expectation because these winter wheat genotypes have rye (*Secale cereale*) in their genetic background.
The plant extracts of these two winter wheat genotypes evaluated in this study act by inhibiting seed germination and may have potential for preemergence weed control.
Wheat and triticale varieties differ in allelepathic potential against ryegrass and amaranth and the differences were evidentiate by both methods.
The genotypes with higher allelophatic potential can be used for breeding purposes.

REFERENCES

Andrew I.K.S., Storkey J., Sparkes D.L., 2015. A review of the potential for competitive cereal cultivars as a tool in integrated weed management. Weed Research 55 (3), 239-248.

Oueslati O., 2003. Allelopathy in two durum wheat (*Triticum durum* L.) varieties. Agric. Ecosyst. Environ. 96:161–163.

Kashif M., Farooq S., Zahid M., Cheema A., Ahmad Nawaz., 2016. Allelopathic potential of bread wheat helps in suppressing the littleseed canarygrass *(Phalaris minor* Retz.) at its varying densities. Agronomy and Soil science. Vol. 62.

Khanh T.D., Chung I.M., Xuan T.D., Tawata S., 2005. The exploitation of crop allelopathy in sustainable agricultural production. Journal of Agronomy and Crop Science 2005; 191 172–184.

Khaliq A., Matloob A., Aslam F., Bismillah Khan M., 2011. Influence of wheat straw and rhizosphere on seed germination, early seedling growth and biochemical attributes of *Trianthema portulacastrum. Planta daninha,* Vol 29, No. 3.

Lu Y., Hong Lu., Kilung Kim K., Sun Y., Fu J., Yiqing Guo., 2016. A New Bioassay Method for Evaluation Allelopathic Potential of Rice Germplasm. Journal of Life Sciences 10 (2016) 128-133 doi: 10.17265/1934-7391/2016.03.003.

Fang Cheng, Zhihui Cheng., 2015. Research Progress on the use of Plant Allelopathy in Agriculture and the Physiological and Ecological Mechanisms of Allelopathy. Frontier in Plant Sci. 6: 1020. doi: 10.3389/fpls.2015.01020.

Mardani R., Yosef A. R., Fotovat R., Oveis M., 2014. New bioassay method to find the allelopathic potential of wheat cultivars on rye (Secale cereale L.) seedlings. Allelopathy Journal 33 (1): 53-62.

Rizvi S.J.H., Ketata H., Bazazi D., Roostaii M., Pala M., 2004. Weed suppressing ability of bread wheat genotypes under greenhouse and field conditions. In: Proceedings of Second European Allelopathy Symposium-Allelopathy:From Understanding to Application. p. 25. Pulawy, Poland. New bioassay method to find the allelopathic potential of wheat cultivars on rye (*Secale cereale* L.) seedlings. Available from: https://www.researchgate.net/publication/259975637_New_bioassay_method_to_find_the_allelopathic_potential_of_wheat_cultivars_on_rye_Secale_cereale_L_seedlings [accessed Feb 22, 2017].

WU H., Hang T., Paratley J., Lemerle D., 2000. Distribution and exudation of allelochemicals in wheat (*Triticum aestivum L.*). J. Chem. Ecol., v. 26, n. 9, p. 2141-2154.

Olasdotter M., Andersen S., 2004. Improvement of allelopathy in crops for weed management – possibilities, breeding, strategies and tools. In: Weed biology and management, edited by Inderjit. P: 317-328.

WU H., Hang T., Paratley J., Lemerle D., 2001. Allelochemicals in wheat (*Triticum aestivum* L.): Variation of phenolic acids in shoot tissues. J. Chem. Ecol., v. 27, n. 1, p. 125-135, 2001.

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IDENTIFYING GENETIC VARIATION IN 12 WHEAT CULTIVARS FOR NITROGEN USE EFFICIENCY

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Abstract

*The article introduces Normalized Difference Vegetation Index (NDVI), Flag-leaf Chlorophyll Content, which was performed for 12 Triticum aestivum wheat (Shuha-4, Attila50, Seri.1B*2, Jawahir-1, Seri.1B, KBG-01, Flaf-3, Kauz, Hubara-3, Adana99 and Arehane). The two rate of nitrogen fertilizer (high-200 kg N ha-1 and low-0 kg N ha-1) was applied to the wheat varieties. Measurements were recorded in pre and post anthesis for both high and low nitrogen input plots. The NDVI value for (Aras) was the lowest (0.62) and (Seri.1B and Kauz/Pastor) were the highest (0.78) under LN condition. Significant differences were detected at post anthesis stage, Flag-3 had the lowest flag-leaf chlorophyll content (37), while (Seri.1B*2) had the highest flag-leaf chlorophyll (50). And under HN condition, KBG-01 had the lowest flag-leaf chlorophyll content (43), and (Seri.1B*2) had the highest flag-leaf chlorophyll (51). At pre anthesis stage, the genotypes differed in NDVI, it ranged from 0.64 (Flag-3) to 0.81 (Kauz/Pastor) under LN condition, and the range was 0.73 (Hubara-3*2) to 0.82 (Adana99) under HN condition.*

Key words*: Normalized Difference Vegetation Index, fag-leaf chlorophyll content*.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the major cereal crops and the most widely grown crop (Sakin et al., 2015). It is essential to increase the grain yield in order to supply the rest demand on food due to growing world population (Asrar et al., 1984). The intensive cultivation and the modern wheat cultivars require a high amount of fertilizers to be applied to increase the grain yield, especially nitrogen fertilizers (Colwell, 1963; Blackshaw et al., 2002). Large amounts of nitrogen fertilizer inputs have a great impact on the environment, health and cost on the production (Zhu and Chan, 2002; Quiao et al., 2015). Improving nitrogen use efficiency through identifying related traits such as stay-green might be a possible mechanism to reduce the environmental impacts of nitrogen input (Hawkesford, 2014). The aim of this study is to determine the effects of the pre and post anthesis of wheat on the effects of low and high nitrogen input.

MATERIALS AND METHODS

This study was carried out at Directoriate of Agriculture Research in Bakrajo province of Iraq. The soil type was clay loam. 12 strains of aestivum wheat (Shuha-4, Attila50, Seri.1B*2, Jawahir-1, Seri.1B, KBG-01, Flaf-3, Kauz, Hubara-3, Adana99 and Arehane), and Arass cultivar as local check, were sown by applying two rates of nitrogen fertilizer; high N (200 kg $N.ha^{-1}$) and Low N (0 kg $N.ha^{-1}$).

The experimental design was a split plot design with two nitrogen fertilizer rates, High (200 kg $N.ha^{-1}$) and low nitrogen (0 kg $N.ha^{-1}$), and 160 kg/h daimio phosphate, randomised on the main-plots and 12 genotypes randomised on sub-plots in three replicates. The plot size was 2.5 m x 0.8 m with 4 rows with 0.2 m between rows. The genotypes within the experiment were sown at the same seeding rate 120 kg/h.

Normalized difference vegetation index (NDVI)

Spectral reflectance indices are important tools for evaluating photosynthetic traits (Sims and Gamon, 2002; Gitelson et al., 2003). The Normalized Difference Vegetation Index (NDVI) is one of the most widely used vegetation indices as an indicator of canopy green area and it is associated with grain yield as well (Reynolds et al., 2007; Tanrıverdi, 2010). It is based on the difference between the maximum absorption of radiation in the red spectral band and the maximum reflection of radiation in the near-infrared spectral bands (Ghorbani et al., 2012; Tucker et al., 2005; Carlson and Ripley, 1997). Canopy NDVI values are between –1.0 and +1.0 and for soil and vegetation are usually positive values. The healthy green plant absorbs most of the incident red light and they reflect a large rate of the near infrared radiation (high NDVI value) while in non-green plants the absorption of red light is less (low NDVI value). Hence, this difference in adsorption and reflection of the light waves is measured using the NDVI equation: NDVI = (NIR - RED)/ (NIR + RED) or (R900-R680)/R900-R680) (Moriondoa et al., 2007).

NDVI was measured on two occasions at pre and post anthesis using in each plot under high nitrogen HN and low nitrogen LN conditions in three replicates using GreenSeeker HandHeld (Greenseeker, USA). This instrument measures the amount of near infrared (NIR) and red light reflected by the canopy.

Flag-Leaf Chlorophyll Content

Chlorophyll content is used for the determination of stay green or leaf senescence in agricultural research (Bahar, 2015). Flag-leaf chlorophyll concentration is an important parameter that is frequently measured as an indicator of chloroplast development, photosynthetic capacity, leaf nitrogen content or general plant health (Ling et al., 2011). Flag-leaf greenness was measured using the SPAD 502 meter (Minolta Japan) which is a hand-held device that is widely used for rapid, accurate and non-destructive measurement of leaf chlorophyll concentration. This device is based on two light-emitting diodes and a silicon photodiode receptor, that measures leaf transmittance in the red (650 nm; the measuring wavelength) and infrared (940 nm; a reference wavelength) regions of the electromagnetic spectrum (Uddling et al., 2007). These transmittance values are used by the device to derive a relative SPAD meter value that is proportional to the amount of chlorophyll in the sample.

In this experiment, samples of three fertile shoots (those with an ear) were randomly measured before and after anthesis stage from each plot in the HN treatment in all replicates. Three measurements were taken from each flag-leaf at the base, middle and top of the flag leaf.

The most significant event when the leaf start to senesce is the changes that happens in the leaf chloroplast where photosynthesis occur. Decline in photosynthetic activity is associated with reducing in dark reactions of the Calvin cycle which is mainly due to the degradation of Rubisco disassembly of the photosynthetic apparatus (Lu et al., 2002).

High flag-leaf chlorophyll content has been known to be related with high photosynthesis rate as higher amounts of chlorophyll increase the photosynthesis rate. More light will be absorbed by the flag leaf and this will improve the radiation use efficiency and hence enhancing photosynthesis rate (Foulkes et al., 2009; Makino, 2011; Garnett and Rebetzke, 2013).

RESULTS AND DISCUSSIONS

Normalized Difference Vegetation Index (NDVI)

This measurement was determined using the GreenSeeker HandHeld where the equipment sensor was held about 50 cm above the canopy. Two measurements were recorded in pre and post anthesis for both high and low nitrogen input plots.

At pre anthesis stage, the genotypes differed in NDVI, it ranged from 0.64 (Flag-3) to 0.81 (Kauz/Pastor) under LN condition, and the range was 0.73 (Hubara-3*2) to 0.82 (Adana99) under HN condition (Table 1). However, there were no significant differences among the genotypes and the N x G interaction (Table 2).

Significant differences were detected among cultivars at post anthesis stage (Table 3). The NDVI value for (Aras) was the lowest (0.62) and (Seri.1B and Kauz/Pastor) were the highest (0.78) under LN condition. The value of NDVI was the lowest for (Hubara-3*2) 0.68, and the highest value was 0.78 for (Seri.1B) (Table1).

Flag-Leaf Chlorophyll Content

Flag-leaf chlorophyll content was determined at GS61 using a SPAD 502 meter (Minolta, Japan). Three different points on the flag-leaf were measured for 3 fertile shoots per plot under LN and HN conditions.

The genotypes differed in flag-leaf chlorophyll content but the variation was non-significant (Table 5); at pre anthesis stage the flag-leaf chlorophyll content ranged from 36 (Flag-3) to 54 (Hubara-3*2) under LN condition, and from 41 (Attila 50y) to 54 (Kauz/Pastor) under HN condition (Table 4).

Significant differences were observed at post anthesis stage (Table 6), Flag-3 had the lowest flag-leaf chlorophyll content (37), while (Seri.1B*2) had the highest flag-leaf chlorophyll (50).

And under HN condition, KBG-01 had the lowest flag-leaf chlorophyll content (43), and (Seri.1B*2) had the highest flag-leaf chlorophyll (51) (Table 4).

Table 1. Mean data for NDVI at pre and post an thesis stage

Genotypes	PRE		POST	
	LN	HN	LN	HN
Shuha-7	0.76	0.78	0.67	0.72
Attila 50y	0.73	0.79	0.68	0.72
Seri.1B*2	0.78	0.80	0.73	0.74
Jawahir-1	0.73	0.77	0.69	0.73
Seri.1B	0.80	0.80	0.75	0.78
KBG-01	0.80	0.78	0.72	0.74
Flag-3	0.64	0.76	0.67	0.74
Kauz/Pastor	0.81	0.77	0.75	0.74
Hubara-3*2	0.71	0.73	0.67	0.68
Adana99	0.75	0.82	0.72	0.75
Arehane	0.74	0.76	0.70	0.73
Aras	0.76	0.78	0.62	0.70

Nguyen et al., 2016, are conducted a study on 15 wheat varieties, grown under three N levels, were phenotyped for NUE-related traits under field conditions. Significant genotypic differences were observed in varieties having low to high responsiveness to N applications. The results suggest that basal low N can be used to screen wheat varieties that are less responsive to N, whereas N supply from 80 to 160 kg N.ha^{-1} could be used to screen high N-responsive varieties. Normalised difference vegetation index (NDVI) measured by using Crop Circle.

Gaju et al., 2016, found that flag-leaf chlorophyll content was positively associated with at anthesis leaf Amax (R2 = 0.74) amongst 15 wheat genotypes under high N conditions. Schlemmer et al., 2013, carry out that leaf nitrogen and chlorophyll content were retrieved accurately from leaf reflectance spectra. Canopy nitrogen and chlorophyll content were closely related, vegetation indices using green and red-edge spectral bands were used for accurate chlorophyll and nitrogen estimation at canopy level, optimal spectral bands found for nitrogen and chlorophyll estimation match well-spectral bands of near future space systems. Kapp et al., 2016, state that wheat grain yield was high and it did not follow the gains in the production.

Table 2. Statistical analysis for NDVI at pre anthesis stage

S.O.V	d.f	SS	MS	F cal.	F 0.05
Blocks	r-1=2	0.007	0.003	1.505	
A	a-1 = 1	0.014	0.014	6.156	18.513
Error (a)	(r-1)(a-1)= 2	0.005	0.002		
B	b-1= 11	0.060	0.005	1.064	2.014
AB	(a-1)(b-1) = 11	0.030	0.003	0.527	2.014
Error (b)	a(b-1)(r-1) = 44	0.225	0.005		
Total	abr-1 = 71	0.340			

A lot of research has been done about the wheat which is the most important agricultural product of the world. In all studies, it was observed that nitrogen fertilization was effected on wheat production, the effect of chlorophyll content and spectral reflection. In addition, Normalized Difference Vegetation Index measurements pre and post anthesis were used by different researchers.

Table 3. Statistical analysis for NDVI at post an thesis stage

S.O.V	d.f	SS	MS	F cal.	F 0.05
Blocks	r-1=2	0.015	0.008	13.302	
A	a-1 = 1	0.002	0.002	4.230	18.513
Error (a)	(r-1)(a-1)= 2	0.001	0.001		
B	b-1= 11	0.118	0.011	5.880	2.014
AB	(a-1)(b-1) = 11	0.004	0.000	0.220	2.014
Error (b)	a(b-1)(r-1) = 44	0.080	0.002		
Total	abr-1 = 71	0.222			

Table 4. Mean data for flag-leaf chlorophyll content at pre and post an thesis stage

Genotypes	PRE		POST	
	LN	HN	LN	HN
Shuha-7	48	48	44	44
Attila 50y	40	41	41	44
Seri.1B*2	43	48	50	51
Jawahir-1	41	49	41	47
Seri.1B	47	48	44	47
KBG-01	48	53	48	43
Flag-3	36	43	37	40
Kauz/Pastor	45	54	47	48
Hubara-3*2	54	50	47	50
Adana99	39	43	43	45
Arehane	43	48	40	46
Aras	44	51	46	45

Table 5 shows the mean values for flag-leaf chlorophyll content at pre and post anthesis stages.

Statistical analyzes of these data were carried out and the results are given in Table 5 and Table 6. In many genotypes the average flag-leaf chlorophyll content shows differences between pre and post anthesis. However, in some genotypes the average flag-leaf chlorophyll content showed differences. The significance levels of these differences are given below as a statistical analysis table.

Table 5. Statistical analysis for flag-leaf chlorophyll content at pre an thesis stage

S.O.V	d.f	SS	MS	F cal.	F 0.05
Blocks	r-1=2	366.667	183.334	179.421	
A	a-1 = 1	277.694	277.694	271.768	18.513
Error (a)	(r-1)(a-1)= 2	2.044	1.022		
B	b-1= 11	1115.693	101.427	1.669	2.014
AB	(a-1)(b-1) = 11	201.546	18.322	0.301	2.014
Error (b)	a(b-1)(r-1) = 44	2674.676	60.788		
Total	abr-1 = 71	4638.320			

Table 6. Statistical analysis for flag-leaf chlorophyll content at post an thesis stage

S.O.V	d.f	SS	MS	F cal.	F 0.05
Blocks	r-1=2	535.947	267.973	26.907	
A	a-1 = 1	50.167	50.167	5.037	18.513
Error (a)	(r-1)(a-1)= 2	19.919	9.959		
B	b-1= 11	632.942	57.540	2.134	2.014
AB	(a-1)(b-1) = 11	140.272	12.752	0.473	2.014
Error (b)	a(b-1)(r-1) = 44	1186.501	26.966		
Total	abr-1 = 71	2565.747			

CONCLUSIONS

Chlorophyll retention or stay-green is regard as an indicator of the plant performance under stress conditions such as nitrogen.

The improvement of genotypes for nitrogen use efficiency and photosynthesis are requiring identification associated traits among various genotypes and select the superior.

The genotypes showed variation in their flag leaf chlorophyll content as the value of SPAD. The genotype (Kauz/Pastor) had the advantage in NDVI values as it was significantly different from all other genotypes under low nitrogen condition and post anthesis measurements.

The genotype with higher NDVI had a greater potential for grater grain filling.

This is an indicator that the plants have better nitrogen utilization and they are capable of retain their tissues green for longer period of time, more nitrogen will be accumulated from the soil and more active in their photosynthesis.

REFERENCES

Asrar G.Q., Fuchs M., Kanemasu E.T., Hatfield J.L., 1984. Estimating absorbed photosynthetic radiation and leaf area index from spectral reflectance in wheat. Agronomy journal, 76(2), 300-306.

Bahar B., 2015. Relationships among flag leaf chlorophyll content, agronomical traits, and some physiological traits of winter wheat genotypes. Dicle University Institute of Natural and Applied Science Journal, 4(1), 1-5.

Blackshaw R.E., Semach G., Janzen H.H., 2002. Fertilizer application method affects nitrogen uptake in weeds and wheat. Weed Science, 50(5), 634-641.

Carlson T.N., Ripley D.A., 1997. On the relation between NDVI, fractional vegetation cover, and leaf area index. Remote sensing of Environment, 62(3), 241-252.

Colwell J.D., 1963. The estimation of the phosphorus fertilizer requirements of wheat in southern New South Wales by soil analysis. Animal Production Science, 3(10), 190-197.

Foulkes M.J., Hawkesford M.J., Barraclough P.B, Holdsworth M.J., Kerr S., Kightley S., Shewry P.R., 2009. Identifying traits to improve the nitrogen economy of wheat: Recent advances and future prospects. Field Crops Research, 114 (3), 329–342.

Gaju O., DeSilva J., Carvalho P., Hawkesford M.J., Griffiths S., Greenland A., Foulkes M. J., 2016. Leaf photosynthesis and associations with grain yield, biomass and nitrogen-use efficiency in landraces, synthetic-derived lines and cultivars in wheat. Field Crops Research, 193, 1-15.

Garnett T., Rebetzke G., 2013. Improving Crop Nitrogen Use in Dry land Farming: Interaction and potential Trade-offs between Water and Nutrient-Use Efficiency. In improving water and nutrient-use efficiency in food production systems, pp. 105-123. (Ed. Rengel, Z.) Wiley-Blackwell.

Ghorbani A., Mossivand A., Ouri A., 2012. Utility of the Normalised Difference Vegetation Index (NDVI) for land/canopy cover mapping in Khalkhal County (Iran). Annals of Biological Research, 3 (12), 5494-5503.

Gitelson A.A., Gritz Y., Merzlyak M.N., 2003. Relationships between leaf chlorophyll content and spectral reflectance and algorithms for non-destructive chlorophyll assessment in higher plant leaves. Journal of plant physiology, 160(3), 271-282.

Hawkesford M.J., 2014. Reducing the reliance on nitrogen fertilizer for wheat production. Journal of cereal science, 59(3), 276-283.

Kapp Junior C., Guimaraes A.M., Caires E.F., 2016. Use of active canopy sensors to discriminate wheat response to nitrogen fertilization under no-tillage. Engenharia Agrícola, 36(5), 886-894.

Ling Q., Huang W., Jarvis P., 2011. Use of a SPAD-502 meter to measure leaf chlorophyll concentration in Arabidopsis thaliana. Photosynth Research, 107, 209–214.

Lu Q., Lu C., Zhang J., Kuang T., 2002. Photosynthesis and chlorophyll a fluorescence during flag leaf senescence of field-grown wheat plants. Journal of Plant Physiology, 159, 1173-1178.

Makino A., 2011. Photosynthesis, Grain Yield, and Nitrogen Utilization in Rice and Wheat. Plant Physiology January, 155 (1), 125-129.

Moriondoa M., Maselli F., Bindi M., 2007. A simple model of regional wheat yield based on NDVI data. European Journal of Agronomy, 26, 266–274.

Nguyen G.N., Panozzo J., Spangenberg G., Kant S., 2016. Phenotyping approaches to evaluate nitrogen-use efficiency related traits of diverse wheat varieties under field conditions. Crop and Pasture Science, 67(11), 1139-1148.

Qiao C., Liu L., Hu S., Compton J.E., Greaver T.L., Li Q., 2015. How inhibiting nitrification affects nitrogen cycle and reduces environmental impacts of anthropogenic nitrogen input. Global change biology, 21(3), 1249-1257.

Reynolds M., Dreccer F., Trethowan R., 2007. Drought-adaptive traits derived from wheat wild relatives and landraces. Journal of Experimental Botany, 58 (2), 177–186.

Schlemmer M., Gitelson A., Schepers J., Ferguson R., Peng Y., Shanahan J., Rundquist D., 2013. Remote estimation of nitrogen and chlorophyll contents in maize at leaf and canopy levels. International Journal of Applied Earth Observation and Geoinformation, 25, 47-54.

Sims D.A., Gamon J.A., 2002. Relationships between leaf pigment content and spectral reflectance across a wide range of species, leaf structures and developmental stages. Remote sensing of environment, 81(2), 337-354.

Tanriverdi C., 2010. Improved agricultural management using remote sensing to estimate water stress indices. Applied Remote Sensing Journal, 1(1), 19-24.

Tucker C.J., Pinzon J.E., Brown M.E., Slayback D.A., Pak E.W., Mahoney R., El Saleous N., 2005. An extended AVHRR 8 km NDVI dataset compatible with MODIS and SPOT vegetation NDVI data. International Journal of Remote Sensing, 26(20), 4485-4498.

Uddling J., Gelang-Alfredsson J., Piikki K., Pleijel H., 2007. Evaluating the relationship between leaf chlorophyll concentration and SPAD-502 chlorophyll meter readings. Photosynth Research, 91, 37–46.

Zhu Z.L., Chen D.L., 2002. Nitrogen fertilizer use in China–Contributions to food production, impacts on the environment and best management strategies. Nutrient Cycling in Agroecosystems, 63(2), 117-127.

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EFFECT OF *Bradyrhizobium japonicum* AND *Pseudomonas putida* APPLICATION ON GROWTH AND YIELD OF SOYBEAN UNDER PHOSPHORUS AND WATER DEFICIENT CONDITIONS

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Abstract

In recent years, the use of soil microorganisms has generated great interest in crop production, by reducing the damage from drought stress and improving nutrition, hence, providing alternative solutions for sustainable agriculture. A pot experiment was conducted to examine the impact of two rhizobacteria Bradyrhizobium japonicum and Pseudomonas putida on growth and grain productivity of soybean (Glycine max (L.) Merr.*) under phosphorus insufficiency and moderate drought conditions. Soybean seeds were inoculated with Bradyrhizobium japonicum and Pseudomonas putida was administered in soil before the sowing. Soybean plants were grown in a soil: sand mixture with low phosphorus supply. Plants were treated with two regims of irrigation water, i.e., 70% of water holding soil capacity (WHC) and 35% of WHC as moderate drought. The water deficit was imposed at the flowering stage for 12 days. Plant growth traits and soybean yields were significantly altered by low P supply, water stress and PGPR treatments. P insufficiency and temporary drought had a sinergetic negative effect on soybean performance. The results of this experiment revealed significant positive effects of Rhizobium inoculation and Pseudomonas putida on growth, nodulation and yield of plants under both water regimes but drought reduced their beneficial impact. Experimental data demonstrated that integrated application of nitrogen-fixer bacteria and P. putida better improved the growth and plant productivity as compared to the application of B. japonicum alone. In conclusion, the combined utilization of B. japonicum and P. putida can mitigate deleterious effects of temporary drought stress in soybean under phosphorus and water deficiency conditions.*

Key words: *drought, growth, nodulation, phosphorus*, *rhizobacteria, soybean.*

INTRODUCTION

In the last two decades, the use of chemical phosphorus (P) fertilizers in crop systems has decreased in many countries, particularly in countries with vulnerable resources of rock phosphates, due to their higher price. Beneficial free-living bacteria, referred to as plant growth promotion rhizobacteria (PGPR) are components of the plant rhizosphere and have been found in association with many plant species including leguminous plants (Majeed et al., 2015). The exploitation of rhizobacteria is an alternative of industrial amendments and has a considerable importance for crop production (Yadav et al., 2013). Among the various microorganisms with potential to enhance plant growth, the role of biofertilizers such as *Rhizobium* and *Pseudomonas* in tolerating environmental stress has been well established and has received increased attention from researchers (Kadian et al., 2013). PGPR can enhance plant growth directly by providing plants with nutrients such as nitrogen via nitrogen fixation or by supplying phosphorus from soil bound phosphate due to the activities of soil microorganisms (Berg, 2009; Yadav and Dadarwal, 1997). Likewise, these microorganisms are known for their ability to synthesize several plant growth hormones such as auxins, cytokines and others (Berg, 2009; Yadav et al., 2013).

Drought and low phosphorus supply are the major abiotic factors which are responsible for reducing the production of soybean in semi-arid regions of the world. The soybean (*Glycine* *max.* L) is a member of the family *Leguminosae*, mainly cultivated for oil production as well as for animal fodder. Soybean plants are sensitive to phosphorus deficiency and drought. Adequate phosphorus nutrition has fundamental physiological and biochemical roles, influencing the water economy and plant growth, affecting water uptake, root growth, transpiration and stomatal regulation (Singh et al., 1997). Many studies have documented the role of *Bradyrhizobium* inoculation in improving the growth and yield of soybean (Egamberdiyeva et al., 2004; Israel, 1993). The research of Tilak et al. (2006) concluded that growth, nodulation and enzymes activity were significantly increased in plants co-inoculated with *Pseudomonas putida*, *P. fluorecens* and *Bacillus cereus*, compared with those inoculated only with *Rhizobium.* However, there are limited studies referring to the utilization of *Bradyrhizobium japonicum* together with other genera such as *Pseudomonas putida.* It is necessary to note their effects on crops have been studied under favorable soil moisture conditions, as a rule, and little is known about their interactions under multiple environmental stresses. Therefore, the present investigation was undertaken to evaluate the effects of seed pre-treatment with *B. japonicum* alone or in combination with the application of *Pseudomonas putida* under insufficiency or adequate P supply of soybean plants subjected to moderate drought conditions.

MATERIALS AND METHODS

To evaluate the effect of *B. japonicum* and *P. putida* inoculation on the growth and yield of soybean plants under drought stress a pot experiment was conducted in a greenhouse. The soil of carbonated cernoziom with low phosphate availability was mixed with sand in a proportion of 3:1 (soil: sand). The seeds were treated pre-sowing with the suspension of *Bradyrhizobium japonicum* of local strain 646. For rhizosphere inoculation, live cultures *Pseudomonas putida* were added into the soil before the sowing of the seeds. These rhizobacteria were tested without fertilization (low P supply - P0) and on soil fertilized with potassium phosphate at a rate of 100 mg P kg^{-1} soil (P100). The experiment was laid out in a randomized complete block design, with eight replicas of each treatment. The study was carried out using Horboveanca cultivar of soybean sensitive to drought. Soybean seeds were surface-sterilized by washing them with 96% ethanol for 30 seconds and 2.5% sodium hypochlorite for 3 minutes, and then rinsed several times with sterile, distilled water. In each pot, six healthy and uniform seeds of soybean were sown at a depth of 3 cm. After complete germination, the plants were thinned to two plants per pot. Half of the pots were well watered throughout the experiment (70% WHC) while half was subjected to water stress conditions by reducing the irrigation rate (35% WHC) at the flowering stage. Plant drought of moderate stress was imposed for 12 days. A set of plants was carefully harvested at the beginning of the pod setting stage to study the growth, root development and nodulation potential of soybean while the other set of plants was harvested at R8 stage to determine grain productivity. After the harvest, roots and shoots were weighed separately to determine fresh weight, and then placed in an oven to dry at 60°C until a constant dry weight was obtained. Data were subjected to varying means off analysis and categorized using the “least significant difference” test in the Statistic program 7.

RESULTS AND DISCUSSIONS

The main parameter for evaluation of rhizobacteria and chemical fertilizer effect in crop cultivation is considered the accumulation of dry matter. The experimental results have shown that plant growth displayed significant responses to biofertilizer application as well as to P fertilization. Biomass production in all treatments with PGPR of soybean increased significantly in comparison to uninoculated plants (Figures 1 and 2). According to the results, root biomass was also found to be increased significantly irrespective of treatments over control (data not shown). The least accumulation of dry matter was recodered in treatment with insufficiency of P and water deficit. Experimental data found that the dry weights of plants increased by 13.1% after *B. japonicum* inoculation under normal soil moisture (Figure 1). Similarly, the growth promotion of soybean by inoculation with *Bradyrhizobium* was reported by Rahmani and Saleh-Rastin (2001) in P-deficient soil. The best increase was recorded in the treatment of the combined application of *B. japonicum* and *P. putida* in comparison with the single inoculation of nitrogen-fixer rhizobacteria.

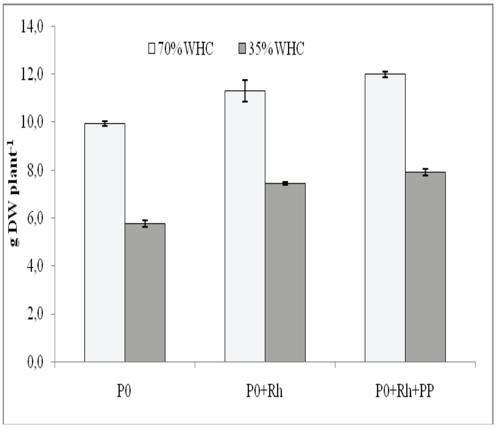

Figure 1. The effect of *Bradyrhizobium japonicum* (Rh) and *Pseudomonas putida* (PP) isolates on dry weight of soybean plants under P insufficiency and moderate drought. Columns are means of four replicates ± SE

Their synergic interaction was observed under both soil moisture levels. The treatments' effect indicated that the combination of *B. japonicum* and *P. putida* increased the dry weight of the plant by 25% over control i.e. P0 under well-irrigated plants. This increment may be due to more absorption of nutrients, especially P due to the increase in root surface area and nutrients available in the soil through rhizobacteria administration (Yadav and Dadarwal, 1997) and the ability of plants to produce phytohormones like gibberellins, auxin, citochinine as well as phosphatases enzymes and other stimulants (Noumavo et al., 2016). Gull et al. (2004) reported that the co-application of phosphate solubilizing bacteria and *Rhizobium* isolates increased P absorption and promoted the growth of pea plants. Soybean plants are sensitive to P deficiency (Israel, 1993). It is documented that phosphorus nutrition plays an important role in crop responses to water stress, but how P fertilization interacts with PGPR, particularly under low moisture of soil, is not elucidated. The application of phosphorus at the rate of 100 mg/kg of soil without inoculation also seemed to be an effective approach for the growth of soybean (Figure 2). However, the integrated application of rhizobacteria and chemical fertilizer promote plant growth and development more significantly as compared with chemical fertilizer alone (P100) under drought conditions.

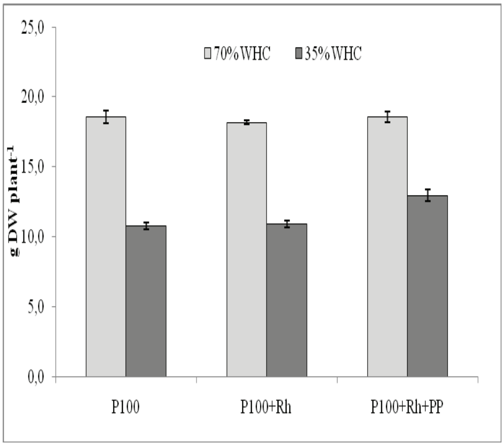

Figure 2. The effect of *Bradyrhizobium japonicum* (Rh) and *Pseudomonas putida* (PP) isolates on dry weight of soybean plants under P fertilization and moderate drought. Columns are means of four replicates ± SE

In general, drought significantly reduced the performance of plant growth irrespective of biofertilzer or P aplication. Therefore, the positive influence of PGPR was also established under drought conditions. In that case, they increased growth by 13.8% in treatment with P insufficiency supply and by 16.2% in the treatment of P supplementation. Probably, the phosphate's solubilization, production of auxin, the fixation of nitrogen and enhanced nutrient uptake are likely responsible for better accumulation of dry matter by soybean (Bashan and Holguin, 1998). The legume's growth correlates with nitrogen atmosphere assimilation and this process is dependent on root nodulation. Hence, nodules provide plants with an alternative nitrogen source due to nitrogen fixation. The enhancement of plant development with biofertilizers and phosphorus led to a better nodule initiation. The supply of phosphorus directly and positively stimulates nodulation in red clover (Hellsten and Huss-Danell, 2000), peas (Jacobsen, 1985) and soybeans (Israel, 1993). There were also other reports suggesting that phosphorus indirectly induced nodulation with a positive effect on the plant growth (Yang, 1995).

Table 1. The effects of *Bradyrhizobium japonicum* (Rh) and *Pseudomonas putida* (PP), phosphorus fertilization and water regime on root nodule number. Mean of four replications ± SE

Treatments	70% WHC	35% WHC
P0	2±0.29	1±0.25
P0+Rh	14±1.04	10±2.55
P0+Rh+PP	29±3.46	13±1.00
P100	3±1.08	2±0.87
P100+Rh	50±1.87	17±1.49
P100+Rh+PP	64±11.88	39±3.57

Experimental data demonstrated that the nodules' growth and development showed significant responses to the application of biofertilizers and phosphorus fertilization, but the response was affected by the water supply level (Table 1). On average, drought decreased the nodule number by 40-123% irrespective of P or PGPR treatments. The significant increase in nodule number under normal water supply both in unfertilized and fertilized soils following inoculation indicated that inoculation with *B. japonicum* is an essential practice for maximum nodulation that would certainly affect the N_2 fixation and N assimilation by soybean plants. So, it was established that combined utilization of these strains significantly increased the number of nodules on soybean roots over the control. Few nodules in uninoculated plants indicated that the indigenous *bradyrhizobia* population was low in the soil (Table 1). Experimental results showed a greater proportion of nodules developed on the root of the soybean after inoculation and phosphorus fertilization.

Drought stress caused a significant reduction in the number of nodules as compared to well-watered plants. In addition, P deficiency essentially diminished the number of nodules, especially under low soil moisture level. The administration of *P. putida* in the soil increased the number of nodules of plants inoculated with *Bradyrhizobium japonicum* (Table 1). It was observed that their combined utilization doubled the number of nodules in plants grown with low P supply under normal water conditions.

The beneficial effect of *P. putida* was established in plants with P supplementation and this parameter increased by 28% at good irrigation levels of the plants and two times more under moderate drought conditions in comparison with the reference uninoculated treatment. The presented results on improved nodulation of soybean induced by *Pseudomonas* confirm the findings by other authors for faba beans (Grimes and Mount, 1984) and lentils (Verma et al., 2013). Therefore, we concluded that the symbiotic system had a positive and significant response to biofertilizers applied separately or in combination irrespective P supply. Our experimental results are consistent with other research obtained in leguminous species (Kadian et al., 2013).

Many studies have demonstrated that rhizosphere microorganisms have a beneficial impact on crop yields (Verma et al., 2013).

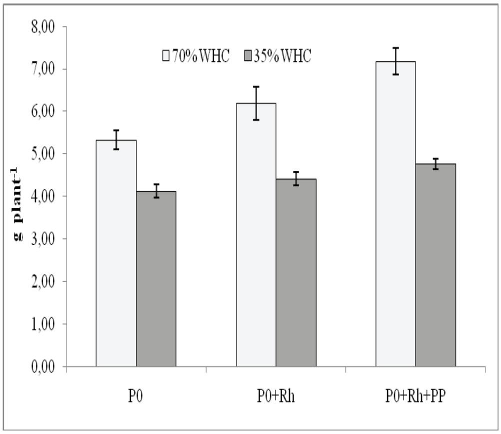

Figure 3. The effect of *Bradyrhizobium japonicum* (Rh) and *Pseudomonas putida* (PP) isolates on grain yield of soybean cultivated on soil with P insufficiency supply under well water and water stress conditions. Columns are means of four replicates ± SE

The use of microorganisms has also created favorable conditions for soybean grain productivity irrespective of soil moisture regime (Figure 3). Low P supply significantly reduced grain production, particularly under temporary drought conditions. Likewise, Tsvetkova and Georgiev (2003) reported that P deficiency treatments in soybean decreased the entire plant dry mass and nodule weight. In our experiment, yield parameters differ significantly between well-watered and drought exposed plants. Data on grain yield (Figure 3) showed that biofertilization as well as phosphorus fertilizer application significantly increased productivity of soybean over the control. The seed treatment with *B. japonicum* increased the yield by 14.1% under normal water conditions. In drought conditions, only a 6.5% increase was observed with respect to control plants without inoculation (Figure 3). We suggest that the water deficit had a direct impact on the leaves' canopy, decreased storage capacity of the source and, subsequently, caused a reduction in seed weight. The percent increase in seed yield due to the inoculation of soybean by two strains used as biofertilizers of unfertilized soil was 19.1% over the control under normal water regime.

Therefore, the combined inoculation produced the maximum result followed by the singular inoculation of *Bradyrhizobium japonicum* compared to the controls. Grain yield was increased by P fertilization and the dry weight of shoots and pods per plant had a significant positive association with grain yield. The integrated application of microorganisms and chemical fertilizer increased the productivity by 19.1% in normal water conditions, while under drought the increase was more modest, around 13.2%, in comparison to the plants without microoganisms administration. Uninoculated plants had the lowest seed yield, probably, because the native rhizobium was ineffective and did not fix much N_2 to increase the growth and seed yield. Egamberdiyeva et al. (2004) reported that the yield of soybean was 48% higher for inoculated than for uninoculated plants grown on calcareous soil. The results of our experiments with *Bradyrhizobium* spp. strains clearly demonstrated that rhizobium inoculation with soil applied with *P. putida* significantly increased soybean seed yield. The drought stress had an undesirable impact on growth, yield and nodulation in all treatments in comparison to well-watered plants. Dashti et al. (1998) revealed that plant co-inoculation of PGPR with *Bradyrhizobium* has been reported to increase legume nodulation and plant tolerance even at low soil temperatures. Similar effects of inoculation with plant growth promoting rhizobacteria and *Sinorhizobium fredii* was observed by Guarcia et al. (2004).

According to the obtained results, we conclude that these microorganisms could provide a better productivity of soybean under phosphorus insufficiency and moderate drought conditions. The significant response of the two strains indicated the synergistic effect of the interaction.

CONCLUSIONS

The results of a greenhouse pot experiment indicate that the soil insufficiency of phosphates in association with drought considerably decreases the growth and productivity of soybean. The seed inoculation with *B. japonicum* strain in combination with soil inoculation with *P. putida* strain significantly increases the plant growth and yield of soybean grain under insufficient phosphorus and moderate drought conditions.

Integrated application of *Bradyrhizobium japonicum* and *Pseudomonas putida* promote nodulation of soybean and increased drought tolerance of soybean.

Inoculation with rhizobium strains alone show less influence in seed yield over the control but the use of both strains *B. japonicum* and *P. putida* increased seed yield significantly.

Hence, certain co-operative microbial species could be used as a low-input biotechnology that provides the stable production of crops and forms the basis for a strategy to develop sustainable and environmental agriculture.

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REFERENCES

Bashan Y., Holguin G., 1998. Proposal for the division of plant growth-promoting rhizobacteria into two classifications: biocontrol-PGPB (plant growth-promoting bacteria) and PGPB, Soil Biol. Biochem. 30: 1225-1228.

Berg G., 2009. Plant–microbe interactions promoting plant growth and health: perspectives for controlled use of microorganisms in agriculture. Appl. Microbiol. Biotechnol. 84:11-18

Dashti N., Zhang F., Hynes R., Smith D.L., 1998. Plant growth promoting rhizobacteria accelerate nodulation and increase nitrogen fixation activity by field grown soybean [*Glycine max* (L.) Merr.] under short season conditions. Plant and Soil 200: 205-213.

Egamberdiyeva D., Qarshieva D., Davranov K., 2004. The use of *Bradyrhizobium* to enhance growth and yield of soybean in calcareous soil in Uzbekistan. J. Plant Growth Regul. 23: 54-57.

Grimes H.D., Mount M.S., 1984. Influence of *Pseudomonas putida* on nodulation of *Phaseolus vulgaris*. Soil Biology and Biochemistry, 16: b27-30.

Guarcia L., J.A., Probanza A., Ramos B., Barriuso J., Gutierrez M., 2004. Effects of inoculation with plant growth promoting rhizobacteria (PGPRs) and *Sinorhizobium fredii* on biological nitrogen fixation, nodulation and growth of *Glycine max* cv. Osumi. Plant and Soil 267: 143-153.

Gull M., Hafeez F.Y., Saleem M., Malik K.A., 2004. Phosphorus uptake and growth promotion of chickpea by co-inoculation of mineral phosphate solubilizing bacteria and a mixed rhizobial culture. Australian Journal of Experimental Agriculture. 44: 623-628.

Hellsten A., Huss-Danell K., 2000. Interaction effects of nitrogen and phosphorus on nodulation in red clover (*Trifolium pratense* L.). Acta Agriculturae Scandinavica, Section B. Soil Plant Sci. 50: 135-142.

Israel D.W., 1993. Symbiotic dinitrogen fixation and host- plant growth during development of and recovery from phosphorus deficiency. Physiol. Plant. 88: 294-300.

Jacobsen I., 1985. The role of phosphorus in nitrogen fixation by young pea plants (*Pisum sativum*). Physiol. Plant. 64: 190-196.

Kadian N., Yadav K., Badda N., Aggarwal A., 2013. AM fungi ameliorates growth, yield and nutrient uptake in AM fungi ameliorates growth, yield and nutrient uptake in *Cicer arietinum* L. under salt stress. Russ. Agri.Sci. 39, 321-329.

Majeed A., Kaleem M.A., Sohail H., Asma Imran, Rahim N., 2015. Isolation and characterization of plant growth-promoting rhizobacteria from wheat rhizosthere and their effect on plant growth promotion doi:10.3389/fmicb.00198.

Noumavo P.A., Nadège A.A., Baba-Moussa F., Adolphe A. Baba-Moussa L., 2016. Plant growth promoting rhizobacteria: Beneficial effects for healthy and sustainable agriculture. African J. of Biotechnology. 15(27): 1452-1463.

Rahmani A.H., Saleh-Rastin N., 2001. A study of the effect of soil available N and indigenous rhizobial population on the growth and yield of soybean and modelling of the inoculation prediction. In : W.J. Horst et al. eds., Plant Nutrition–Food Security and Sustainability of Agro-ecosystems. Wiley, New York, p. 680-681.

Singh D.K., Sale P.W.G., McKenzie B.M., 1997. Water relations of white clover (*Trifolium repens* L.) in a drying soil, as a function of phosphorus supply and defoliation frequency. Australian Journal of Agricultural Research 48: 675-682.

Tilak K.V., Ranganayaki N., Manoharachari C., 2006. Synergistic effects of plant-growth promoting rhizobacteria and *Rhizobium* on nodulation and nitrogen fixation by pigeon pea. Eur. J. of Soil Sci. 57: 67-71.

Tsvetkova G.E., Georgiev G.I., 2003. Effects of phosphorous nutrition on the nodulation, nitrogen fixation and nutrient use efficiency of *Bradyrhizobium japonicum* soybean (*Glycine max* L. Merr.) symbiosis. Bulg. J. Plant Physiol. special issue: 331-335.

Verma J.P., Tiwari K.N., Kumar A., 2013. Effect of indigenous *Mesorhizobium* spp. and plant growth promoting rhizobacteria on yields and nutrients uptake of chickpea (*Cicer arietinum* L.) under sustainable agriculture. Ecol. Eng. 51: 282-286.

Yadav S., Shivani Yadav S., Kaushik R., Anil K., Saxena K., Arora D.K., 2013. Genetic and functional diversity of *fluorescent Pseudomonas* from rhizospheric soils of wheat crop. J. Basic. Microbiol., p. 1-13.

Yadav K.S., Dadarwal K.R., 1997. Phosphate solubilization and mobilization through soil microorganisms. Biotechnological approaches in soil microorganisms for sustainable crop production, p. 293-308.

Yang Y., 1995. The effect of phosphorus on nodule formation and function in the Casuarina-Frankia symbiosis. Plant and Soil, 176: 161-169.

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ASSESSMENT OF THE QUANTITATIVE AND QUALITATIVE YIELD OF THE WINTER WHEAT VARIETY „SELECT" IN POLYFACTORIAL FIELD EXPERIMENTS

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Abstract

Investigating the productive potential of the variety „Select" under the action of three technological factors with different graduations it was proved the priority of the forerunner peas due to the nitrogen-fixing bacteria. The forerunner spring vetch is less ensured with nitrogen because a part of biological nitrogen is used by the oat plants. Yield increase, provided statistically by a significantly positive record, was obtained as a result of sowing on the recommended and admissible planting dates and constituted respectively 133.3 and 41.6 kg/ha. The limit difference was of 68.2 kg. At the same time, the yield level was higher on the recommended planting date reaching the following values: 5016.6 kg/ha at the seed density of 4 million germinating seeds per hectare, 5100.0 kg/ha at 5 million germinating seeds per hectare, and 5233.3 kg/ha at 6.0 million germinating seeds per hectare. The average yield of the variety „Select" sowed after the forerunner spring vetch was lower by 648.7 kg/ha compared to the yield obtained after the forerunner peas.

Analyzing the factors that induce fluctuations in the protein content of wheat kernels it was established that the most important one is the planting date when the protein surplus, after the forerunner peas, constituted +1.84 % and +2.05 % provided statistically by a positive record compared to the control variant, the LD being 0.73%. High protein content with difference provided statistically by a significantly positive record was obtained after the forerunner peas + 0.73% compared to the spring vetch, the limit difference being of 0.58%. Sowing the variety „Select" on admissible and late planting dates in terms of the crop year 2014/2015 provided a higher content of protein substances with difference provided statistically by a significantly positive record after both forerunner plants, however the values of this indicator were higher after the forerunner peas. Seed density did not influence kernel quality.

***Key words**: Triticum aestivum, density, common winter wheat, yield, proteins, forerunner plants, gluten.*

INTRODUCTION

Triticum aestivum (winter wheat) is one of the most important cultivated plant species. Its value is not limited only to the fact that it is the main source of food, but it also consists in the importance of including wheat in the crop rotation system, thus improving soil structure, monitoring weed control as well as reducing the number of pathogens that attack other varieties included in the crop rotation system. Thus, *Triticum aestivum* is an important partner in the crop rotation sequence increasing its productivity.

The major problems regarding *Triticum aestivum* cultivation are connected with autumn droughts, cold winters and arid conditions during the growing season (summer), factors limiting quantitative and qualitative yield in the Republic of Moldova.

Therefore, in order to cultivate wheat it is important to adapt the cultivation technology to real conditions. Among the basic elements of advanced technology we could mention the planting date, seed density in the seminal track and the forerunner plant.

The importance of these elements consists also in the fact that as a result of climate change in the optimal planting date of winter wheat (second decade of October), often the soil is still very dry and later planting date reduces the jointing of plants and their resistance to wintering, diseases and pests.

Based on the above-mentioned facts, we planned to study the influence of planting date, seed density on the seminal track and forerunner plants on some quality indicators of the common winter wheat variety „Select" in polyfactorial field experiments.

MATERIALS AND METHODS

The method of experiment establishment is a systematic one as it was performed in four repetitions (3 repetitions to determine the yield and the 4^{th} repetition was destined to observations and measurements). Plot area was of 50 m^2. During the growing season, there were made phenological observations and biometric measurements according to the experimental technique regarding the number of ears/m^2, plant height, number of kernels per ear, mass of kernels/spike etc. Statistical interpretation of obtained results was done using the dispersion analysis method.

The factors included in the study:

- Factor A – forerunner plants with graduations:
  - Peas **(Mt)**;
  - Spring vetch.
- Factor B - planting dates with graduations:
  - September 27 (**Mt-recommended**);
  - October 22 (**admissible**);
  - November 12 (**late**).
- Factor C – seed density with graduations:
  - 4 million of viable seeds per ha;
  - 5 million of viable seeds per ha (**Mt**);
  - 6 million of viable seeds per ha.

Biological material – the variety „Select" – was created at the Research Institute of Field Crops of the Republic of Moldova by the repeated individual selection method of the elite plant out of the hybrid population. The variety belongs to *ferrugineum* variety. Average plant size was of 73-90 cm and it possesses the resistance to lodging. It is characterized by high resistance to powdery mildew, brown rust and *Ustilago tritici*. The ear is dense with about 25-40 kernels. 1000 kernel weight was about 35-43 grams. The average yield of variety during the test years constituted 4430 kg/ha.

RESULTS AND DISCUSSIONS

The crop year 2014 - 2015 was a favorable year for the common winter wheat growth and development. In terms of the thermal regime, the deviation from the annual average was of + 2°C. In terms of rainfall, this year was characterized by an increase of +86 mm compared with the annual average (492 mm).

The weather in June, when the development and filling of common winter wheat grains take place, was warmer by 1.4°C and the rainfall amount constituted 69.0 mm, which was by 2.9 mm less than the norm.

The main indicator that reflects the results of our experiments is the yield, which largely depends on the weather conditions and quality of implemented technological elements. Testing the productive potential of the variety „Select" (Table 1) under the action of three technological factors with different graduations, it was confirmed the priority of peas as a forerunner plant due to nitrogen-fixing bacteria. Spring vetch used as a forerunner plant is less ensured with nitrogen because a part of biological nitrogen is used by the oat plants. Yield increase provided statistically by a significantly positive record was obtained as a result of sowing on the recommended and admissible planting dates and constituted 133.3 and 41.6 kg/ha respectively.

The limit difference was of 68.2 kg. At the same time, the yield level was higher in the case of recommended planting date reaching the values of 5016.6 kg/ha at the seed density of 4 million viable seeds per hectare, 5100.0 kg/ha at 5 million and 5233.3 kg/ha at 6.0 million of germinating seeds per hectare. The average yield of variety „Select" sowed after the forerunner spring vetch was lower by 648.7 kg/ha compared to the yield obtained after the forerunner peas.

In our polyfactorial field experiments the values of quality characteristics are strongly influenced by the applied technology. Analyzing the factors that induce fluctuations in the protein content of wheat kernels (Table 2), it was established that the first place is occupied by the planting date when the surplus of protein after the forerunner peas constituted +1.84 % and +2.05 % provided statistically as positive compared to the control variant, LD being of 0.73%.

High protein content with difference provided statistically by a significantly positive record was obtained after the forerunner peas + 0.73% compared to the spring vetch, the limit difference being of 0.58.

Table 1. The yield of winter wheat variety „Select”, kg/ha

Seed density, million/ha Factor „C”	Forerunner plant – Factor „A”						Average of the Factor „C” Dl_{05} = 68.2 kg	± Compared to the control variant
	Peas (Mt)			Spring vetch				
	Planting dates – Factor „B”							
	Recommended (Mt)	Admissible	Late	Recommended (Mt)	Admissible	Late		
4	5016.6	3850.0	3056.6	4408.3	3375.0	2658.3	3727.4	- 68.0
5 (Mt)	5100.0	4141.6	3082.3	4375.0	3508.3	2566.6	3795.6	-
6	5233.3	4300.0	3375.0	4416.6	3541.6	2475.0	3890. 2	+94.6
Average of the Factor „A”	4128.3			3480.5				
LD_{05} A = 55.6 kg	- 647.8							
Average of the Factor „B”	5116.4	4097.2	3771.3	4401. 7	3474.9	2566. 6		
LD_{05} B = 68.2 kg	-	-1019.2	-1345.1	-	-926.8	-1835.1		
LD_{05} of the experiment, kg	167.0							

Table 2. The content of protein substances in the kernels of common winter wheat variety „Select” in polyfactorial field experiments, %

Seed density, million / ha Factor „C”	Forerunner plant – Factor „A”						Average of the Factor „C” LD_{05} = 0.73 %	± Compared to the control variant
	Peas (Mt)			Spring vetch				
	Planting dates – Factor „B”							
	Recommended (Mt)	Admissible	Late	Recommended (Mt)	Admissible	Late		
4	2.03	4.12	4.64	1.87	2.76	4.65	3.35	0.05
5 (Mt)	2.84	4.48	4.10	1.80	2.79	4.39	3.40	
6	2.34	4.20	4.60	1.50	2.83	4.14	3.27	0.13
Average of the Factor „A”	13.70			12.97				
LD_{05} A = 0.58%	-0.73							
Average of the Factor „B”	12.40	14.24	14.45	11.72	12.79	14.39		
LD_{05} B = 0.73%	-	+1.84	+2.05	-	+1.07	+2.67		
LD_{05} of the Experiment, %	1.75							

Table 3. Gluten content in the kernels of common winter wheat variety „Select” in polyfactorial field experiments, %

Seed density, million / ha Factor „C”	Forerunner plant – Factor „A”						Average of the Factor „C” LD_{05}, %= 0.76	± Compare d to the control variant
	Peas (Mt)			Spring vetch				
	Planting dates – Factor „B”							
	Recommended (Mt)	Admissible	Late	Recommended (Mt)	Admissible	Late		
4	25.50	29.93	31.03	25.16	27.05	31.05	28.30	-0.10
5 (Mt)	27.22	30.69	29.89	25.05	27.11	30.50	28.40	-
6	26.16	30.10	30.95	24.38	27.19	29.79	28.13	-0.27
Average of the Factor „A”	29.05			27.49				
LD_{05} A, % = 0.62	-1.56							
Average of the Factor „B”	26.29	30.25	30.62	24.85	27.12	30.50		
LD_{05} B, % = 0.76	-	+3.96	+4.33	-	+2.27	5.65		
LD_{05} of the General Experiment, %	1.9							

Table 4. Protein content, variety „Select”, in polyfactorial field experiments, kg/ha

Seed density, million / ha Factor „C”	Forerunner plant – Factor „A”						Average of the Factor „C” LD_{05}, kg= 68.2	± Compare d to the control variant
	Peas (Mt)			Spring vetch				
	Planting dates – Factor „B”							
	Recommended (Mt)	Admissible	Late	Recommended (Mt)	Admissible	Late		
4	520.30	467.51	384.84	601.65	341.33	334.92	443.26	-9.29
5 (Mt)	563.16	515.74	347.25	443.98	416.06	317.63	433.97	-
6	553.38	525.12	452.12	436.80	451.69	300.97	453.35	+19.38
Average of the Factor „A”	481.05			405.00				
	+76.05							
Average of the Factor „B”	545.61	502.79	394.74	494.14	403.03	317.84		
± compared to the control variant	-	-42.82	-150.87	-	-91.11	-176.3		

The sowing of variety „Select” on admissible and late planting dates under the conditions of the crop year 2012/2013 provided a higher content of protein substances with difference provided statistically by a significantly positive record after both forerunner plants, however the values of this indicator were higher after the forerunner peas. Seed density did not influence kernel quality.

The data presented in Table 3 show an increased gluten content in the kernels of common winter wheat variety „Select” sowed after the forerunner peas +1.56 % compared to the forerunner spring vetch, provided statistically by a significantly positive record, the LD being of 0.62%. The sowing performed on admissible and late planting dates provided an increase of gluten with statistically significant positive values of 3.96% and 4.33% compared to the control LD, which was of 0.76%. Seed density did not influence gluten content. Taking into account quality indicators of the variety „Select” in polyfactorial field experiments we can confirm that this variety belongs to the first quality group „B” – valuable and excellent for bakery.

Wheat is among the major components of mixed fodder recipes. The nutritional value of wheat is determined primarily by the high content of accumulated starch (up to 65%), also proteins (10-15% and up to 26% in the best varieties), fats (2%), mineral salts, vitamins of the groups B and PP, which supplement energy needs.

Protein amount obtained from the kernel yield of variety „Select” (Table 4) reflects the superiority of the forerunner peas compared to spring vetch, the values of this indicator constituting 481.05 kg/ha or by 76.05 kg per ha more. The sowing of seeds on admissible and late planting dates didn’t increase protein amount per hectare. Seed density of 600 viable seeds per m^2 provided by 19.38 kg/ha more compared to the control variant of 500 seeds per m^2. Extensive use of new technologies and farming practices could increase protein amount up to 50%.

CONCLUSIONS

Analyzing the obtained data, we can conclude that common winter wheat variety „Select” ensures increased yields provided statistically by a significantly positive record after the forerunner peas sowed on the recommended planting date at the density of 6.0 million viable seeds per hectare.

The values of protein and gluten content reached by the variety „Select” proves the fact that it belongs to the high-quality class of valuable wheat, especially for the baking industry.

RECOMMENDATIONS

Common winter wheat variety „Select” sowing after the forerunner peas on the recommended planting date at seed density of 6.0 million viable seeds per hectare is better provided with symbiotic nitrogen compared the forerunner spring vetch.

REFERENCES

Boincean B.P. et al., 2013. Tehnologii alternative de cultivare a grâului de toamnă în Republica Moldova. (Îndrumar). Chișinău, 47 p.

Lăzureanu A., Alda S., Cârciu Gh., 2009. Variaţia producţiei şi a unor indici calitativi la două soiuri de grâu de toamnă zonate în partea de vest a ţării. Buletinul AGIR, nr.1-2, p. 186- 190.

Starodub V., Gheorghiev N., Burdujan V., Rurac M., Angela Melnic, 2011. Tehnologia de cultivare a cerealelor de toamnă (Recomandări practice). Chişinău, Centrul de Edit. UASM, 34 p.

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TO CLARIFY THE EFFECTS OF TRADITIONAL AND DIRECT PLANTING ON SECONDARY PRODUCT CORN'S PRODUCTIVITY AND WATER CONSUMPTION

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Abstract

This study is carried on to clarify Traditional Planting and Direct Planting's effects on growth, water consumption and productivity in secondary corn product. On the trial that set up as random parcels, Pioneer 3394 corn variety is used. During the irrigation season, corn crops grown with TP and DP methods are watered 450 and 397 mm. Number of irrigation are 7 in both methods. With DP method 13.4% water saving is provided according to TP method. In Turkey on 9.87 million of deacres land where corn is produced choosing DP method instead of TP method, will save 522.9 million tons of water. Crop water consumption (ET) is calculated as 647 mm depending on soil samples. Plant height is measured as 207 cm on TP method, and 204 cm on DP method. Plant height and a year's day numbers consisting of growth period are used to obtain plant height growth model. Average leaf number is 16 in both TP and DP methods after the crop growth season. Average productivity is 1070 kg da^{-1} in TP method and 1048 kg da^{-1} in DP method. Depending on the study results, there are no differences in crop growth and productivity, between TP and DP methods (P>0.005). In DP method, under favour of mulch leftovers from primary product, soil surface preserves humidity better and doesn't need irrigation water for longer terms. Choosing DP method, will prolong the irrigation interval, provides less usage of water and reducing demand for cultivation, that means reduces main costs of agricultural jobs like irrigation water and labour costs.

Key words: *traditional and direct planting; water consumption; crop growth model.*

INTRODUCTION

In many parts of the world, increasingly declining water resources used for agricultural purposes constitutes a major challenge (Gencoglan, 1996; Rey et al., 2007; Tanrıverdi and Degirmenci, 2011) and thus importance of irrigation is increasing with day by day (Khairy et al; 2001; Tanriverdi, 2005). Water usage and industrial requirements of increasing world population also accelerate the decrease in water resources to a certain extent (Guitjens, 1982; Gençoğlan and Yazar, 1999; Tanrıverdi et al., 2011). Inadequacy of rainfall in terms of optimum plant growth and its irregular distribution in regions located in arid and semi-arid climatic zone pose a great risk in corn farming, and render irrigation as the most important factor of yield (Gençoğlan and Yazar, 1999). Turkey is located in arid and semi-arid climatic zone, which further increases the importance of irrigation. If for any reason the level of moisture in the soil is less than that required for optimum development, a reduction in production can be expected. In that case, the most appropriate approach is to make a decision by water and agricultural area, while making an irrigation program. Programs aiming to obtain the highest yield from unit water should be made in places where water is expensive, while those aiming to obtain the highest yield from unit area should be made in places with limited agricultural area (Korukçu and Kanber, 1981; Yıldırım and Kodal, 1998).

Agricultural irrigation and cultivation methods also have a significant impact on water resources. As in the world, the industry using the most water in Turkey is agriculture with a percentage of 73% (DSI State Hydraulic Works, 2014). If this percentage of water usage continues, it is estimated that there may be water shortages in almost the whole of Turkey and very serious shortages in about half of Turkey by 2030 (Lehner et al., 2001; EEA 2007; Konukcu et al., 2007). Although the amount of water used for irrigation in many regions of the world varies by climate, soil type, plant variety, water quality and irrigation techniques, many environmental and economic issues arise due to failure to utilize irrigation technologies (EEA, 2005). For this purpose, it is of great importance that technologies allowing use of less water, energy, and labor by appropriate methods and techniques are introduced into the use of limited fresh water resources for agricultural irrigation so that Turkey's sustainable crop production is more stable and sustainable (EU, 2014). Half of the water used in irrigated farming can be saved by irrigation techniques increasing irrigation efficiency and reducing the need for irrigation water (Seckler, 1996; Shiklomanov, 1998).

Tillage in agricultural production is performed in order to maintain soil fertility, reduce erosion, prepare a good seed bed, minimize loss of water in the soil, ensure good root growth, prevent soil compaction and ensure conservation of flora and diversity of the soil (Önal, 1995; Aykas and Onal, 1999). However, tillage is the biggest factor affecting the production costs (Gökçebay, 1983). At least 15% of the agricultural areas in the world has undergone serious erosion (Kececioğlu and Gulsoylu, 2002). A large part of this erosion has occurred due to inappropriate and unconscious tillage. 34.4% of Turkish territories are comprised of high slope (15-40%) lands fueling erosion so traditional tillage entails intensive and excessive tillage especially in Turkey, increasing soil compaction and erosion (Korucu et al., 1998). Conservation tillage requires covering minimum 30% of soil surface with pre-plant residues after planting to reduce erosion by water and wind (Köller, 2003). In conservation tillage, soil is exclusively cultivated to prepare seed bed, apply chemicals, remove weeds and sow seeds (SD, 2014). In areas where direct planting (DP) is performed, fall tillage is permissible to some extent. After decomposition of stubble residues in the fields, soil is tilled using non-inversion tillage tools. In that case, at least 50% of stubble residues should remain on the soil surface. Crop residues on the soil surface are of great importance for conservation of soil. The amount of soil loss would be 13 tons ha^{-1} if there is no crop residue in the soil, whereas there would be no soil loss if the amount of crop residues is 10 tons ha^{-1}. This demonstrates that the amount of soil loss decreases with increasing amount of crop residues in the medium (Korucu et al., 1998; Aykas et al., 2005). Today, not only the profitability but also environmental, social and agronomic dimensions of agricultural production should be taken into account (Berkman, 1996). In this conceptual framework, it is of utmost importance to conserve particularly nonrenewable natural resources or those which take a long time to be renewed, and reduce environmental pollution. Developments, including the spread of herbicide use, understanding the benefits of leaving organic matter on the field surface without burning the stubbles and before they decompose too much, development of modern stubble drills and their use in existing production systems, allowed reducing tillage or provided the opportunity of no-till farming practices (Zeren, 1985). Timely performance of DP method, which protects natural resources, protects the environment from degradation and pollution, by utilizing suitable machinery is recommended (GTHB, 2014).

When all these factors are examined, the advantages of DP method have been established as reducing soil loss caused by erosion, environmental factors, high input costs arising from energy and soil and environmental damage caused by stubble burning for the purpose of making the field ready for planting secondary crop. However, the impact of cultivation methods (TP and DP) on plant growth, yield and water consumption hasn't been discussed much. Therefore, the aim of this study was to establish the effects of planting method on irrigation water demand, plant growth and yield by comparing TP and recently developed DP methods in the case of secondary corn product.

MATERIALS AND METHODS

The study was conducted in a farmer's field in Kahramanmaras province, which is located at an altitude of 640 m and dominated by Mediterranean climate.

According to the data obtained from the meteorological station in the study site, the annual average temperature was 17.7 °C, whereas the average temperature for the period between June and November, the growth period for secondary corn product, was 24.2 °C. The temperature reached the highest value (30.1 °C) in August and the lowest value (13.2 °C) in November.

The average maximum and minimum temperatures for the growth period were 31.2 °C and 18.2 °C, respectively. In addition, the rainfall in this period was 96.2 mm.

The study site was a first-grade agricultural land with a slope in the range of 6 to 12% and a shallow soil depth of 20-50 cm, in which irrigated farming is performed. These lands have good drainage because of their slope and structure, and have no problems as salinity or alkalinity (KHGM, 1997).

Pioneer 3394 was used as secondary corn variety in the trial. Planting was set up according to the randomized block trial design. Parcel sizes in the trial site were taken as 8.4 x 50 m (420 m^2), considering existing field conditions and the work widths of planting machines, and gaps of 1 m and 4 m were allowed between parcels and blocks, respectively (Figure 1).

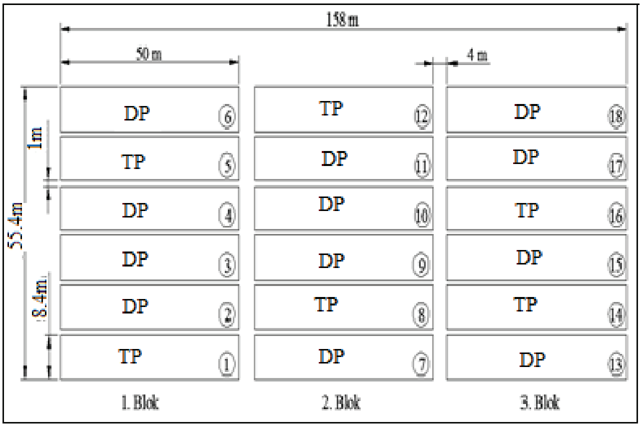

Figure 1. Trial area and parcel sizes

Accordingly, dimensions of the trial area were 158 x 55.4 m. In 6 of these parcels, planting was performed by traditional planting method (TP), while in 12, planting was performed by direct planting method (DP). Secondary corn product was planted on 25 June (175 DOY). There were 12 rows of plants in each parcel. Row spacing and seed spacing were 70 cm and 18 cm, respectively.

In traditional planting method (TP), 20 cm deep tillage was performed using chisel, and then disc harrow was used twice in order to break clods on the soil surface and smooth the soil surface. In order to enhance the success of the planting machine, the soil surface was harrowed, and then planting was performed using a four sequential pneumatic precision planting machine. In direct planting method (DP), planting was performed directly on primary product wheat stubble using the planting machine, without using any tillage tool to prepare the seed bed. While planting secondary corn product, row spacing, seed spacing and seeding depth were 70 cm, 16 cm, and 6 cm, respectively.

Following the planting procedure, the percentage of the residue cover was determined using the image processing method. It was determined that wheat residue cover was 18-22% in traditional planting method (TP) and 89-90% in direct planting method (DP).

Drip irrigation method was used in the study. In the irrigation system, laterals incorporating a 75 mm PE main pipe and a dripper with a diameter of 16 mm with a flow rate of 4 L h^{-1} with dripper spacing of 33 cm were used. Pressure and water required by the system were provided by a submersible pump system previously set up in the field. Lateral pipes were arranged so that there was one pipe in each row and their lateral lengths were taken as 50 m due to parcel length. The amount of irrigation water was measured by a water counter installed in the drip irrigation system.

Upon planting, 30 kg da^{-1} of NPK (15x15x15) base fertilizer was provided using a machine and mixed with the soil and when the plants reached a height of 15 to 20 cm, 40 kg da^{-1} of urea fertilizer was provided in the same way. First irrigation was performed immediately after planting and the next irrigation (6 further irrigation) were performed when 50% of the available water (Ry) allowed to be used in the soil was consumed, resulting in a total of 7 irrigation. To remove weeds, chemicals (22.5 g l^{-1} of a herbicide (Ekipp) with active agent Foramsulfuron) as well as mechanical control method using a hoeing machine at the time of earthing up were utilized.

Undisturbed soil samples were collected using 100 cm^3 standard cylinders from 4 different depths (0–30, 30–60, 60-90 and 90-120 cm) from the central point of each parcel in the study site, and after they were dried at 105 ^oC in a drying oven for 24 h until reaching a constant weight, their moisture contents and bulk density values were calculated by standard methods (Craig, 1984). Then, time of irrigation, the amount of irrigation and plant water consumption (ET) values were determined according to these values (Table 1).

Irrigation water was provided to the parcels when 50% of the available water (Ry) allowed to be used was consumed. For this purpose, field capacities, wilting points and bulk densities were determined under laboratory conditions using undisturbed soil samples collected from soil profiles of 0-30, 30-60, 60-90 and 90-120 cm.

Table 1. Physical characteristics of soil belonging to trial area

Depth (cm)	Texture	Pw (TK) g/g (%)	Pw (MN) g/g (%)	A_s (g cm^{-3})
0–30 cm	SC	26.9	14.5	1.49
30–60 cm	SC	26.0	15.5	1.40
60–90 cm	SC	26.8	12.0	1.39
90–120 cm	SCL	29.6	12.9	1.34

The amount of irrigation water that will bring the existing moisture up to field capacity was calculated using equation 1 (Güngör et al., 2002).

$$d_n = \frac{\left(P_{w(TK)} - P_{w(MN)}\right)}{100} \times A_s \times D \times R_y \quad [1]$$

where dn is the amount of irrigation water provided (mm); Pw(TK), the field capacity by weight g/g (%); Pw (MN) , the wilting point by weight g/g (%); As, bulk density (g cm^{-3}); D, the soil depth (mm) and Ry, the amount of water allowed to be used (%).

Soil samples representing each parcel in the trial area were collected from 12 sites by Auger-hole method and soil structures were established (Table 1). As a result of structural analysis conducted on soil and water samples collected from the area, it was established that the soils have a clay structure and that water quality was C2S1 (Table 2). As can be seen in Table 2, irrigation water doesn't pose a threat to irrigation corn in terms of its cations and anions.

Table 2. Chemical analyse results of irrigation water

EC (µS m^{-1})	pH	SAR (me l^{-1})	Kation (ppm)			Anion (ppm)				Irrigation Quality
			Ca^{+2}+Mg^{+2}	Na^+	K^+	CO_3^{-2}	HCO_3^-	SO_4^{-2}	Cl^-	
402	7.55	0.12	213.59	8.20	7.20	-	0.63	16.88	0.53	C_2S_1

A total of 12 plants were randomly selected from rows 6 and 7 of each parcel in order to observe the growth of the corn plant. The height of selected plants was measured and their leaves were counted. These procedures were repeated once every 7 days throughout the growth period of the plant.

In order to identify the effects of various tillage methods on corn yield, corn crops within a distance of 5 m from each parcel were collected for 3 times. To eliminate the edge effect, plant samples were collected from middle row of the parcel. Plants within a distance of 5 m with 70 cm of inter-row distance were cut and harvested so each sample harvested area was

3.5 m^2. Total parcel weights, grain weights, corncob weights and moisture contents of the collected samples were measured. Parcel yield was calculated according to a humidity of 15% using the following equations and the measurement values (Cerit, 2001).

$$TKO = \frac{TPA - SA}{TPA} \times 100 \quad [2]$$

$$DA = \left[TPA \times \left(\frac{100 - Nem}{100} \right) \times \left(\frac{100}{85} \times \frac{TKO}{100} \right) \right] / 1000 \quad [3]$$

$$V = \frac{1000}{3.5} \text{ x } DA \quad [4]$$

Where TKO is the ratio of grain/cob (%); TPA, the weight of cobs harvested from the whole parcel (kg/3.5 m^2); SA, corncob weight (kg/3.5 m^2); DA, the corrected weight (kg/3.5 m^2); moisture, the moisture content of the product (%) and V, the yield (kg da^{-1}).

RESULTS AND DISCUSSIONS

The amount of irrigation water applied to cultivated secondary corn product by drip irrigation method was measured as 450 mm in traditional planting method (TP) and 397 mm in direct planting method (DP). According to the data obtained from regional meteorological station, the rainfall throughout the growth period of secondary corn product was 96.2 mm. When the rainfall was added to the amount of applied irrigation water, a total of 546.2 mm of water was applied to TP method and of 493.2 mm of water to DP method (Table 3).

Table 3. The irrigation water values that applied to planting methods

Planting method	Number of irrigation	Irrig. (mm)	Rainfall (mm)	Total water (mm)	ET (mm)
TP	7	450	96.2	546.2	647
DP	7	397	96.2	493.2	647

Thus, considering the amount of irrigation water applied to DP method through a total of 7 irrigation, a water saving of 13.4% was achieved. In that case, it emerges that if TP method is preferred, rather than DP, there will be additional costs due to excess water usage and loss of labor and time. Existing amount of moisture at the beginning of the trial, the rainfall throughout the trial and also soil water contents before and after each irrigation were established, and the calculated ET value was 647 mm (Figure 3).

According to TUIK data for 2012, corn is grown in 9,866,976 da of land in Turkey. If it is assumed that in this entire area, corn is produced by traditional method utilizing drip irrigation method and a further irrigation water of 450 mm is provided, total annual water consumption is estimad to be 4.4 billion tons. If direct planting is performed in the same area and if this area is irrigated by drip irrigation method by providing 397 mm of water, total annual water consumption would be 3.9 billion tons, and water saving of 522.9 million tons would be achieved.

Compared to TP method, in DP method, the soil was covered by mulch and tillage was performed to a lesser extent so loss of moisture from the soil surface was less. Accordingly, although irrigation time varies by season and plant growth period, it was delayed by one day on average in the parcels in which DP method was applied.

The following growth model was developed by utilizing plant growth (Equation 5) and the parameters of the model are given in Table 4.

$$PL = a / \left(1 + \exp^{b - cDOY}\right) \quad [5]$$

Where b and c represent constant coefficients, PL, the plant height (cm), a estimated plant height; DOY, a specific day of the year.

Table 4. Parameters acquired on corn plant growth model

Treatment	Parameter	Estimate	Std error	95%	Confidance bound
TP	a	205.30	2.97	197.00	213.60
	b	31.83	1.39	27.97	35.69
	c	0.15	0.01	0.13	0.17
DP	a	199.60	2.50	192.60	206.40
	b	36.80	1.56	32.48	41.13
	c	0.17	0.01	0.15	0.19

Graphical illustrations of plant growth model obtained using plant heights measured throughout the growth period of corn plant for TP and DP applications are given in Figure 2 and Figure 3. The dashed line in Figure 2 represents measured values, while the solid line represents expected values in plant growth model. Hence, when the value for a specific day of the year (DOY) is entered in the formula as the desired day value, the plant height expected on that particular day can be calculated.

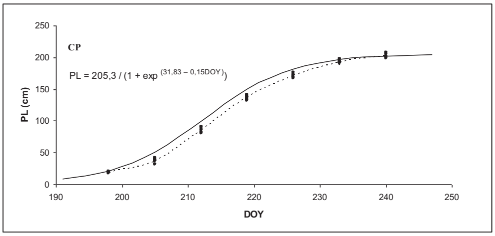

Figure 2. Height growth and model in secondary corn product for TP

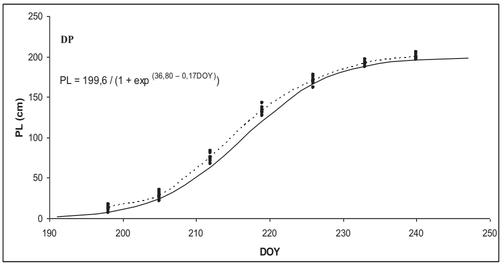

Figure 3. Height growth and model in secondary corn product for DP

It is clear from Figure 3 (DP) that there are height differences between the measured values. In the measurements made on plants grown by TP method, the average difference between plant heights (PL) was 8.84 cm, whereas in DP method, average difference between plant heights (PL) was 12.58 cm (Table 5).

Table 5. Differences in plant length (PL) on growth period

DOY	Vegetation of the day	TP	DP
198	23	3.33	10.00
205	30	10.17	13.20
212	37	10.92	16.03
219	44	10.90	16.08
226	51	9.58	15.50
233	58	8.58	8.72
240	65	8.39	8.51
	Mean PL Difference	8.84	12.58

In Table 5, small difference between plant heights in TP method shows regular growth, while high difference until 226 DOY in DP method irregular growth. After 226 DOY (day 51 of vegetation), in the measurements made in DP parcels, differences between minimum and maximum plant heights (PL) were significantly reduced. As a result, despite the irregular growth in the parcels in which DP was applied, during periods when plant height increased, plant heights became similar over time. This is a result of the fact that although the growth of corn plants whose plant height reached maximum values stopped, other short plants continued to grow.

In this study, the average plant height at the end of plant growth period was measured as 207 cm for TP and 204 cm for DP. Similar plant height values were also obtained by various researchers in studies conducted under various conditions (Dervis, 1986; Ul, 1990; Altuntaş and Dede, 2007; Çıkman et al., 2008; Yalçın et al., 2009). In that case, the average plant heights measured in the study were similar to plant heights measured by previous studies conducted in various regions under different conditions.

Plant growth was also monitored using the number of leaves, in addition to the heights of the corn plant (Figure 4). The number of leaves was calculated by taking the average of the values measured using the same method as the plant height measurements. As illustrated in Figure 4, the number of leaves was higher in TP method by a narrow margin (1 on average). Average number of leaves at the end of the growth period of the plant was 16 in both methods in this study.

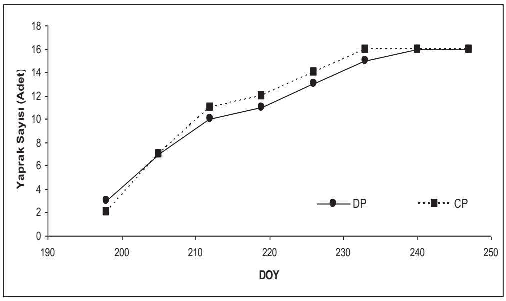

Figure 4. Leaf number on secondary corn product

According to t tests, it was revealed that the effects of TP and DP methods on plant growth were insignificant in terms of plant height (P=0.84) and the number of leaves (P=0.87) (P>0.05).

CONCLUSIONS

Throughout the irrigation season, corn crops grown using TP and DP methods were watered by 450 and 397 mm. DP method provided a water saving of 13.4%, as compared to TP method. Given that corn is produced in 9.87 million decare of land in Turkey, choosing DP method instead of TP method would save 522.9 million tons of water per annum.

Corn yield values were measured for each parcel in the study site. Yield values varied in the range of 628.7 to 1254.7 kg da^{-1} in TP method and of 636 to 1398.1 kg da^{-1} in DP method. In calculations made over mean yields per parcel, a yield of 1070.27 kg da^{-1} (sp ± 205.24) was obtained in TP method and a yield very similar to this, i.e. 1048.24 kg da^{-1} (sp ± 226.82) was obtained in DP method. According to independent two samples t test, the difference (P=0.85) between the yields by method of planting was found to be insignificant (P>0.05).

In this study, it was revealed that the total amount of water was 493.2 mm and average yield was 1048 kg da^{-1} in DP method. Yields reported by previous studies conducted in the same region for secondary corn product were 885.4 kg da^{-1} (Önder, 1994); 677 kg da-1 (MAR, 1995, 2012); 1001.5 kg da^{-1} (Gencoglan, 1996) and 994 kg da^{-1} (Idikut et al., 2005). In studies on secondary corn product conducted using drip irrigation method, yields obtained by applying 581 mm, 644 mm, and 571 mm of water were 1192 kg da^{-1} (Gençel, 2002), 1040.3 kg da^{-1} (Gökçel, 2008) and 641.6 kg da^{-1} (Vural and Dağdelen, 2008), respectively. It emerged that DP method didn't cause any adverse effect on yield, on the contrary, it allowed a water saving of 13.4%.

In view of soil density values (Table 1), as values in upper layers were higher than those in lower layers, which may be ascribed to compaction caused by tillage tools in TP method. Therefore, in DP method, in which tillage is used to a lesser extent by about 60%, it is estimated that soil density values for various soil profiles would be much similar over time.

At the end of this study, it was revealed that when TP and DP are compared, there is no difference in terms of plant growth and yield, however, DP method was identified to be superior in terms of several parameters, including the amount of irrigation, labor, costs and time saving. Therefore, it was concluded that DP method should be preferred.

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REFERENCES

Altuntaş E., Dede S., 2007. The effects of various tillage and planting methods on soil properties and yield in cultivation of second crop silage corn in transition climate zone of middle Black Sea region. Journal of Tekirdag Agricultural Faculty 4(3): 283-296.

Ministry of Agriculture and Rural Affairs (MAR), 1995. Work Report for 1994. Provincial Directorate of Ministry of Agriculture and Rural Affairs, Branch Office of Plant Conservation, Adana.

EEA, 2005. Current State and Appearance of Environment in Europe 2005 Director's report, www.reports.eea.eu.int (Accessed on: 01.06.2014).

EEA, 2007. Climate and Water Adoptation Issue. EEA Technical Report No. 2/2007. http://www.eea.europa.eu/publications/technical_report_2007_2 (Accessed on: 01.06.2014).

EU, 2014. Irrigation and Importance of Irrigation. http://arsivbelge.com/yaz.php? sc=1869 (Accessed on: 07.06.2014).

SD, 2014. Tillage Systems. http://www.suyunmerkezi.com/sayfalar.asp? LanguageID=1&cid=3&id=16&id2=63&b=detay (Accessed on: 12.06.2014).

GTHB, 2014. Direct Planting Method On Stubble Was Applied In Our District. http://www.aksehirtarim.gov.tr/Haber/AnizDirek.htm (Accessed on: 07.01.2014).

Aykas E., Önal İ., 1999. Effects of different tillage seeding and weed control methods on plant growth and wheat yield. In: Proceedings of the 7th International Congress on Mechanization and Energy in Agriculture, 26–27 May, Adana, Turkey, p. 119-124.

Aykas E., Yalçın H., Çakır E., 2005. Protective tillage methods and direct planting. Journal of Agricultural Faculty of Ege University 42(3): 195-205.

Berkman A., 1996. Research and development activities in sustainable agricultural development and the Southeastern Anatolia Project In: Proceedings(I) of the Relations between Agriculture and Environment Symposium, 13-15 May, Mersin, Turkey, p. 19-35.

Cerit İ., 2001. The effects of several tillage methods, which can be an alternative to wheat stubble burning in cultivation of secondary products, on corn grain yield and agricultural properties. Master's Thesis, Institute of Sci., Çukurova University, Adana, Turkey.

Craig R.F., 1984. Soil Mechanics (Third Edition). Wokingham, England. Van Nostrand Reinhold (UK) Co. Ltd.

Cıkman A., Saglam R., Vurarak Y., Monis T., Tobi İ., Nacar A.S., 2008. The effects of strip tillage methods on corn yield in secondary corn product under the conditions of Harran Plain. Journal of Agricultural Faculty of Harran University 12(4): 1-8.

Dervis O., 1986. Water consumption of second crop corn cultivated after wheat under the conditions of Çukurova Plain. General Directorate for Rural Services (K.H.G.M.), Publications of Directorate of Research Institute in Tarsus. General Publication No: 106, Report Series No: 56, Tarsus.

General Directorate of State Hydraulic Works – DSİ, 2014. Soil and water resources. http://www.dsi.gov.tr (Accessed on: 20.05.2014).

Gençel B., 2002. Irrigation of second crop maize by drip irrigation method in GAP (the Southeastern Anatolia Project) region. Master's Thesis, Institute of Science, Çukurova University, Adana, Turkey.

Gençoğlan C., 1996. Determination of water-yield relations, root distribution and plant water stress index of corn plant and investigation of the suitability of Ceres-Maize plant growth model for the region PhD Thesis, Institute of Science, Çukurova University, Adana, Turkey.

Gençoğlan C., Yazar A., 1999. The effects of deficit irrigations on corn yield and water use efficiency. Turkish Journal of Agriculture & Forestry 23:233-241.

Gökçebay B., 1983. Minimum Tillage Technique, Professional Publications of T.Z.D.K., No:121, Ankara.

Gökçel F., 2008. The effects of partial root zone drying (PRD) and deficit dripirrigation on yield and water use efficiency of secondary corn product underthe conditions of Çukurova plain. Master's Thesis, Institute of Sci., Çukurova University, Adana, Turkey.

Guitjens J.C., 1982. Models of alfalfa yield and evapotransipariton. Journal of the Irrigation and Drainage Division 108: 212-222.

Güngör Y., Erözel A.Z., Yıldırım O., 2002. Irrigation. Publications of the Department of Agriculture, Ankara University: 1443, Textbook: 424, Ankara.

Idikut L., Cesur L., Tosun S., 2005. Effect of planting time and growing technique on green yield and some characteristics of sweet corn. KSU Journal of Science and Engineering 8(1): 91-101.

Keçecioğlu G., Gülsoylu E., 2002. Tillage machines. Publications of the Department of Agriculture, Ege University, No: 545, İzmir.

Khairy W.M., Abdel-Dayem M.S., Coleman T.L., 2001. Determining a better water management using a geographical technique - a case study in Egypt. Geoscience and Remote Sensing Symposium, 09-13 July, Australia, 1: 453-455.

K.H.G.M., 1997. Land size of Kahramanmaraş province. Publications of General Directorate for Rural Services, Ankara.

Konukcu F., İstanbulluoğlu A., Kocaman İ., Albut S., Gezer E., 2007. Küresel su krizi: Today, tomorrow of global water crisis and opportunities to prevent it, the size of the global water crisis from the perspective of Turkey and the world. Irrigation Sector Association, SUSED Publication No:1, p. 24-49.

Korucu T., Kirişçi V., Görücü S., 1998. Conservation tillage and its applications in Turkey. In: Proceedings of National Agricultural Mechanization Congress, 17-18 October, Tekirdağ, Turkey, p. 321-333.

Korukçu A., Kanber R., 1981. Water-yield relations, TOPRAKSU research main project, 435-1, Tarsus Central Topraksu Research Institute, 49, Mersin, Turkey.

Köller K., 2003. Conservation tillage-technical, ecological and economic aspects. In: Proceedings of Conservation Tillage and Direct Planting Workshop, 23-24 October, İzmir, Turkey, p. 9-34.

Lehner B., Henrichs T., Döll P., Alcamo J., 2001. Eurowasser-model based assessment of european water resources and hydrology in the face of global change, World. http://www.usf.uni-kassel.de/ftp/dokumente/kwws/5/ew_0_contents.pdf (Accessed on: 20.05.2014).

Önal İ., 1995. Planting, care and fertilizing machines. Publications of the Department of Agriculture, Ege University: 490, İzmir.

Önder S., 1994. Water-yield relations of corn under the conditions of Çukurova plain. PhD Thesis, Institute of Science, Çukurova University, Adana, Turkey.

Rey J.R.D., Franco G., Berrelleza R., Gutierrez J., Gonzalez J., Gonzalez L., 2007. EchoTech: A water management system. In: Proceedings of the 17th International Conference, Electronics, Communications and Computers, 26-28 Feb, Cholula, Puebla, Mexico, p. 31-36.

Seckler D., 1996. The new era of water resources management. Research Report 1. Colombo, Sri Lanka: Internat. Irrigation Management Institute (IIMI), p. 17.

Shiklomanov A.I., 1998. World water resources "A new appraisal and assessment for the 21st Century". Unesco Publications, Paris, p. 37.

Tanrıverdi Ç., 2005. Using TDR in the agricultural water management. KSU Journal of Science and Engineering 8(2), 108-115.

Tanrıverdi Ç., Degirmenci H., 2011. Assessment of management transfer of kahramanmaras irrigation system. Scientific Research and Essays 6(3): 522-528.

Tanrıverdi Ç., Degirmenci H., Sesveren S., 2011. Assessment of irrigation schemes in Turkey based on management types. African Journal of Biotechnology 10(11): 1997-2004.

Ul M.A., 1990. A study on the effects of the irrigations applied during various development stages of corn plant grown as a second crop under the conditions of Menemen plain. PhD Thesis, Institute of Science, Ege University, İzmir, Turkey.

Vural C., Dağdelen N., 2008. The effects of various irrigation programs on yield and several agronomic properties in the case of flint corn irrigated by drip irrigation method Journal of Agricultural Faculty of Adnan Menderes University 5(2): 97-104.

Yalcın İ., Topuz N., Yavas I., Unay A., 2009. Determination of Practicability of Ridge Tillage Method in Second Crop Maize Journal of Agricultural Faculty of Adnan Menderes University 6(1): 35-40.

Yıldırım Y.E., Kodal S., 1998. The effect of irrigation on corn yield under the conditions of Ankara province. Turkish Journal of Agriculture and Forestry 22: 65-70.

Zeren Y., 1985. No-Till Farming Technique and Its Application On Second Crop Soybeans and Maize. Professional Publications of Turkish Agricultural Equipment Association, No:39, Ankara.

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EVALUATING THE EFFECT OF KINETIN APPLICATION ON SESAME CULTIVARS

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Abstract

This study aimed to evaluate the effects of kinetin hormone application on sesame. In this plan, Dashtestan II, Yekta, Halil, Oltan and Darab14 cultivars were planting in mid-July 2015. Kinetin hormone was applied as foliar application 30 days after planting. The results showed that Dashtestan and Halil cultivars were taller than other cultivars during simultaneous spraying kinetin hormone. It was also concluded that the number of leaves on Oltan cultivar was more than other ones during simultaneous spraying kinetin hormone and the leaves of other cultivars was reduced due to simultaneous spraying of kinetin. The results of sesame yield showed that the grain yield in sesame cultivars was not significant changes in kinetin foliar application treatment. But grain yield between cultivars with 0.01% signification levels were different. According to the mean comparison analysis the Dashtestan II and Yekta cultivars by 2.2 and 2.1 t/ha had the highest seed yield respectively. There was also a significant difference in the final height of the plants between kinetin applied and not control plots. Also results showed that there was no significant difference between stem diameter, leaf area index, number of pods per plant, grain yield and harvest index.

***Key words**: sesame cultivars, plant hormones, kinetin, yield.*

INTRODUCTION

The great importance of oilseeds is in human nutrition, production and processing as has long been considered. However, some problems in sesame (*Sesamum indicum* L.) production have always been a barrier to achieving high yield. Several studies in order to review practical strategies achieve better production sesame is taken. Sesame is one of the oldest oil plants (Bedigian and Harlan, 1986) and because of the oil quality, protein and antioxidants are widely used in food and medicine (Zhang et al., 1995). This plant is native in Iran and due to its unique characteristics as well as the possibility of a second crop after wheat in arid and semi-arid areas is beneficial (Rezvani Moghaddam et al., 2010). Sesame seed oil is one of the products in the group for having polyunsaturated fatty acids and high stability against oxidative oil, the higher quality and durability and numerous applications in medicine and desirable properties to the development of the crop and thus increase its per capita consumption. According to statistics contained in the PGRO (Center for Research sesame plant genetic resources conservation) of the important plant genetic resources sesame, is in eighth place. For this reason, the Feasibility Study and effective ways to achieve high yield cassava, especially with regard to the climatic conditions of each region has been the focus of attention. One of the factors of farmers in the cultivation of this product can be, as the low value of production per unit area. Besides identifying the best performance figures can help identify performance enhancing strategies for manufacturers to increase the performance of this product. There is a high nutritional properties of sesame seeds, other oil seeds cultivation of these plants to have had little and for cultivation in areas such as agriculture and industrial design advanced equipment for planting operations, and improving the cultivation and harvesting of the product, and harvesting to improve their nutritional properties and grain yield and resistance to pests types are needed. Therefore, future research is needed to develop nutritious and healthy foods based on Sesame been important in the country (Ashaghi et al., 2014). The operation of this plant, like other crops affected by various factors including genotype, sowing date, density, humidity, temperature, light and soil fertility and growth stimulants are used. According to the study, Bennett et al. (1996) Sesame chemical fertilizers do not show much reaction. There is necessity of finding a suitable replacement for chemical fertilizers in order to enhance the performance necessary for the plant. On the other hand, nutrient management using the excessive application of chemical fertilizers was used. Leading to the destruction of ecosystems, agriculture and human health is compromised. Environmental problems caused by the use of chemical fertilizers and fertilizer production costs; the revision of the methods has necessitated increased food production (Sajjad Nick and Yadvi, 2013).

Having a diverse genetic material appropriate to the climatic conditions of different regions of the country reflects long-standing sesame cultivation in Iran. Sesame's research achievements in product, in both figures include the introduction of Darab 14, Varamin 2822, cute flower several and single branches and also figures Dashtestan II, Yekta, Oltan and Darab I. Sesame research in recent years has continued with more consistency and other recommendations in the cultivation and identification of genotypes adapted to dry conditions of other efforts in the field of research is sesame. Plants have evolved the ability to adapt in response to environmental stimuli have their growth pattern. A proper balance in roots and shoots pattern for proper absorption of food, light and water is very important. Producing organs and tissues in plants by plant stem cells (meristematic cells) continued and complicated by the effects of the different hormones regulated (Muraro et al., 2012).

In fact, growth regulators and plant hormones, which can also be synthesized by plants as well as for synthetic chemistry, are made by professionals. In general, plant hormones into two general categories activator (Auxin, gibberellins and Kinetin) and inhibitors (including Abscisic acid and methyl Jasmonate) are classified. Growth drivers, in processes such as cell division and growth, flowering, fruiting and seed formation, and inhibiting growth companies also play an important role in the field of plant response to environmental stress and other environmental stresses and as well as on growth-inhibiting activity such as stratification, the fall and are active (Giannakoula et al., 2012).

Hormones regulate the physiological processes that synthetic growth regulators, growth and development of crops through increasing its total solid matter, cause; so that research has shown that the use of these hormones lead to improved crop yield (Patel et al., 2015). So far, many reports have stated that the plant hormone growth promoters, it play an important role in the growth of plants and crops yields (Verma and Sen, 2009; Ud-deen, 2010; Mostafa and Abou Al-Hamd, 2012).

Kinetin (kinetins) is a group of plant hormones that stimulate the growth stimulatory effect is more associated with cell division. Many potential applications for use kinetin in agriculture of the late twentieth century (Weaver, 1972) was proposed among which to increase fruit set and modify the size and shape of the grape cultivars of apples were delicious. In soils with high temperature (25°C) Seeds of lettuce may be secondary to sleep but if the seeds are treated with kinetin, the germination increase the influence of "BA" (Benzyladenine) (Fahimi, 2008). So, In this regard, this study aimed to evaluate the effects of kinetin hormone on agronomic characteristics and yield of sesame cultivars.

MATERIALS AND METHODS

The field experiment was done in 2015 and in Tehran Municipality plant research center with longitude 35.7288 and latitude 51.2868 and height of 1270 meters. A split-plot experimental design in randomized complete block design with three replications was selected. To preparation of soil and treatments the land field was prepared for 30 same plots and sown sesame seeds cultivars Dashtestan II, Yekta, Halil, Olten and DarabI as V1 to V5 in main plots and two levels of Kinetin hormone application and control treatment in sub plots (F1 and F2). The kinetin application was sprayed at 1.0 Molar concentration in early flower stage (F2).

Following the establishment of plant the samples were taken from 1st September and repeated in interval of 10 days.

The traits were plant height, main stem diameter, number of leaves, leaf area index LAI, seed yield were measured by using methods of Amri et al. (2010).

Plant height (Borjian and Khaki, 2001) and number of pods per plant also were measured (Matin Far et al., 2012).
Pod number per plant was measured in final ripening stage too (Matin Far et al., 2012).
Grain yield and harvest index were measured too. To data analysis use of the MSTAT-C software and to mean comparison calculate we use of Duncan multiple range tests at 5%.

RESULTS AND DISCUSSIONS

Data analyzed show that the sesame cultivars did not affected in growth characteristics according to results of ANOVA Table. Although, plant height and seed oil content in different cultivars showed significant difference at 1% level and number of leaves per plant cultivars are significant difference in the level of 5%. But in stem diameter and leaf area index we cannot see significant differences among cultivars (Table 1).In another part of data analysis to investigate the interactions between treatments the results showed that plant height, number of leaves per plant and seed oil has a significant effect.

Height of plant

The results presented in Table 1 and Table 2 show that plant height in sesame cultivars is not significant changes by Kinetin application treatment.
But, there are significant differences between cultivars with 0.01 percent validity in height. However, the interactions between treatments are also significant differences at 0.01 of signification level (Table 1).
According to Table 2 data among of cultivars the Dashtestan II with 63.5 cm had maximum plant height and Darab-14 with an average of 47.17 cm had lowest height. Halil had the highest elevation in treatments without spraying kinetin (F1V3), Dashtestan II with kinetin (F2V1) and Olten (F2V4) under kinetin spraying, respectively.
The lowest plant height was in Darab-14 with kinetin foliar application (F2V5 and F2V2) and Olten without spraying (F1V4), respectively.

Table 1. Effect of Kinetin on sesame cultivars characteristics

SOV	DF	MS						
		Plant height	Stem diameter	No. leaves /plant	LAI	No.f pod /plant	Harvest index	Grain yield
Replication	2	114.4 ns	0.01 ns	17.7 ns	0.12 ns	3.33 ns	2.0 ns	3.33 ns
Kinetin (F)	1	3.3 ns	0.2 ns	34.13 ns	2.45 ns	6.53 ns	0.01 ns	6.53 ns
Error1	2	11.2	0.05	6.93	2.30	2.13	4	2.13
Cultivars (V)	4	290.5**	0.01 ns	33.12*	0.34 ns	95.80**	17.16**	95.80**
Interactions (F.V)	4	203.2**	0.04 ns	47.05**	2.79 ns	7.87 ns	24.76**	7.87 ns
Error 2	16	34.5	0.04	8.96	2.07	5.23	1.80	5.23
Coefficient of variation %		10.67	8.86	14.62	30.90	12.00	2.57	23.7

ns, * = non-significant and significant probability level at 5%, respectively

Table 2. Mean comparison of sesame treats

Treatments	Means						
	Plant height	Stem diameter	No. leaves /plant	LAI	No.f pod /plant	Harvest index	Grain yield
F1	54.73a	2.20a	21.53a	4.94a	2.64a	0.57a	1.7a
F2	55.40a	2.05a	19.40a	4.37a	2.69a	0.57a	1.8a
V1	63.50a	2.08a	21.33a	4.74a	2.67ab	0.71a	2.2a
V2	49.00a	2.13a	17.50a	4.71a	2.52b	0.68ab	2.1a
V3	59.83a	2.08a	23.33a	4.90a	2.60ab	0.59b	1.8ab
V4	55.83a	2.17a	21.50a	4.65a	2.75a	0.43bc	1.3b
V5	47.17a	2.15a	18.67a	4.26a	2.78a	0.37c	1.5b
F1V1	61.33 ab	2.13a	22.67 abc	5.69a	2.67a	0.71b	2.0a
F1V2	50.67 bc	2.30a	18.33 bc	4.93a	2.53a	0.61ab	2.0a
F1V3	65.33 a	10.2a	28.00 a	4.19a	2.70a	0.56bc	1.7a
F1V4	46.33 c	2.17a	20.33 bc	4.72a	2.67a	0.42cd	1.2a
F1V5	50.00 bc	2.30a	18.33 bc	5.16a	2.63a	0.49cd	1.8a
F2V1	65.67 a	2.03a	20.00 bc	3.79a	2.67a	0.71b	2.3a
F2V2	47.33 c	1.97a	16.67 c	4.49a	2.50a	0.74a	2.3a
F2V3	54.33 abc	2.07a	18.67 bc	5.61a	2.50a	0.62ab	1.8a
F2V4	65.33 a	2.17a	24.67 ab	4.59a	2.83a	0.44c	1.5a
F2V5	44.33 c	2.00a	17.00 c	3.36a	2.93a	0.24d	1.1a

Means in a column followed by the same letter are not significantly different at P≤0.05. S as sowing dates and F as foliar application treatments F1: control or without spraying with Kinetin hormone and F2: hormone sprayed with Kinetin; sesame cultivars include V1: Dashtestan II, V2: Yekta, V3: Halil, V4: Oltan and V5: Darab14

Stem diameter

The results presented in Tables 1 and 2 show the stem diameter reactions in the sesame cultivars treated via Kinetin that is not a significant difference. This trait also among cultivars and interaction between foliar and figures are not significant differences. The number of leaves per plant in the sesame cultivars and via Kinetin application also, had not significant difference.However, the interaction between foliar and cultivars is a significant difference in the level 0.01. Habibi et al (2015) reported that the use of kinetin had positive effects on morphological parameters like LAI and number of leaf per plant in pumpkin plant species.

Number of leaves per plant

Halil with 23.33 leaves had the highest number of leaves and Yekta by 17.5 leaves had the lowest number of leaves. The highest number of leaves in the Halil cultivar was recorded when they were without spraying of kinetin (F1V3).

Leaf area index

The results presented in Table 1 and 2 show that the leaf area index as one of the traits measured in the cultivars sesame treated via Kinetin had significant difference and this trait also among cultivars and interaction between foliar and cultivars was not meaningful difference. However, the interaction between foliar cultivars is significant differences at 0.01. The Halil by 4.90 LAI and Darab-14 BY 4.26 LAI had the maximum and minimum leaf area index respectively. But in interaction effects the maximum leaf area index was measured in Dashtestan II without kinetin application (F1V1) and minimum LAI treatment Darab 14 by spraying (F2V5) obtained. Alshdad et al (2012) tested 20 micromoles of Kinetin hormones, IAA and GA3 and mix it considers to be tested on corn. Sprayed with hormones, performance, leaf area and photosynthetic pigments had a significant increase, indicating the hormones were high performance.

Pods number per plant

The pods number per plant as one of the target traits measured in the all 5 sesame cultivars that treated via Kinetin but the results showed the treatments had not significant effects. By means of there are no significant differences between cultivars with 0.01% (Table 1). According to table 2, Darab-14 cultivar with 25.17 pods showed the most numbers of pods per plant compare to 17 pods in average. Mardani et al., (2013) reported the positive effect of Kinetin at a concentration of 5.0 mM on the number of embryos in some dicotyledons plants.

Harvest index

Sesame harvest index as important detector of plant change condition and yield was measured for all cultivars in Kinetin and non kinetin application. The results showed that the kinetin effect was not significant effect on HI%, but in this significant difference between cultivars with 0.05% was observed. The interaction effects of treatments also could change the HI% significantly.

In this case the Dashtestan II cultivar with 71% had the highest and Darab 14 by 37% had the lowest harvest index rates.

The highest harvest index in the Yekta treatment by spraying was 74% (F2V2) and the lowest harvest index was in Darab-14 with foliar treatments by24% (F2V5).

Grain yield

The results presented in Tables 1 and 2 showed that the grain yield in sesame cultivars was not significant changes in kinetin foliar application treatment. But grain yield between cultivars with 0.01% signification levels were different. According to the mean comparison analysis the Dashtestan II and Yekta cultivars by 2.2 and 2.1 t/ha had the highest seed yield respectively. The lowest yield was obtained by 1.3 t/ha. Kochaki et al (2014) reported that the application of kinetin can put significant effects on the increase of sesame yield. Esmaeilzadeh and Tafazoli Bandari (2000) reported that the use of kinetin (50 mg) was useful in developing and growth of the Shiraz grapes. They use of kinetin by different concentration and reported increase effects in leaf area index whenever in drought stress conditions. Bahradfar et al. (2015) examined the effect of foliar application of kinetin on safflower (*Carthamus tinctorius* L.) they determined that kinetin hormone treatment plant, number of branches per plant, number of heads per plant, dry matter accumulation, biological yield, grain yield and oil were increased.

CONCLUSIONS

The results showed the Halil and Dashtestan cultivars and simultaneous spraying of Kinetin hormone has been higher than in the other cultivars. It was also concluded that the number of leaves per plant by spraying were more than control.

It can be concluded that the Kinetin hormones application play different important roles in different plant treats. To improving agronomic characteristics such as number of pod per plant, grain number and seed yield in sesame we need to more study.

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REFERENCES

Alshaddad M.A.K., Hamdia Abd El-Samad, M., Mohammed H.T., 2011. Interactive Effects of Drought Stressand Phytohormones or Polyamines on Growth and Yield of Two M (Zea maize L.) Genotypes. American Journal of Plant Sciences 2: 790-807.

Amri M., Kazemi Arbat, Osku, H., Rural M., 2010. Relations with some morphological and physiological traits with yield and yield components in wheat (Triticum aestivum L) The first national conference on new issues in agriculture: Islamic Azad University of Saveh.

Bahradfar A., 2015. The effect of foliar application of CCC, kinetin and the seaweed extract, safflower (Carthamus tinctorius L.) under different irrigation regimes. Agriculture PhD thesis Urmia University, College of Agriculture

Bedigian D., Harlan J.R., 1986. Evidence for cultivation of sesame in the ancient world. Economic Botany.40: 137-154.

Benet M.R., Thaigalingam K., Beech D.F., 1996. Effect of nitrogen application on growth, leaf nitrogen content, seed yield and seed components of sesame. Sesame and Safflower Newsletter. 11: 21-28.

Borjian B., Khakian Gh., 2001. Instructions on how to do proposed monitoring phenology of rapeseed. University of Mashhad.

Eshaghi M.R., Vakili H., Salimi H., 2014. Sesame, oil seeds queen Sepidbarg: Tehran.

Esmaili Zadeh M., Tafazoli Bandari E., 2000. The effects of kinetin and gibberellic acid on flower induction and fruit characteristics (*Vitis vinifera* L) Black Shiraz varieties. Journal of Horticultural Science and Technology, No. 2-1, pp: 54-43

Fahimi H., 2007. Plant growth regulators, Tehran University Press.

Giannakoula A.E., Ilias F.L., Jelena J.D., Dragisˇic´, M., Vuk M., Branka D.Z., 2012. The effects of plant growth regulators on growth, yield, and phenolic profile of lentil plants. Journal of Food Composition and Analysis, No, 28, pp: 46–53

Habibi M., Niakan M., Nouri Nia-AA., 2015. The effect of cytokinin (kinetin) on morphological parameters plant species pumpkin (*Cucurbita maxima*. L) levels of drought. Proceedings of the Second Symposium on new issues in agriculture: Tehran

Kochaki AR., Nasiri Mahalati M., Noorbakhsh F., 2014. Reaction growth and yield of sesame (*Sesamum indicum* L) affected some agronomic management, Crop Science Conference of Iran and Iran's Third Conference on Science and Technology Seed, Crop Science Society of Iran

Mardani H., Azizi M., Majid., Ziarat Nia M., Raziq L., 2013. Effect of Kinetin hormones and BA on embryos for AG Kelussia odoratissma Mozaff, Iran's third national conference on agricultural biotechnology (plant, animal and industrial)

Masoumi Zvarian A., Asghari M., Rastgoo Sendan Reza, Farjami Nezhad R., 2013. By kinetin priming effects on seed germination indices and Proline Activity of Purple Coneflower. National Conference of passive defense in the agricultural sector

Matin Far, M., Matin Far M., Mohammadi R., Shiranyrad A.H., Mahjor M., 2012. The effect of density on yield and seed yield components of canola in Qazvin, Journal of Crop Ecophysiology, No. 4, pp: 414-405

Mostafa G.G., Abou Al-Hamd M.F., 2012. Effect of gibberellic acid and indole-3 acetic acid on impro-ving growth and accumulation of phytochemical com-position in Balanites aegyptica plants. American Journal of Plant physiology 6, 36–43.

Muraro D., Byrne H., King J., VoB U., Kiber J., Bennett M., 2012. The influence of Kinetin–auxin cross regulation on cell-fate determination in Arabidopsis thaliana root development. Journal of Theoretical Biology 283:152–167.

Patel V.P., Lal E.P., Suchit A.J., 2015. Comparative study of the effect of plant growth regulators on growth, yield and physiological attributes of chilli, Capsicum annuum L cv Kashi Anmol. International Journal of Farm Sciences 6(1): 199-204.

Rezvani Moghaddam C., Mohammad Abadi P.A., Moradi, 2010. The effect of organic fertilizers on yield and yield components of sesame (*Sesamum indicum* L) in different densities. Journal of agricultural ecology, 2 (3): 265-256

Sajadi Nik R., Yadavi A.R., 2013. Effects of nitrogen fertilizer, vermicompost and nitroxin on growth, phenology and grain yield Journal of Crop Production, No. 2, pp 100-73

Ud-deen M.M., 2010. Effect of plant growth regulators on growth and yield of *mukhi kachu*. Bangladesh Journal of Agricultural Research 34, 233–238.

Verma P., Sen N.L., 2009. The impact of plant growth regulators on growth and biochemical constituents of coriander (*Coriandrum sativum* L.). Journal of Herbs, Spices and Medicinal Plants 14, 144–153.

Viour M., 1972. Introduction plant physiology. Hall Of India Private Limited

Zhang T.Q., Mackenzie A.F., Liang B.C., 1995. Long-term changes in Mehlich-3 extractable P and K in a sandy clay loam soil under continuous corn (*Zea mays* L.). Canada Soil Science. 75(3): 361-367.

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IMPACTS OF IRRIGATION WATER SALINITY ON LEAF CARBON ISOTOPE DISCRIMINATION, STOMATAL CONDUCTANCE AND YIELDS OF SWEET CORN (*Zea mays saccharata*)

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Abstract

This study was carried out in a greenhouse in the pot experiments in order to determine the effects of the irrigation water salinity on leaf carbon isotope ratio of maize (Zea mays saccharata). Salinity treatments were imposed by irrigation water containing NaCl, $CaCO_3$, $MgSO_4$ salts and having electrical conductivity of 0, 1.5, 3, 5 and 10 dS/m. The experiment was conducted in a completely randomized plot design with 3 replications. The fully expanded leaves were collected for carbon isotope analysis. Then plant samples were harvested for dry matter analysis. Carbon isotope ratio of leaves and crop yields were strongly affected by increasing irrigation water salinity. According to the results of the research, leaf carbon isotope ratio (ΔL; ^{13}C ‰) has increased in parallel with the increase of the irrigation water salinity. While the average carbon isotope ratio of leaves in T_1 is at the lowest (4.00), the average carbon isotope ratio of leaves in T_5 is found as the highest (4.65). Crop yields decreased with increasing irrigation water salinity. The highest yield (33.14 g) and the lowest yield (8.22 g) was found. A negative correlation was observed between crop yields and carbon isotope ratio of leaves.

***Key words**: Carbon isotope discrimination, corn, irrigation water salinity.*

INTRODUCTION

Salinity is one of the most important environmental factors limiting crop production of marginal agricultural soils in many parts of the world. Salinity effects on plants include ion toxicity, osmotic stress, mineral deficiencies, physiological and biochemical perturbations, and combinations of these stresses (Hasegawa et al., 2000; Munns and Tester, 2008; Neumann, 1997; Yeo, 1998). Salt stress affects many aspects of plant metabolism and, as a result, growth and yields are reduced and excessive concentrations kill growing plants (Garg and Gupta, 1997; Mer et al., 2000; Donahue et al., 1983).

Determination of stable carbon isotopic composition (δ13 C) of plants has resulted in significant progress toward understanding the influence of environmental stresses (water, light, salinity and air pollution) on CO_2 fixation and transpiration (O'Leary, 1981, Farquhar et al., 1989, Ehleringer et al., 1993). Stable isotope techniques are useful in studying carbon metabolism involved with photosynthesis and salinity (Farquhar et al., 1989). Relatively little information is available concerning the effects of salinity on carbon isotope composition in C_4 plants (Meinzer et al., 1994). Farquhar et al. (1989) reported that $\delta^{13}C$ increased with rising salinization degree whether the plant is halophyte or not, which was also proven by Yang et al. (2006). The change of $\delta^{13}C$ in soil carbonates or plants may reflect the soil salinization degree (Yang et al., 2006). There is a negative correlation between $\delta^{13}C$ value of plant and CO_2 molefraction in the intercellular air space for plants growing under different saline environments (Wei et al., 2008). A positive relationship observed between carbon isotope ratio with increasing soil salinity in C_4 species (Maricle and Lee, 2006).

The present study was undertaken to examine effects of irrigation water salinty concentrations on Δ and crop yield of corn.

MATERIALS AND METHODS

Experiment side characteristics

Experimental site was located in Isparta (37°45'N and 30°33'E) of Mediterranean Region of Turkey. The pot experiment was conducted under greenhouse conditions (humidity around 65-75 %, air temperature 23-30°C) in Suleyman

Demirel University's Agricultural Research and Training Center.
The plastic pots were filled with 2.5 kg of soil. The experimental soil was taken from Aridisol great soil group. It was calcareous (26.44 % $CaCO_3$), clay loamy in texture (clay 41.20 %, silt 28.71 % and sand 30.09 %), slightly alkaline (pH 7.74, EC 0.30 dS/m; both in 1:2.5 water extract). Field capacity and wilting point on the volume basis were 34.50% and 21.20 % respectively. According to soil fertility analysis results for basal fertilizer, 10 ml NPK (sodium phosphorus potassium, 3.5 % NH_4, 5.5 % NO_3, 10 % urea 19N-19P-19K+micro elements) was applied to the pots.
The experimental design was completely randomized block design. The experiment consists of 5 different irrigation water salinity given below with 3 replications. Salinity treatments were; $\mathbf{T_1}$; 0 dS/m (control), $\mathbf{T_2}$; 1.5 dS/m, $\mathbf{T_3}$; 3 dS/m, $\mathbf{T_4}$; 5 dS/m, $\mathbf{T_5}$; 10 dS/m.
Salinity levels were supplied from a mixture of NaCl, $CaCO_3$ and $MgSO_4$ salts in the ratio of Ca:Mg 1:1 and Sodium Adsorpsion Ratio (SAR) around 5. Pots were weighed regularly and irrigation treatments were made when soil moisture content decreased below the 50 % field capacity.
Sweet corn (*Zea mays saccharata*) of Merit F_1 variety was used in this study and this genotype was moderately sensitive to the salt stress. Five seeds were planted in each pot and watered to field capacity to facilitate germination, salinity stress was imposed when the seedlings were 15 days old. After 2 weeks, the seedlings were thinned to 3 per pot.
Plants were maintained for 80 days in their respective salinity treatments. Before harvest, 2 complete middle-aged leaves were sampled from similar-sized shoots from all plants for subsequent isotope analysis. The leaves were dried at 65°C for 48 h, then ground to a fine powder in order to carbon isotope analysis.
Carbon isotopes were analyzed on the leaf samples. Carbon isotope ratio ($^{13}C/^{12}C$) of the samples ($^{13}C/^{12}C_{sample}$) and the standard ($^{13}C/^{12}C_{standard}$) was determined by means of a mass spectrophotometer (Turkey Atomic Energy Agency/Ankara). $^{13}C/^{12}C$ value was transformed into $\delta^{13}C$ (‰; per mil) with the help of the equation [1].

$$\delta\ ^{13}C\ (‰) = \frac{(^{13}C/^{12}C)_{sample} - (^{13}C/^{12}C)_{standard}}{(^{13}C/^{12}C)_{standard}} x1000 \quad [1]$$

The standard used to evaluate the carbon is known as PDB (Pee Dee Beliminate). PDB standard is the CO_2 isotope ratio obtained from the Belemnite limestone present in the Peedee formation in South Carolina (Akhter et al., 2008). $\delta^{13}C$ values is transformed into the carbon isotope ratio/difference (Δ) using the equation [2] developed by Farquhar et al. (1982):

$$\Delta = \frac{\delta_a - \delta_p}{1 + \delta_p} \quad [2]$$

where δa and δp are the carbon isotope composition of source air and plant material, respectively. Carbon isotope composition of air was taken as 8.00% while transforming the $\delta^{13}C$ value into Δ (Keeling et al., 1979; Farquhar et al., 1989; Bolger and Turner, 1998).
Plants were cut at ground level, dried in the oven at 70°C until constand weight and after which they were weighed for dry matter.
Variance analysis of data for all variables was computed using MINITAB computer package (Minitab Release 10.51) program (Version 3.00) was used to compare treatment means by Tukey test.

RESULTS AND DISCUSSIONS

Treatment effects on crop yields
The effects of salinity on the yield (dry matter production) were summarized Table 1.
The highest yield (33.14 g) was found at 0 dS/m, which is 75.2% more than the lowest yield (8.22 g) produced at 10 dS/m.

Table 1. Yield of sweet corn (g/plant) for different salinity treatments

Treatments	Average	Range (%)
T_1	33.14[a]	100.00
T_2	30.04[ab]	90.65
T_3	29.26[bc]	88.29
T_4	25.39[c]	76.61
T_5	8.22[d]	24.80

The relationship between irrigation water salinity and crop yield

The present study showed that irrigation water salinity inhibited plant growth and caused a decrease in yield of sweet corn plant. For each treatment relationship between salinity and crop yield and correlation coefficient are provided in the Figure 1.

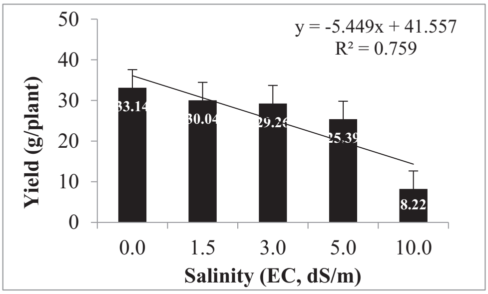

Figure 1. Relationship between salinity and yield

A negative relationship was found between irrigation water salinity and the yield. Results indicated that the yield of sweet corn plants were significantly decreased in with increase of the irrigation water salinity. The reduction in yield shows specific ions accumulated in high concentrations to have toxic effect on plants, as well as that the osmotic pressure in soil to be high and thus the plant has not benefited enough from availability of water. Similar results were found by Ashraf and McNeilly, (1990); Ungar, (1982); Khan et al. (1984); Çiçek et al. (2002); Maricle and Lee, (2006); Turan et al. (2009); Kachout et al. (2009).

According to variance analysis results, a statistical difference of 0.05 was observed between irrigation water salinity and yield. Variance analysis results were provided in the Table 2.

Table 2. Crop yields variance analysis values

Variation Source	D.F	S.S	M.S	F	Table F
					0.05
Blocks	2	17.4	8.7	1.76	4.46
Treatments	4	1173.6	293.4	238.0*	4.46
Error	8	39.4	4.9		
General	14	1230.5			

* Statistically significant at $P<0.05$

Carbon Isotope Ratio of Leaves

The average leaf carbon isotope ratio (ΔL; ^{13}C ‰) values were calculated using the average carbon isotope composition ($\delta^{13}C$) values. The values obtained from the leaf carbon isotope (ΔL; ^{13}C ‰) ratios are provided in the Table 3. The value of the average carbon isotope in T_1 is registered 4.00, which is the lowest whereas in T_5 it was the highest value with 4.65. As a result, carbon isotope ratio has increased in parallel with the increase of the irrigation water salinity. The concentration of salinity signify-cantly increased carbon isotope ratio of leaves at T_5 level by 13.98 from T_1 salinity level.

Table 3. Carbon isotope ratio (ΔL, ^{13}C ‰) of leaf samples for different salinity treatments

Treatments	Average	Range (%)
T_1	4.00[c]	86.02
T_2	4.18[bc]	89.89
T_3	4.37[abc]	93.98
T_4	4.56[ab]	98.06
T_5	4.65[a]	100

The Relationship between Irrigation Water Salinity and Δ of Leaves

The sweet corn plant in this study showed increases in leaf $\Delta^{13}C$ with increasing irrigation water salinity. For each treatment relationship between salinity and leaf $\Delta^{13}C$ and correlation coefficient are provided in the Figure 2.

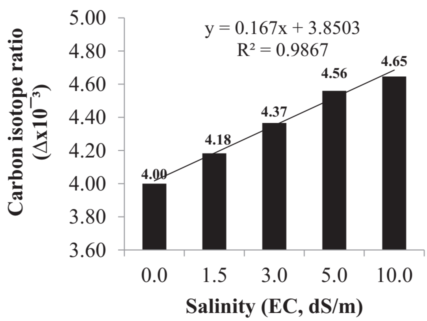

Figure 2. Relationship between salinity and leaf $\Delta^{13}C$

Analysis of variance indicated that there was a highly significant effect of salinity on Δ. A positive correlation was found between irrigation water salinity and the leaf $\Delta^{13}C$. Results indicated that the leaf $\Delta^{13}C$ of sweet corn plants were significantly decreased in with increase of the irrigation water salinity. While a positive relationship observed between carbon isotope ratio with increasing soil salinity in C_4 (corn, sugarcane, sorghum etc) species (Maricle and Lee, 2006), a negative relationship was observed in C_3 (wheat, barley, sugar beet etc) plants (Guy et al., 1986). The difference in $^{13}C/^{12}C$ ratio between C_3 and C_4 plants is related to difference in the isotopic fractionation existing between the ribulose 1.5 biphosphate carboxylase oxygenase (Rubisco) activity in C_3 plants and the phosphoenol pyruvate carboxylase (PEPC) activity in C_4 plants. Rubisco discriminates more against ^{13}C (around 29 ‰) (Estep et al., 1978) than PEPC (around 2.2. ‰) (Delens et al., 1983). Similar results were found by Meinzer et al. (1994); Sandquist and Ehleringer (1995); Bowman et al. (1989); Henderson et al. (1992); Maricle and Lee (2006); Kafi et al. (2007); Dubey and Chandra (2008).

Analysis of variance result, a statistical difference of 0.05 was observed between irrigation water salinity and leaf $\Delta^{13}C$. Variance analysis results were provided in the Table 4.

Table 4. Carbon isotope ratio of the leaf samples (ΔL; ^{13}C ‰) variance analysis

Variation Source	DF	S.F	M.S	F	Table F
					0.05
Blocks	2	0.0	0.0	0.21	4.46
Treatments	4	0.8	0.2	33.51*	4.46
Error	8	0.2	0.0		
General	14	1.1			

* Statistically significant at $P<0.05$

The Relationship Between Δ of Leaves and Crop Yields

The $\Delta^{13}C$ values declined while the crop yields values increased with increasing irrigation water salinity in this study. For each treatment, the leaf $\Delta^{13}C$ relationship and crop yields are provided in the Figure 3.

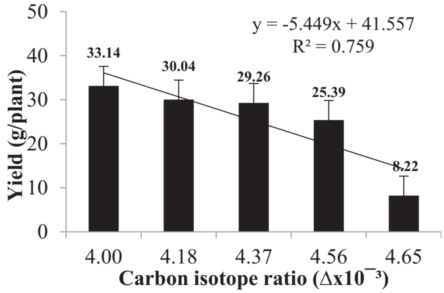

Figure 3. Relationship carbon isotope ratio and yield

A negative and remarkable correlation was found between irrigation water salinity and the crop yields and the leaf carbon isotope ratios. The crop yields were reduced from 33.14 to 8.22 g per plant and carbon isotope ratio of leaves was increased from 4 to 4.65 per plant when EC increased from 0 dS/m to 10 dS/ m. The values obtained from crop yields and the leaf carbon isotope (ΔL; ^{13}C ‰) ratios are provided in the Table 5.

Table 5. Crop yields and leaf carbon isotope ratio values

Treatments	Yield (g)	$\Delta\ ^{13}C$ - Leaf (‰)
T_1	33.14^{a}	4.00^{c}
T_2	30.04^{ab}	4.18^{bc}
T_3	29.26^{bc}	4.37^{abc}
T_4	25.39^{c}	4.56^{ab}
T_5	8.22^{d}	4.65^{a}

Results indicated that there was a negative significant relationship between $\Delta^{13}C$ and crop yields with increasing irrigation water salinity levels. Similar results were found by Ueno et al. (2006); Monneveux et al. (2007).

CONCLUSIONS

At the end of the research study the highest crop yields were determined at the lowest irrigation salinity level. Decline in yield was observed with increasing salinity level. Carbon isotope ratio of leaves values varied between 4.00 and 4.65‰ and were higher at 10 dS/m salinity level. A significant negative correlation was found between carbon isotope ratio of leaves and crop yields. It may be emphasized that pot techniques on carbon isotope studies can provide useful preliminary information about salinity effects on crop yields.

Stable carbon isotope discrimination appears to be a worthful index for assessing whole-plant response to salinity. It can help clarify the effects of salinity on carbon isotope composition in C_4 plants.

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REFERENCES

Akhter J., Sabir S.A., Lateef M.Z., Ashraf Y., Haq M.A. 2008. Relationships between carbon isotope discrimination and grain yield, water-use efficiency and growth parameters in wheat (*Triticum aestivum* L.) under different water regimes. Pakistan Journal Botany, 40(4), 1441-1454.

Ashraf M., McNeilly T., 1990. Improvement of salt tolerance in maize by selection and breeding. Plant Breeding, 104, 101–107.

Bolger T.P., Turner N.C., 1998. Transpiration Efficiency of Three Mediterranean Annual Pasture Species and Wheat, Oecologia 115, 32–38.

Bowman W.D., Hubick K.T., Caemmerer von S., 1989. Short-term changes in leaf carbon isotope ratio in salt and water stressed c_4 grasses. Plant Physiology, 90, 162-166.

Çiçek N., Çakırlar H., 2002. The effect of salinity on some physiol. parameters in two maize cultures. Bulgaria Journal Plant Physiology, 28(1-2), 66-74.

Donahue R.L., Miller R.W., Shickluna J.C., 1983. Soils: an introduction to soils and plant growth. 5th ed. Prentice Hall, Inc., Englewood Cliffs, NJ. 630-656.

Deleens E., Ferhi A., Queiroz O., 1983. Carbon isotope fractionation by plants using the C_4 patway, Physiology, Vegatation, 21, 897-905.

Dubey A., Chandra A., 2008. Effect of water stress on carbon isotope discrimination and its relationship with transpiration efficiency and specific leaf area in *Cenchrus* species. Journal of Enviromental Biology. 29(3), 371-376.

Ehleringer J.R., Hall A.E., Farquhar G.D., 1993. Stable isotopes and plant carbon/water relations. Academic Press, 127-132, San Diego.

Estep M.F., Tabita F.R., Parker P.L., Van Baalen C., 1978. Carbon isotope fractionation by ribulose-1.5-diphosphate carboxylase from various organisims. Plant Physiology, 61, 680-687.

Farquhar G.D., Q'Leary M.H., Berry J.A., 1982. On the relationship between carbon isotope ratio and the intercellular carbon dioxide concentration in leaves. Austuralian Journal Plant Physiology, 9, 121-137.

Farquhar G.D., Ehleringer, J.R., Hubick, K.T., 1989. Carbon isotope discirimantion and photosynthesis. Annu. Rev. Plant Physiology, Plant Molecular Biology, 40, 503-537.

Garg B.K., Gupta I.C., 1997. Saline wastelands environment and plant growth. Jodhpur Scientific Publishers.

Hasegawa P.M., Bressan R.A., Zhu J.K., Bohnert, H.J., 2000. Plant cellular and molecular responses to high salinity. Annual Rewiev Plant Physiology, Molecular Biology, 51, 463-499.

Henderson S.A., Von Caemmerer S., Farquhar G.D., 1992. Short-term measurements of carbon isotope discrimination in several C4-Species. Austuralian Journal Plant Physiology, 19, 263–285.

Kachout S.S., Ben Mansoura A., Jaffel K., Leclerc J.C., Rejeb M.N., Oureght Z., 2009. The effect of salinity on the growth of the *Halophyte atriplex hortensis* (*Chenopodiaceae*). Applied Ecology and Enviroment Research, 7(4), 319-332.

Kafi M., Griffiths H., Nezami A., Kazaie H.R., Sharif A., 2007. Effects of salinity on carbon isotope discrimination of shoot and grain of salt-tolerant and salt- sensitive wheat cultivars. Asian Journal of Plant Sciences, 6(8), 1166-1173.

Keeling C.D., Mock W.G., Tans P.P., 1979. Recent trends in the $^{13}C/^{12}C$ ratio of atmospheric carbondioxide. Nature, 277, 121-123.

Khan M.A., Ungar I.A., 1984. The effect of salinity and temperature on germination of polymorphic seeds and growth of artiplex triangularis. American Journal of Botany, 71, 481-489.

Maricle B.R., Lee R.W., 2006. Effects of enviromental salinity on carbon isotope ratio and stomatal conductance in *Spartina grasses*. Marine Ecology Progress Series, 313, 305-310.

Meinzer F.C., Paut Z., Saliendra N.Z., 1994. Carbon isotope ratio, gas exchange and growth of sugargane cultivars under salinity. Plant Physiology, 104, 521-526.

Mer G., Bochkarev A., Gupta R., Bochkareva E., Frappier L., Ingles C.J., Edwards A.M., Chazin W.J., 2000. Structural basis for the recognition of DNA repair proteins UNG2, XPA, and RAD52 by replication factor RPA. Cell 103, 449-456.

Monneveux P., Sheshshayee S.M., Akhter J., Ribaut J.M., 2007. Using carbon isotope discrimination to select maize (*Zea mays* L.) inbred lines and hybrids for drought tolerance. Plant Sciences, 173, 390-396.

Munns R., Tester M., 2008. Mechanism of salinity tolerance. Annual Rewiev of Plant Biology 59, 651-81.

Neumann P., 1997. Salinity resistance and plant growth revisited. Plant Cell Environment. 15;28-32.

O'Leary M.H., 1981. Carbon isotope fractionation in plants. Phytochemistry 20, 553-567.

Sandquist D.R., Ehleringer J.R., 1995. Carbon isotope discrimination in the C_4 shrub *Atriplex confertifolia* along salinity gradient. Great Basin Naturalist, 55, 135–141.

Turan M.A., Avad Elkarim A.H., Taban N., Taban S., 2009. Effect of salt stress on growth, stomatal resistance, proline and chlorophyll concentration on maize plant. African Journal of Agricultural Research, 4(9), 893-897.

Ueno O., Sentoku N., 2006. Comparison of leaf structure and photosynthetic characteristics of C_3 and C_4 *Alloteropsis semialata* subspecies, Plant Cell Enviroment, 29, 257.

Ungar I.A., 1982. Germination Ecology of Halophytes. In, Sen DN, Rajpurohit KS, Ds. Contributions to The ecology of halophytes. The Hague, Dr. W. Junk Publishers, 143-154.

Yang J.P., Hu K., Liu Y.Y., 2006. The stable carbon isotopic characteristics of carbonates in salini-alkani soil in the west jilin province. Journal of Jilin University, Earth Science Edition, 36(2), 245-249.

Yeo A.R., 1998. Molecular biology of salt tolerance in the context of whole-plant physiology. Journal Experiment Botany, 49, 915-929.

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SOME BIOLOGICAL PECULIARITIES AND PRODUCTIVITY OF THE SPECIES *Anthyllis macrocephala* IN MOLDOVA

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Abstract

The results of the evaluation of the growth and development rates, the green mass yield, the biochemical composition and the content of amino acids, phosphorous and calcium, the nutritive and energy value of the forage, as well as the biomethane production potential of the local ecotype of the leguminous species Anthyllis macrocephala, maintained in monoculture in the Botanical Garden (Institute) of the Academy of Sciences of Moldova, are presented in this article. It has been determined that the green mass yield in the first mowing reached 24.1 t/ha; 100 kg green mass contain 27 nutritive units, 282 MJ metabolizable energy and 3.90 kg digestible protein, exceeding substantially Medicago sativa; the calculated gas forming potential of the fermentable organic matter reached 507 litre/kg volatile solid, content of methane - 52.5 %.

Key words*: anthyllis macrocephala, biological peculiarities, biochemical composition, biogas yield, fodder value.*

INTRODUCTION

In the conditions of the biologization for a sustainable development of agriculture, the legumes are of great ecological importance due to their capacity to fix biological nitrogen by symbiotic associations, improve the physical properties of soil, form a large amount of organic raw material for various industries and, besides, they are an important source of food and feed protein. Considering the limited material and technical resources in the Republic of Moldova, the efficient use of the biological potential of the local wild leguminous plants that are adapted to the specific climatic conditions becomes more and more relevant (Teleuţă and Ţîţei, 2016).

Temperate herbaceous legumes constitute a major proportion of plants. The genus *Anthyllis* L. belongs to the tribe *Loteae* DC., family *Fabaceae* Lindl., is taxonomically complex, with many intergrading variants which are to some extent ecologically and geographically separated. The genus is considered to range from 25 (Cullen, 1986) to 60 (Minjaev and Akulova, 1987) species, distributed in Europe, Middle East and North Africa.

The species of the genus *Anthyllis* L. possess valuable biological properties, are not demanding to soil and can grow on poor sandy, marly, loamy and calcareous soils where such legumes as genus *Trifolium* L. and *Medicago* L. do not grow. That is why *Anthyllis* is called "clover of sandy soils". These species are frost hardy and can withstand temperatures of -8°C, are drought tolerant and propagate easily by self-seeding. The species of the genus *Anthyllis* are used as fodder, melliferous, medicinal plants and to produce dyes (Bailey, 1949; Peterson, 1967; Medvedev and Smetannikova, 1981; Akulova, 1985). In folk medicine, they are used as plants with soothing, astringent, diuretic, wound healing and tonic properties.

Many species of genus *Anthyllis* are pasture plants for livestock (eaten mostly by sheep), are also used as hay and have been known since the XIX century as forage plants, are able to regenerate rapidly after trampling and grazing and can be used for livestock grazing for many years. Werner (1907) described in details the biological features and the advantages of forage species of genus *Anthyllis* in the Central Europe.

In the wild flora of the Republic of Moldova, there is only one species - *Anthyllis macrocephala* Wend., which has insufficiently researched (Gheideman et al., 1962).

The synonyms of *Anthyllis macrocephala* Wend.: *Anthyllis grossheimii* Chinth., *Anthyllis polyphylla* (Ser.) Kit. ex Loudon, *Anthyllis* *vulnearia* L. subsp. *polyphylla* (Ser.) Nyman, *Anthyllis arenaria* (Rupr.) Juz., *Anthyllis schiwereckii* (DC.) Blocki. Common names: macrocephalous kidney-vetch, Kidney Vetch, ladyfinger. Romanian names: vătămătoare.

It is a biennial or perennial plant. Stems (1-6 in number) are erect and tall, 25-50 (90) cm in height, thick, robust and straight, branchy in the upper part. The lower part of the stems is covered with long and stiff squarrose hairs. Root leaves have 1-2 pairs of small lateral leaflets and a large ovoid or elliptic terminal leaflet ending with a rounded tip or a small sharp point. Stem leaves are 3-6 in number; they are uniformly distributed along the stem or may be absent in the upper third. Usually there are 5-6 pairs of leaflets on a leaf, elliptic or ovate on the lower leaves and linear-lanceolate in the upper ones. The terminal leaflet is large, obtuse in a lower leaf, and sharpened in an upper one. The leaflets of the uppermost leaf are often drawn together, so this leaf looks like a digitate one. All leaflets are naked or covered with sparsely set, small, rough hairs from above, and rather thickly villous from below, owing to slightly squarrose, long, rough hairs. Leafstalks are covered with small squarrose hairs. The inflorescences may be single, set on the top of a stem, or they are several (2-4), connivent enough, large (3-5 cm in diameter), compact and polyanthous. Bract leaves are equal in length to the calyx, dissected deeper than by one-half. Calyx is long and narrow, 12 mm in length and 3-5 mm in width, a little swollen under fruit, covered with long squarrose hairs, pale coloured. Corolla is usually yellow, often with a reddish-tipped carina, less frequently reddish all over. Banner blade is short, about 6 mm long, with an unguis – 6-7 mm long. Blossoms in June; bears fruit in August. Pods are ovoid monospermous, indehiscent. Seeds are ellipsoid, biconvex, lateral compressed. Hilum in the middle of the ventral side – 2.3-2.5 x 1.6-1.8 mm. The surface is glabrous, faint lustrous, the upper 2/5 – green, the bottom 3/5 – yellowish. Chromosome number 2n=12. Entomophilous (Bojnansky and Fargasova, 2007; Smekalova, 2008). *Anthyllis macrocephala* grows in dry meadows, steppes, river valleys, in dry open forests, forest edges, clearings and open slopes. (Abushaeva, 2013). It can abundantly grow in soils containing more than 3 % of $CaCO_3$. *Anthyllis macrocephala* has been included in the list of protected plants of the Republic Moldova, status: 4R - a rare species.

This research was aimed at evaluating the biological peculiarities, the productivity and the biochemical composition of the local ecotype of *Anthyllis macrocephala* and the possibility to use it as forage for ruminant animals or as biogas substrate.

MATERIALS AND METHODS

The local ecotype of the species *Anthyllis macrocephala*, maintained in monoculture, served as subject of study. The traditional leguminous fodder crops *Medicago sativa* and *Onobrychis viciifolia* served as control variants. The experiments were performed on non-irrigated experimental land in the Botanical Garden (Institute) of the Academy of Sciences of Moldova, latitude 46°58′25.7″ and longitude N28°52′57.8″E. The experimental design was a randomised complete block design with four replications, and the experimental plots measured 10 m^2. The seeds were sown at a depth of 2.0-3.0 cm with soil compaction before and after sowing. The scientific researches on growth and development, yield and biochemical composition of the plants were carried out according to the methodical indications (Novosiolov et al., 1983; Petukhov et al., 1989). The carbon content of the substrates was determined from data on volatile solids (organic dry matter), using an empirical equation reported by Badger et al. (1979). The biogas production potential and specific methane yields were evaluated by the parameter “content of fermentable organic matter”, according to Weissbach (2008).

RESULTS AND DISCUSSIONS

After the phenological observations, it was found that, in the first growing season, the growth and development rates of the species *Anthyllis macrocephala* differed from those of the traditional leguminous forage crops. Thus, the seedlings emerged uniformly on the soil surface 12 days after sowing, or, 5 days earlier than the control *Medicago sativa* and 11 days earlier than *Onobrychis viciifolia*.

The type of germination – epigeal (aboveground). The cotyledons of plants were better developed, larger, with thicker leaf blade. The true leaves appeared 2-4 days earlier, in comparison with the control, had more developed leaf blades, were brightly coloured. At the stage of the emergence of the 3^{rd}-4^{th} true leaves, the seedlings had well-developed system of the main root with lateral roots. The development of the root system in *Anthyllis macrocephala* was considerably faster than the growth of the aerial organs. When the cotyledons emerged at the soil surface, the taproot of plants reached a depth of 3.8-5.7 cm. This characteristic makes possible to obtain large amounts of nutrients from soil and provides high life potential of plants at the earliest stages of development. At the stage when the first true leaves started developing, the size of the root system reached 4.9-8.3 cm, it later influenced positively the formation and development of the rosette, the capacity of the plants to grow shoots, the number of leaves on shoots and the further development of the root system, which reached 1.8-2.1 m depth. *Anthyllis macrocephala* was distinguished by slower growth and development of the aerial part and, by the end of the growing season, it reached the budding-flowering initiation stage, but *Medicago sativa* and *Onobrychis viciifolia* went through all the ontogenetic stages. Alfalfa was harvested twice, common sainfoin – once. The fresh mass yield of *Anthyllis macrocephala* was 0.99 kg/m^2 with high content of leaves (78 %) and dry matter (39 %), suitable for grazing.

In the following years, *Anthyllis macrocephala* plants resumed their development in spring when the average temperatures were above 5°C, but they needed higher temperatures than the control, so, they started developing more rapidly about 2 weeks later than *Medicago sativa* and *Onobrychis viciifolia.*

In the second year, *Anthyllis macrocephala* plants were characterised by the formation of shoots from the shortened internodes of rudimentary stems of the rosette from the first year, the leaves mostly retained their structure and provided protection to the meristem of the shoots. The juvenile period of development determines the presence of rosette leaves with an enlarged terminal leaf, and the virginile period is associated with several generations of compound odd-pinnate cauline leaves and the beginning of the generative period is accompanied by the formation of bracts – leaves surrounding the inflorescences, simple, palmate-dissected, and the formation of inflorescences. Thus, the leaf morphology is a diagnostic feature for establishing the age and the period of development of *Anthyllis macrocephala* plants.

The root system developed intensively, long ramifications of the root system were observed and a decrease in the mass of roots, as they grew deep in the soil, occurred gradually, in comparison with the control species. The research carried out by Abushaeva, 2015 has shown that when sowing in wide rows (45 cm), *Anthyllis macrocephala* had the most developed root system – 6.53 t/ha, but *Medicago falcata, Medicago varia, Lotus corniculatus* – 4.20 - 4.81 t/ha. This characteristic is of great importance due to the anti-erosion effect it can have on grass-covered slopes and any areas with loose soil, where it is necessary to secure the mechanical particles and to maintain the structure of soil.

Analyzing the 3-year-old plants (Table 1), we noted that the *Anthyllis macrocephala* plants had resumed the development 7-9 days later, their growth and development rates being very slow in comparison with *Medicago sativa* and *Onobrychis viciifolia.* Therefore, by the end of April, the *Anthyllis macrocephala* plants reached 16.60 cm high, while the control species – about 35.90-38.10 cm. It was determined that the period of time from the resumption of development till the formation of flower buds was shorter for *Anthyllis macrocephala* and constituted 64 days, but for the control species – from 70 to 75 days. In the budding period a faster growth rate of thick hairy stems was observed, probably due to the weather conditions (warmer weather), this tendency was maintained during the flowering stage, when *Anthyllis macrocephala* plants reached 74.40 cm, while the traditional leguminous forage crops reached 83.20-85.50 cm.

In other studies, it was mentioned that *Anthyllis macrocephala* plants in the budding-flowering period might reach development rates of 1.4-4.4 cm/days (Abushaeva, 2013). The flowering period of *Anthyllis macrocephala* started in June with 5 days earlier than *Onobrychis viciifolia*.

Table 1. Some biological peculiarities and productivity of *Anthyllis macrocephala*

Indicators	*Medicago sativa*	*Onobrychis viciifolia*	*Anthyllis macrocephala*
Resumed development up to:			
- budding, days	70	75	64
- flowering, days	82	99	78
- seed ripening, days	143	133	127
Plant height, cm			
- at the end of April	39.10	35.90	16.60
- at flowering	83.20	85.50	74.40
The yield at the first mowing:			
- fresh mass, kg/m^2	3.11	3.95	2.41
- dry matter, kg/m^2	0.82	1.03	0.82

Table 2. Biochemical composition, nutritive and energy value of *Anthyllis macrocephala*

Indicators	*Medicago sativa*	*Onobrychis viciifolia*	*Anthyllis macrocephala*
Raw protein, % dry matter	17.03	17.44	15.16
Raw fats, % dry matter	2.30	3.39	2.73
Raw cellulose, % dry matter	33.31	33.50	35.47
Nitrogen free extract, % dry matter	39.41	39.43	40.11
Minerals,% dry matter	8.01	6.24	6.53
Nutritive units/ kg green mass	0.21	0.23	0.27
Metabolizable energy, MJ/kg green mass	2.28	2.86	2.82
Dry matter, g/kg green mass	263.70	274.00	338.30
Digestible protein, g/kg green mass	34.50	35.87	39.00
Calcium, g/kg green mass	4.46	3.53	2.32
Phosphorus, g/kg green mass	1.16	1.55	0.81
Carotene, mg/kg green mass	19.05	30.50	13.00
Vitamin C, mg/%	45.58	41.21	53.00
Digestible protein, g/ nutritive unit	164.29	156.00	143.74

Table 3. The content of amino acids in fodder of *Anthyllis macrocephala* (mg/100 mg dry matter)

Amino acids	*Medicago sativa*	*Onobrychis viciifolia*	*Anthyllis macrocephala*
asparagine	1.711	1.751	2.480
threonine	0.564	0.565	0.549
serine	0.687	0.685	0.646
glutamine	1.360	1.398	1.316
proline	0.922	1.154	1.009
glycine	0.550	0.557	0.505
alanine	0.674	0.672	0.590
valine	0.559	0.654	0.570
methionine	0.139	0.091	0.130
isoleucine	0.459	0.459	0.443
leucine	0.913	0.920	0.924
tyrosine	0.458	0.491	0.329
phenylalanine	0.850	0.937	0.490
histidine	0.326	0.371	0.338
lysine	0.619	0.706	0.541
arginine	0.655	0.587	0.473

The studied *Fabaceae* species needed a different period from the beginning of flowering until the full ripening of seeds. Thus, *Anthyllis macrocephala* needed 49 days, while *Onobrychis viciifolia* needed 34 days and *Medicago sativa* - 61 days.

It is well known that yield is the product of a complex interrelationship among climatic, genetic, and agronomic variables. The green mass yield of *Anthyllis macrocephala*, at the first mowing, reached 24.1 t/ha. The harvested fodder was poorer in leaves (33 %), but richer in dry matter (34 %).

The knowledge of constituents of animal feed is of primary importance to animal production and productivity. Forages are a major source of nutrients for herbivores. Sometimes the balance of nutrients or the presence of some constituents in the forage will have positive or negative effects on animal health and productivity. The biochemical composition of green mass *Anthyllis macrocephala*, is presented in Table 2, obtained values are expressed as percentage of dry matter. The dry matter of *Anthyllis macrocephala* was characterized by optimal protein content (15.16 %), which was lower in comparison with traditional forage leguminous crops (17.03-17.44 %), about the same nitrogen free extractive substances (40.11 %) and high level of raw cellulose (35.47 %). As compared with traditional forage leguminous crops, the dry matter of *Anthyllis macrocephala* was characterised by lower fat content (2.73 %) than *Onobrychis viciifolia,* but higher – in comparison with *Medicago sativa.*

Some authors mention similar findings about the quality of *Anthyllis macrocephala* fodder. So, as a result of a research conducted in Penza region, Russia, it was found that the dry matter content of green fodder was 39.66 %, including 4.75 % raw protein, 0.32 % raw fats, 16.07 % raw cellulose, 3.43 % minerals, 15.09 % nitrogen free extracts (Kshnikatkina et al., 2005); in the Kabardino-Balkar Republic, Russia – 15.9 % raw protein in dry matter (Galushko, 1964)

An essential component of the characteristics of protein is its amino acid composition, which is its main structural characteristic, irrespective of the kind, origin and physiological function.

Analyzing the results on the amino acid content in the fodder (Table 3), it was found that the species *Anthyllis macrocephala* was distinguished by an optimal content of both essential and nonessential amino acids. Comparing each amino acid separately, we could mention that the content varied in comparison with traditional forage crops. We could mention that the methionine content, the first deficient essential amino acid limiting the nutritive value of protein of the species *Anthyllis macrocephala* reached 0.130 mg/100 mg dry matter, thus, it was higher than in *Onobrychis viciifolia*, but lower as compared with *Medicago sativa.* The second limiting amino acid for protein biosynthesis – lysine (0.541 mg/100 mg) was much lower as compared with *Onobrychis viciifolia* and *Medicago sativa.* We found that *Anthyllis macrocephala* fodder was very rich in asparagine, contained about the same amount of threonine, serine, glutamine, isoleucine, leucine, but had lower content of phenylalanine, alanine and arginine in comparison with traditional forage crops.

Table 4. Gas forming potential of the fermentable organic matter from the studied species of the family *Fabaceae*

Indicators	*Medicago sativa*	*Onobrychis viciifolia*	*Anthyllis macrocephala*
Ratio of carbon and nitrogen (C/N)	19	19	21
Fermentable organic matter, g/kg VS	642	658	633
Biogas, litre/kg VS	514	526	507
Methane, litre/kg VS	270	276	266
Methane productivity, m^3/ha	2214	2843	2181

The organic matter content, its biochemical composition and digestibility determine the nutritional and energy value of the green mass (Table 2). It was determined that 100 kg green mass of *Anthyllis macrocephala* contained 27 nutritive units, 282 MJ metabolizable energy and 3.90 kg digestible protein, exceeding significantly *Medicago sativa*. The fodder of *Anthyllis macrocephala* was very poor in calcium (2.32 g/kg), phosphorus (0.81 g/kg), carotene (13 mg/kg), but richer in ascorbic acid (53.00 mg/%). A high content of vitamin C in the leaves (191 mg/%) was also mentioned in other studies (Gheideman et al., 1962). Biogas production from energy crops mainly depends on their biodegradability and biochemical composition.

The ratio of carbon and nitrogen (C/N) in the raw material is essential in the production of biogas. The optimal C/N ratio for the methane-producing bacteria is 20:1-30:1. High C/N ratio favours ammonia production, while low C/N ratio limits the growth of bacteria (Dobre et al., 2014).

The C/N ratio of the studied species varied from 19 in the biomass of *Medicago sativa* and *Onobrychis viciifolia* to 21 in the biomass of *Anthyllis macrocephala* (Table 4). The calculated gas forming potential of the fermentable organic matter of local ecotype of the species *Anthyllis macrocephala* reached 507 litre/kg VS, being lower than in the control species (514-526 litre/kg VS), but it had similar content of methane (52.5 %).

The highest methane yield per ha was achieved by *Onobrychis viciifolia*, the lowest – by the biomass of *Anthyllis macrocephala*.

CONCLUSIONS

In the conditions of the Republic of Moldova, it was observed a slower growth and development of the aerial part of *Anthyllis macrocephala* during the first growing season, but it developed stronger root system in comparison with the control.

The 3-year-old *Anthyllis macrocephala* plants had moderate growth and development rates that allowed mowing them in June, when the green mass yield reached 2.41 kg/m^2, but they had higher content of dry matter, in comparison with the traditional crops.

The biochemical composition of the dry matter of *Anthyllis macrocephala*: 15.16 % raw protein, 2.73 % raw fat, 35.47 % raw cellulose, 40.11 % nitrogen-free extractive substances, 6.53 % minerals and a high amount of vitamin C.

The 100 kg of green mass of *Anthyllis macrocephala* contained 27 nutritive units, 282 MJ metabolizable energy and 3.90 kg digestible protein, exceeding essentially *Medicago sativa*.

The gas forming potential of *Anthyllis macrocephala* reached 507 litre/kg VS with 52.5 % methane. The calculated methane yield of the green mass of *Anthyllis macrocephala* harvested at the first mowing reached 2181 m^3/ha.

The local ecotype of the species *Anthyllis macrocephala* is a perennial plant and has xerophytic features (poor foliage, thick hairy stems, well developed roots that grow deep into the soil). It is an excellent plant to prevent erosion on grass-covered slopes and any areas with loose soil, where it is necessary to secure its mechanical particles and to maintain its structure. Besides, *Anthyllis macrocephala* is useful for restoring degraded, polluted and eroded land, and for reseeding and increasing the economic value of grasslands.

REFERENCES

Abdushaeva Ya.M., 2013. Environmental assessment and bioresource potential of the plants family *Fabaceae* Lindl in the landscapes conditions of the Novgorod region. Doctoral dissertation referat, Moscow, 43 [in Russian].

Akulova Z.F., 1985. Useful characteristics of the species genus *Anthyllis* L. in Flora USSR. Rastitelinyye resursy, 21(1): 96-103 [in Russian].

Badger C.M., Bogue M.J., Stewart D.J., 1979. Biogas production from crops and organic wastes. New Zeeland Journal of Science, 22:11 -20.

Bailey L.H., 1949. Manual of cultivated plants most commonly grown in the continental United States and Canada. Ed. Macmillan, New, 116.

Bojnansky V., Fargasova A., 2007. Atlas of seeds and fruits of Central and East-European Flora: the Carpathian Mountains Region. Springer. Dordrecht, 1046.

Dobre P., Farcaş N., Matei F., 2014. Main factors affecting biogas production - an overview. Romanian Biotechnological Letters, 19(3): 9283-9286.

Cullen J., 1968. *Anthyllis* L. Flora Europaea 2:177-182.

Galushko A. I., 1964. The species plant of the grasslands and pastures of the North Caucasus. KBGU, Nalichik, 372 [in Russian].

Geideman T.S., Ivanova B.I., Lyalikov S.I., 1962. Wild useful plants of Moldova. Stiinta, Kishinev, 416 [in Russian].

Kshnikatkina A.N., Gushchina V.A., Galiullin A.A., Varlamov V.A., Kshnikatkin S.A., 2005. Nontraditional fodder crops. RIO PGSKHA Penza, 240 [in Russian].

Medvedev P.F., Smetannikova A.I., 1981. The forage crops of European part of the USSR. Ed. Kolos. Leningrad, 336 [in Russian].

Minjaev N.A., Akulova Z.F., 1987. *Anthyllis* L. In: Flora of the European part of USSR, Nauka, Leningrad, 98-103 [in Russian].

Novoselov Y.K., Kharkov G.D., Shekhovtsova N.S., 1983. Methodical instructions for conducting field experiments with forage crops. Ed.VNNIK, Moscow, 198 [in Russian].

Peterson A., 1967. Klee und Kleeartige als Kulturpflanzen,Wildpflanzen und Unkräuter auf Acker, Wiese und Weide. Akad. Verlag, 214.

Petukhov E.A., Bessarabova R.F., Holeneva L.D., Antonova O.A., 1989. Zoo technical analysis of the feed. Edit. Agropromizdat, Moskva, 239 [in Russian].

Smekalova T.N., 2008. Anthyllis macrocephala Wend. Macrocephalous kidney-vetch http://www.agroatlas.ru/en/content/related/Anthyllis_macrocephala

Teleuţă A., Ţîţei V., 2016. Mobilization, acclimatization and use of fodder and energy crops. Journal of Botany, 1: 112-120.

Weissbach F., 2008. On assessing the gas production potential of renewable primary products. Landtechnik 6:356-358

Werner H., 1907. Handbuch des Futterbaues. Parey, Berlin, 478.

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TESTING OF SOME INSECTICIDES ALLOWED IN ORGANIC FARMING AGAINST *Tanymecus dilaticollis* ATTACK OF MAIZE CROPS

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Abstract

This paper present the results obtained about the effectivess of some insecticides agaist Tanymecus dilaticollis atack in maize crops at NARDI Fundulea. These products are allowed in organic farming by Anexx 2 of Commission Regulation (EC) No 889/2008 for the implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control. The insectisides used in the maize seeds tratament were: Neem-TS, Laser 240-TS and Bactospeine DF-TS in dose of 2.5 g/250 grams of seeds. In vegetation it were used: Neem-TV and Laser 240-TV in dose of 150 ml/ha. The used maize hybrid was Olt variety obtained at NARDI Fundulea. Also, it performed productivity elements and seeds yields and chemical compozition on Laboratory of Yields Quality of Crop Sciences Department, Bucharest Faculty of Agriculture. The insecticides effectiveness fluctuated between 5.5 when it was applied Laser 240-TS (2.5 ml/250 g. s.) and 6.12 when it was applied Laser 240-TV (150 ml/ha). The density of crop maize ranged between 98.5 plants/plot of Laser 240-TV apllied on seeds by comparison with the same product applied in vegetation. The largest yields was of 6676 kg/ha at insecticide variant with the best effectiveness Laser 240-TS (2.5 ml/250 g. s.). The chemical composition of seeds, in average, was: 12.27% protein; 70.83% starch; 4.41% oil; 1.26% ash; fibre 1.77%. These results showed that there was no influence of insecticides on yield quality.

***Key words**: insecticides, maize, Tanymecus dilaticollis, organic agriculture, productivity.*

INTRODUCTION

Care and awareness of the world population on the environment, the dangers to health of the synthetic pesticides using and chemical fertilizers excessively and consumer preference for food produced safely and free of danger are major factors that lead to increased interest of everyone involved in alternative forms of agriculture in the world, as organic farming. Organic production systems are based on specific standards for food production and aims to produce them in a sustainable way both socially and materially. This system should be regarded as an integral part of sustainable development strategies as a viable alternative to conventional agriculture (Nastase and Toader, 2016). According to recent studies of Research Institute of Organic Agriculture FIBL and International Federation of Organic Agriculture Movements (IFOAM), the organic farming area is around 37.4 million ha, being recorded about 2 million of organic farms and the market of organic products means about $ 73.8 billion. In Romania, organic farming summarizes around 290,000 ha and of these, over 100,000 ha are cereals.

In Romania, organic farming has great opportunities for development and the legal basis for the organization of production and sale of organic products has been shaped by the following national and EU legal norms.

The Romanian legislation is up-to-date and follows EU Regulation (EC) No 834/2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91 and Commission Regulation (EC) No 889/2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control. Organic producers must be certified by one of the accredited control and inspection bodies. There is a national logo for organic products, which is owned by the Ministry of Agriculture

and Rural Development. It can be used for products that comply with the Romanian Organic legislation.
On the other hand, maize is an important crop being cultivated on large areas in the world (over 160 million ha), also in Romania (2.5 million ha annually) because it is used in human nutrition, feed production and raw material for many other products (starch, alcohol, biofuel, etc.). In organic farming, the maize is cultivated over 50% from total surface. This importance derives from the fact that maize is mainly intended for animal feed. Also, according to organic farming rules, organic livestock must be fed with fodder crops obtained by organic farming rules.
But as is well known, the maize crop has many advantages, among which we can mention, great production potential, full mechanization, high ecological plasticity.
However, maize has some limited elements of production including pests that attack in the early stages of vegetation as gray maize weevil (*Tanymecus dilaticollis* Gylll.). They feed on young leaves from the leaf margin, and most damage occurs before the 4-leaf stage (BBCH 14). Drought and higher temperatures enhance feeding (Popov, 2006). *Tanymecus dilaticollis* has one generation per year and overwinters as adult in the soil (Paulian, 1972).
Therefore, where maize is cultivation in organic farming conditions, should be adhered to rules imposed by law. This means that to combat various pests in crop production to by maintaining of crop health using preventative measures, such as the choice of appropriate varieties resistant to pests and diseases, appropriate crop rotations, mechanical and physical methods and the protection of natural enemies of pests.
All synthetic insecticides are prohibited.
They may be used only products corresponding to Annex 2 of the Regulation (EC) No 889/2008.
In this context, it is very difficult to find a solution to combat this dangerous pest of maize crop.
This paper present the results obtained about the effectiveness of allowed insecticides in organic farming against *Tanymecus dilaticollis* attack of maize crops at NARDI Fundulea.

MATERIALS AND METHODS

Experience was conducted in the experimental field at Plant Protection Collective (NARDI Fundulea), in 2016.
The biologic material of maize crops was Olt variety, obtained of NARDI Fundulea. The insectisides used in the maize seeds tratament were: Neem-TS (natural neem oil) (2.5 ml/250 g. s.), Laser 240-TS (spinosad 240 g/l active substance) (2.5 ml/250 g. s.) and Bactospeine DF-TS (*Bacillus thuringiensis* subsp. *Kurstaki)* (2.5 g/250 g. s.). In vegetation it was used: Neem-TV (150 ml/ha) and Laser 240-TV (150 ml/ha) (Figures 1 and 2).

Figure 1. Insecticides used for seeds sowing, 2016)
(NARDI Fundulea Experimental Field)

Figure 2. Aspects of seeds preparation and sowing
(NARDI Fundulea Experimental Field,
18th of May 2016)

Experimental plots have 42 m^2 (10 m length, 4.2 m width (6 rows), 0.7 m distance between rows) by randomized blocks, in four repetitions. The maize seeds were sowed manually with a planter, at a 35 cm distance between seeds on the row. This low density has the purpose to concentrate maize leaf weevil on the emerged maize plants to evaluate effectiveness of the insecticides used for the seed treatment. To avoid migration of maize leaf weevil adults from one plot to another, the experimental plots were laterally isolated with a 2 m wide strip sown with pea, a plant repellent to this insect (Paulian et al., 1972; Voinescu and Barbulescu, 1998).

We analyzed 20 of plants from each plot and we removed the plants from marginal rows of the plot.

The attack intensity of the *T. dilaticollis* were assessed when plants arrive at four leaf stage (BBCH 14), using a scale from 1 to 9, elaborated and improved by Paulian (1972). According this scale attack intensity ranged from 1 (unattached plant) to 9 (plant complete destroyed): x Note 1: plant not attacked; x Note 2: plant with 2-3 simple bites on the leaf edge; x Note 3: plants with bites or clips on leaf edge; x Note 4: plants with leafs chafed in proportion of 25 %; x Note 5: plants with leafs chafed in proportion of 50 %; x Note 6: plants with leafs chafed in proportion of 75 %; x Note 7: plants with leafs chafed almost at the level of the stem; x Note 8: plants with leafs completely chafed and beginning of the stem destroyed; x Note 9: plants destroyed, with stem chafed close to soil level (Toader et al., 2016).

Figure 3. *Tanymecus* attack on maize plant (NARDI Fundulea Experimental Field, 13rd of May, 2016)

After 30 days from plant emergence, the saved plants percentage was evaluated by counting all the emerged plants from a plot and comparing them with the sowing seeds number/plot.

On the other hand, chemical analyzes were performed to see if there have been changes in the chemical composition depending on the insecticide applied.

RESULTS AND DISCUSSIONS

Data from figures 4 and 5, demonstrate that, climatic conditions from spring period of the year 2016, at NARDI Fundulea, were medium favourable for maize leaf weevil attack. Monthly and annual average temperatures for the year 2016 compared to the annual average is presented in Figure 4.

Examination of the data, it can be seen that the average temperature for April was 14.0°C, with 2.9°C higher than the multiannual temperature (11.1°C).

For May, they were recorded average monthly temperature values by 0.8°C higher than the multiannual average (16.1).

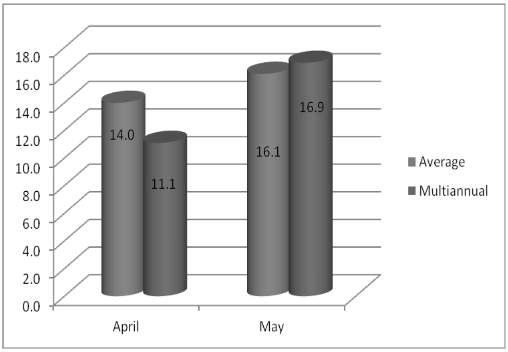

Figure 4. Evolution of the air temperatures in spring, at NARDI Fundulea, in 2016

2016 was characterized in April and May with a surplus of rainfalls. The largest amount fell in April, 73.7 mm, 14.7 mm more than the multiannual average. In May, the difference was only 8.9 mm by comparison with multiannual average (Figure 5).

These climatic conditions, from second decade of May, when maize plants were in first vegetations stages (BBCH 10-14) were mediu favourable for pest attack.

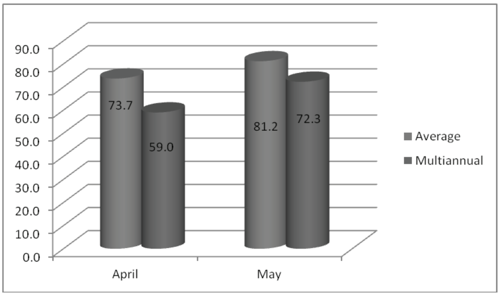

Figure 5. Evolution of the rainfalls in spring, at NARDI Fundulea, in 2016

Figure 6 presents the evaluation of *Tanymecus dilaticollis* attack intensity of maize plants, on a scale from 1 (not attacked plant) to 9 (complete destroyed plants). Using the scale in phase of four leafs, it was found plants with Notes 5 and 6, with leafs chafed were affected in proportion of 50-75% (Figure 7) According the results, the lowest attack was recorded in the treated seed with Laser 240-T5 (2.5. ml/250 g.s.) of 5.5 (Figure 8). Thus, we must emphasize the seed treatment compared with the same product applied in vegetation. It also notes that the other two treatments applied to seeds, efficacy was better than for treatments performed in vegetation. The higher attack intensity was recorded at Control variant, with 6.14.

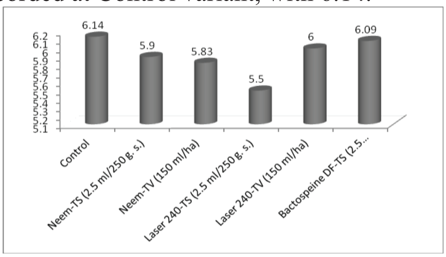

Figure 6. Attack intensity analysis (NARDI Fundulea Experimental Field, 13rd of May)

Figure 7. x Note 5: plants with leafs chafed were affected in proportion of 50-75% (NARDI Fundulea Experimental Field, 13rd of May)

Figure 8. Variant of seed treatment with Laser 240 (2.5 ml/250 g.s.) (NARDI Fundulea Experimental Field, 23rd of June 2016)

Regarding plant density/plots the best result was recorded in the treated variant with Laser 240-T5 (2.5. ml/250 g.s.), where it recorded 132 plant/plot. This result meaning over 77.65% of saved plants. Also, the good result obtained in case of seeds treatment with Bactospeine DF-TS (2.5 g/250 g.s.), respectively, 123.5 plant/plot and 72.65% saved plants (Figure 9).

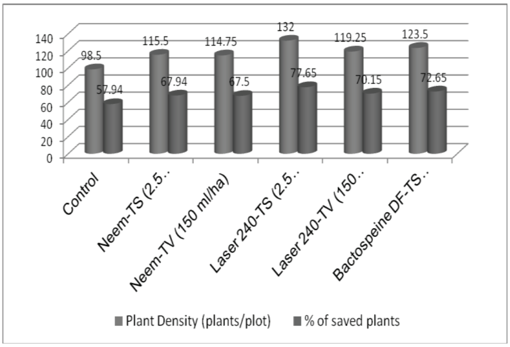

Figure 9. Density of plants at 30th of May 2016 (NARDI Fundulea Experimental Field)

These results demonstrated the effectiveness of treatments to maize seed with specific products comparative with treatments make in vegetation.

In case of the results regarding productivity elements and seeds yields, can highlight the variant of the insecticides were applied to seeds, respectively, Laser 240-T5 and Bactospeine DF-TS (2.5 ml/250 g.s.).

In these conditions, were obtained, 86.55% of grains weight/cob and TGW was 362.3 g for Laser 240-T5 and 85.58% of grains weight/cob and TGW was 336.6 g for Bactospine DF-TS (Figures 10 and 11).

Figure 10. Cobs at harvesting

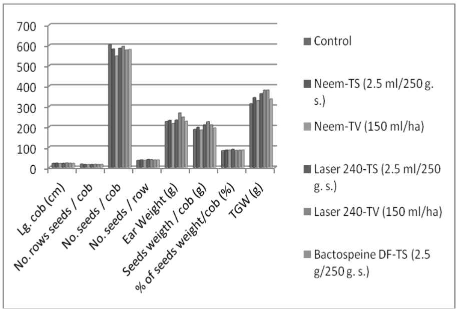

Figure 11. Productivity elements of maize at harvesting (NARDI Fundulea Experimental Field, 2016)

The main factor of yields is plants density (cob) at harvesting. Thus, the best seeds yields were recorded at two variants of insecticides applied on seeds, Laser 240-T5 (6676 kg/ha) and Bactospeine DF-TS (6447 kg/ha). The lowest values were found at Control variant, with 4899 kg/ha. Also, the low yields recorded at treatment in vegetation by comparison with the same produce in vegetation (Figure 12).

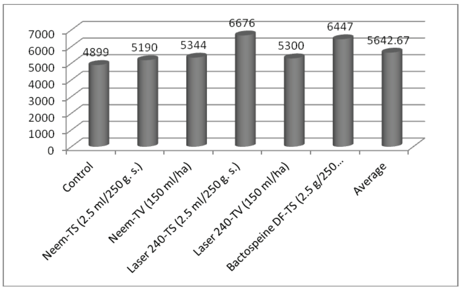

Figure 12. Yields of maize seeds (NARDI Fundulea Experimental Field)

In climatic conditions of 2016, the accumulation of reserve substances were favoured to accumulated more starch, over 70% in all variants. Content in other elements were not different from what is known in the literature about chemical composition of Olt maize variety. The amount of proteins averaged around 12%. The other compounds were, in average: starch - 70.83%; oil - 4.39%; ash - 1.31% and fibre 5.24%. According of these results can emphasis that the insecticides no influence on chemical composition of seeds at harvesting (Figure 13).

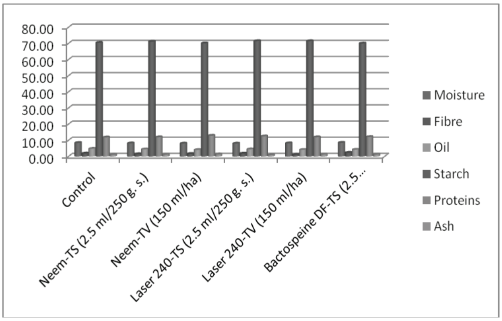

Figure 13. Chemical composition of maize seeds (NARDI Fundulea Experimental Field, 2016)

CONCLUSIONS

Regarding attack intensity, it was found that plants has Notes 5 and 6, when plants with leafs chafed were affected in proportion of 50-75%.

The best result was recorded in the treated seed with Laser 240-T5 (2.5. ml/250 g.s.) with an intensity attack of 5.5.

The higher attack intensity was recorded at Control variant, with 6.14.

Regarding plant density/plots the best result was recorded for the treated variant with Laser 240-T5 (2.5. ml/250 g.s.), with 132 plant/plot (77.65% of saved plants) and Bactospeine DF-TS (2.5 g/250 g.s.), with 123.5 plant/plot (72% saved plants).

In case of the productivity elements results, it can highlight the variant of the insecticides were applied to seeds, respectively, Laser 240-T5 and Bactospeine DF-TS (2.5 ml/250 g.s.) with TGW between 362.3 g and 336.6 g.

The best seeds yields has been obtained at same variants applied on seeds, Laser 240-T5 (6676 kg/ha) and Bactospeine DF-TS (6447 kg/ha).

The lowest values of yields seeds were found at Control variant, with 4899 kg/ha.

The low yields recorded at treatment in vegetation by comparison with the same product in vegetation.

In climatic conditions of 2016, the accumulation of reserve substances were favoured to accumulated more starch, over 70% in all variants.

Content in other elements were not different from what is known in the literature about chemical composition of Olt maize variety: proteins - around 12%, starch - 70.83%; oil - 4.39%; ash - 1.31% and fibre 5.24%.

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REFERENCES

Nastase Paula Ionela, Toader Maria, 2016. Study regarding organic agriculture and certification of products. http://agronomyjournal.usamv.ro/pdf/2016/Art60.pdf.

Paulian F., 1972. Contribution at knowledge of the development, ecology and control of the *Tanymecus dilaticollis* specie (Contribuţii la cunoaşterea dezvoltării, ecologiei şi combaterii speciei *Tanymecus dilaticollis)*. Doctoral thesis, I.A.N.B. Bucharest, pp. 300.

Popov C., Trotus E., Vasilescu S., Barbulescu A., Rasnoveanu L., 2006. Drought effect on pest attack in field crops, Romanian Agricultural Research, 23, pp. 43-52.

Popov C., Barbulescu A., 2007. 50 years of scientific activity in domain of field crop protections, against diseases and pests. Annals of N.A.R.D.I. Fundulea, 75, pp. 371-404.

Toader Maria, Georgescu E., Ionescu Alina Maria, 2016. The insecticides effectiveness on *Tanymecus dilaticollis* attack on maize at NARDI Fundulea. http://www. sciencedirect.com/science/article/pii/S2210784316301991

Voinescu I., Barbulescu A., 1998. Evolution of maize leaf weevil *(Tanymecus dilaticollis* Gyll.*)* in various crops depending on the preceding crop, Proceedings of International Symposium on Integrated Protection of Field Crops, Vrnjaka Banja: 157-164.

***https://shop.fibl.org/fileadmin/documents/shop/1698-organic-world-2016.pdf.

***http://eur-lex.europa.eu/legal-content/en /ALL /?uri =CELEX: 32007R0834

***http://eur-lex.europa.eu/legal-content/en/ALL/?uri= CELEX:32008R0889

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COVER CROPS AGAINST HERBICIDE-RESISTANT INVASIVE WEEDS

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Abstract

A field experiment was conducted to evaluate the effects of several cover crops against a serious invasive weed, Conyza albida. The particular species is characterized by a wide dispersal, an enormous seed production and a high trend for glyphosate-resistance development. In the present study, four different cover crops were tested, namely Lolium multiflorum, L. perenne, Festuca arundinacea and Trifolium repens. The experiment was performed as a randomized complete design and several measurements on soil coverage and weed growth and density were taken. Soil coverage was faster and higher for L. multiflorum, followed by F. arundinacea and T. repens. On the contrary, canopy development for the perennial L. perenne was 62-72% lower than the other cover crops. This rapid and high canopy development especially of L. multiflorum and T. repens resulted to the significant reduction of C. albida density (lower by 87 and 83%, respectively) and also to weeds' growth suppression (plant height reduction up to 50%). Consequently, the specific species could be certainly used, solely or in mixtures of cover crops for the effective management of invasive and herbicide-resistant weeds.

***Key words**: invasive plants, cover crops, glyphosate-resistance, Conyza albida.*

INTRODUCTION

Invasive species infestation has been recognized as one of the largest threats for native species and biodiversity across the world, especially under the observed and expected climate changes (Kriticos et al., 2003; Williamson, 1996). Such species have already or are likely to spread into new habitats, become dominant or disruptive to those areas and sometimes turn to be weeds of high agronomic importance (Reichard and White, 2001; Travlos, 2013). Understanding requirements and identifying environmental resources that promote or restrict the success of invasive species during the critical life stages can be used to prevent introduction and manage them properly (Speziale and Ezcurra, 2011). Many authors have suggested that higher genotypic diversity and phenotypic plasticity are likely to confer greater invasiveness (Gray, 1986; Williams et al., 1995). Once established, these plants have the potential to become troublesome and noxious weeds and pose long-term environmental problems and economic costs (Alpert et al., 2000; Richardson et al., 2000).

According to the review of Bresch et al. (2013), the Mediterranean ecosystem could be considered less prone to invasion than similar ecosystems on other continents. However, factors such as the human population density and the climatic changes may lead to a progressive invasion of the areas of Mediterranean basin (Sanz-Elorza, 2006; Vilà et al., 2008; Celesti-Grapow et al., 2010). Indeed, climate change might induce fluctuations of water availability and thus affect species distributions (Lavorel et al., 1998).

The genus of *Conyza* comprises more than 50 annual and perennial species. In Greece there have been reported the three following species: hairy fleabane (*C. bonariensis* L.), horseweed (*C. canadensis* L. Cronq.), and fleabane (*C. albida* Willd. ex Spreng), with the last one being the most recently introduced (Yannitsaros, 1997). Indeed, fleabane is a weed originated from South America that recently has been reported to invade in urban, natural and agricultural ecosystems. In Greece, it is characterized by a rapid growth and high dispersal potential that enables its establishment as a permanent weed of the urban landscape as well as in many crops. *C.*

albida is now among the most widespread species found in waste dumps, vineyards, orchards, roadsides and natural ecosystems in a variety of regions (Thebaud and Abbot, 1995).
The extended use of herbicides like glyphosate has greatly increased the risks of their reduced efficacy on several weeds. Unfortunately, this is the case also in Greece, with many reports of reduced efficacy of glyphosate against increasingly problematic weeds, such as *Conyza* spp. Today, there are many reports from Greek farmers that *Conyza* spp. has become increasingly difficult to control with several herbicides, especially in no-tillage or minimum-tillage systems, with biotypes of all the three species already confirmed to be resistant (Travlos and Chachalis, 2010; 2012; 2013).
Cover crops are among the agronomic practices with a high weed suppressive ability in perennial crops (Guerra and Steenwerth, 2012). Moreover, they improve water infiltration, carbon sequestration, nutrient supply and retention, increase earthworm populations, reduce water runoff and soil erosion (Smith et al., 2008; Mazzoncini et al., 2011). However, the selection of the most suitable species of cover crop is crucial for the competition with the main crop (Smith et al., 2008; Travlos, 2010).
Limited data are available regarding the performance of several cover crops against invasive and herbicide-resistant weeds under Mediterranean conditions. Therefore, the main objective of this study was to evaluate the efficacy of four cover crops on the suppression of a glyphosate-resistant biotype of the invasive *C. albida*.

MATERIALS AND METHODS

A field experiment was carried out in an olive orchard (cv. Kalamon) in Etoliko region, in western Greece (Latitude: 38°29′39.39″ N, Longitude: 21°17′49.75″ E, Altitude: 13 m above sea level) from February to June 2013. The experiment was established as a randomized complete design with four replicates and a plot size of 6 m^2. The cover crops were *Lolium multiflorum*, *L. perenne*, *Festuca arundinacea* and *Trifolium repens*, while there were also some untreated (control) plots. Sowing of cover crops was performed on 4^{th} of February, 2013. The mean monthly temperature during the experimental period was ranged from 10.4 to 21.6 °C (February and May, respectively). Precipitation was highest on February (167.2 mm) and lowest on June (31.8 mm).
Visual estimations of the soil coverage in the several plots were conducted at 15, 30, 45, 60, 75 and 90 days after sowing (DAS). The weed flora comprised mainly of the invasive *C. albida,* but also a few *Papaver rhoeas, Bromus tectorum, Plantago major*, *Scabiosa lucida*, *Stellaria media*, *and Vicia villosa* also occured. In order to evaluate the weed suppressive ability of the cover crops, plant density of *C. albida* was counted three times within each plot by a 0.1 m^2 frame at 30, 60 and 90 DAS. Measurements of plant height were also made the same days. Data obtained from the field trial were subjected to ANOVA using the randomized block design. Treatment means were separated using Fisher's protected LSD test at a significance level of *P* = 0.05.

Table 1. The physical and chemical properties of the soil in the experimental field

Parameter	Etoliko
Sand (%)	51
Clay (%)	18
Silt (%)	31
Characterization	Sandy loam
pH (1:2 H_2O)	6.6
Total $CaCO_3$ (%)	0
Organic matter (%)	1.5
Nitrogen (g kg^{-1})	0.12
Phosphorus (g kg^{-1})	0.14
Potassium (g kg^{-1})	1.9
Iron (g kg^{-1})	0.37
Electrical conductivity (mS cm^{-1})	0.58

RESULTS AND DISCUSSIONS

ANOVA showed that the density of *Conyza* spp. was significantly (p<0.05) affected by the different cover crops (data not shown). Concerning cover crop coverage, there were some significant differences between the several plants as shown in Figure 1. Noticeable high soil coverage was observed in *L. multiflorum* and *F. arundinacea*, even from 15

DAS. Overall, soil coverage was faster and higher for *L. multiflorum*, followed *by F. arundinacea* and *T. repens*. On the contrary, canopy development for *L. perenne* was rather low reaching only 70 % of the soil at 90 DAS. It is noteworthy that even at 45 DAS, soil coverage for *L. perenne* was 62-72% lower than the other cover crops (Figure 1).
These data are in accordance with previous studies reporting significant differences in the canopy development of several cover crops (Kunz et al., 2017). Such differences could be due to several environmental factors, plant requirements and agronomic practices as stated by Teasdale (1996).
Moreover, it should be taken into account that as stated by Phatak (1992), seeds of species destined for cover crops should germinate at lower temperature than those of common weeds and as showed by our results this is not the case for *L. perenne*.

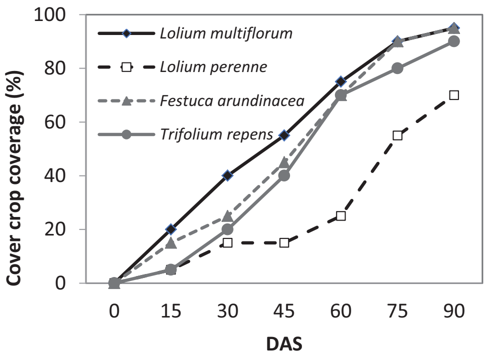

Figure 1. Soil coverage of cover crops over a period of 90 days after sowing (DAS)

Regarding the efficacy of the several cover crops on the emergence and growth of *Conyza* spp. there were also some significant differences between the treatments (Figure 2). In particular, the high density of *C. albida* (up to 81 plants/m^2) confirms the wide dispersal and dominance of this particular species and the high potential for vast seed production and further spread (Travlos and Chachalis, 2010; 2013).
Previous studies have already indicated that invasive plants can form dense monocultures (Petitpierre et al., 2012). *L. multiflorum*, *T. repens* and *F. arundinacea* reduced weed density by 87, 83 and 77%, respectively. The moderate weed suppression observed in *L. perenne* treatment (54% lower plant number compared to the untreated at 60 DAS) was probably due to the slow canopy development of this perennial species.

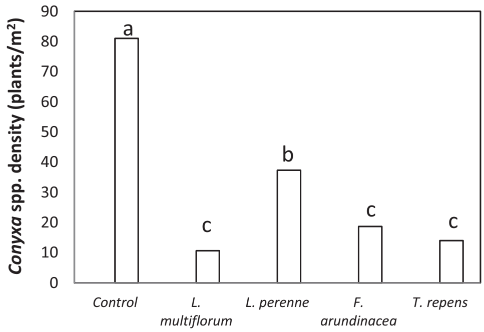

Figure 2. Weed density at the several plots at 60 days after sowing (DAS). Different low case letters indicate significant differences, based on Fisher's LSD test (*P*<0.05)

Another interesting finding is related with the growth of the emerged weeds. As shown in Table 2, there was not any significant difference for the plants' height at 60 DAT in the untreated plots and plots shown with *L. perenne* and *F. arundinacea*.
The explanation for that has to do with the slow development of *L. perenne* and the absence of potential allelopathic effects from *F. arundinacea*. On the other hand, our study revealed that *L. multiflorum* and *T. repens* had a rapid canopy development which resulted not only to the significant reduction of *Conyza* spp. weeds but also to their growth suppression.
The measurement shown in Table 2 is rather indicative; however, it depicts the superiority of the particular cover crops.
This could be attributed to the high competitive ability of the specific species and probably to their allelopathic effects (Macfarlane et al., 1982; San Emeterio et al., 2004). Indeed, the inhibition of neighboring plants by the release of allelochemicals is called allelopathy and it may affect other species directly or indirectly via changes to the soil microbial community (Callaway et al., 2008; Inderjit Wardle et al., 2011).

Table 2. Mean height of *Conyza* spp. plants in the several plots at 60 DAT. Different low case letters indicate significant differences, based on Fisher's LSD test (*P*<0.05)

Cover crop	*Conyza* spp. height (cm)
Control	18 a
L. multiflorum	12 b
L. perenne	22 a
F. arundinacea	17 a
T. repens	9 b

Our results revealed some significant differences between the perennial and the annual species in terms of their establishment, canopy development and weed competition. This is in full agreement with previous studies in which annual species established well and suppressed weeds from the first year, while perennial plants did not provide any early weed suppression but rather during the later years (Miglécz et al. 2015). Nonrhizomatous spread is also desired for cover crops in order to avoid the competition with the main crop (Newenhouse and Dana, 1989). Furthermore, another issue that should be taken into account is that the main competition between the main crop and cover crops is for soil moisture and nutrients (Hatch et al., 2011), with perennial species being more competitive for nutrients as shown by Celette et al. (2009). Unfortunately, many cover crops consume large quantities of water valuable for the main crop (Ruiz-Colmenero et al., 2011) and as stated by Celette et al. (2009) these concerns of sever competition make farmers cautious about cover crops. As indicated in many studies, the most important feature for cover crops is drought resistance (Paine and Harrison, 1993; Leary and DeFrank, 2000).

Consequently, a good idea would be that for the rain fed perennial crops (olive and citrus orchards, vineyards etc) of the Mediterranean regions, annual cover crops which end their growth early in the summer are preferable compared to perennial species which are also present in the summer. Additionally, the presence of glyphosate-resistant *Conyza* ssp. populations is a serious, ongoing phenomenon in various Mediterranean countries, which endangers the adoption of conservation tillage systems and impacts weed management in many crops. Among the most sustainable and promising methods for the management of this problem is the use of cover crops along with other cultural practices and therefore more research is needed towards the optimization of this valuable tool by means of the evaluation of several cover crops and mixtures in a wide range of soil and climatic conditions.

CONCLUSIONS

The results of the present study indicate that specific cover crops could be efficiently used for the control of some invasive and herbicide-resistant weeds, such as *C. albida*. Among the four tested species *L. multiflorum* and *T. repens* had a rapid crop development and significantly reduced weed density and growth. On the other hand, perennial species like *L. perenne* may have poor and slow establishment and therefore are not suitable for weed control from the first year. Among the priorities set in EU Directives is to prevent new introductions or further spread of invasive plants, to promote their early detection and eradication and to manage them. In the case that such species are also herbicide-resistant, the challenge of their management is even bigger, with a clear need for use and integration of all the available practices like cover crops.

REFERENCES

Alpert P., Bone E., Holzapfel C., 2000. Invasiveness, invasibility and the role of environmental stress in the spread of non-native plants. Perspectives in Plant Ecology, Evolution and Systematics 3:52-66.

Bresch C., Mailleret L., Muller M.M., Poncet C., Parolin P., 2013. Invasive plants in the Mediterranean basin: which traits do they share? Journal of Mediterranean Ecology 12:13-19.

Celesti-Grapow L., Alessandrini A., Arrigoni P.V., Assini S., Banfi E., Barni E., Bovio M., Brudu G., Cagiotti M.R., Camarda I., Carli E., Conti F., Del Guacchio E., Domina G., Fascetti S., Galasso G., Gubellini L., Lucchese F., Medagli P., Passalacqua N.G., Peccenini S., Poldini L., Pretto F., Prosser F., Vidali M., Viegi L., Villani M.C., Wilhalm T., Blasi C., 2010. Non-native flora of Italy: Species distribution and threats. Plant Biosystems 144:12-28.

Celette F., Findeling A., Gary C., 2009. Competition for nitrogen in an unfertilized intercropping system: the case of an association of grapevine and grass cover in a Mediterranean climate. European Journal of Agronomy 30:41-51.

Gray A.J., 1986. Do invading species have definable genetic characteristics? Philosophical Transactions of the Royal Society of London B 314:655-674.

Guerra B., Steenwerth K., 2012. Influence of floor management technique on grapevines growth, disease pressure, and juice and wine composition: A review. American Journal of Enology & Viticulture 64:149-164.

Hatch T.A., Hickey C.C., Wolf T.K., 2011. Cover crop, rootstock and root restriction regulate vegetative growth of Cabernet Sauvignon in a humid environment. American Journal of Enology & Viticulture 62:298-311.

Inderjit Wardle D.A., Karban R., Callaway R.M., 2011. The ecosystem and evolutionary contexts of allelopathy. Trends in Ecology & Evolution 26:655-662.

Kriticos D.J., Sutherst R.W., Brown J.R., Adkins S.A., Maywald G.F, 2003. Climate change and biotic invasions: a case history of a tropical woody vine. Biological Invasions 5:145-165.

Kunz C., Sturm D.J., Sökefeld M., Gerhards R., 2017. Weed suppression and early sugar beet development under different cover crop mulches. Plant Protection Science 53-59.

Lavorel S., Canadell J., Rambal S., Terradas J., 1998. Mediterranean terrestrial ecosystems: research priorities on global change effects. Global Ecology and Biogeography 7:157-166.

Leary J., DeFrank J., 2000. Living mulches for organic farming systems. HortTechnology 10:692-698.

Macfarlane M.J., Scott D., Jarvis P., 1982. Allelopathic effects of white clover 1. Germination and chemical bioassay. New Zealand Journal of Agricultural Research 25:503-510.

Mazzoncini M., Sapkota T.B., Barberi P., Antichi D., Risaliti R., 2011. Long-term effect of tillage, nitrogen fertilization and cover crops on soil organic carbon and total nitrogen content. Soil Tillage Research 114:165-174.

Miglécz T., Valko O., Torok P., Deak B., Kelemen A., Donko A., Drexler D, Tothmeresz B., 2015. Establishment of three cover crop mixtures in vineyards. Scientia Horticulturae 197:117-123.

Newenhouse A.C., Dana M.N., 1989. Grass living mulch for stawberries. Journal of American Society of Horticultural Science 114:859-862.

Paine L.K., Harrison H., 1993. The historical roots of living mulch and related practices. HortTechnology 3:137-143.

Petitpierre B., Kueffer C., Broennimann O., Randin C., Daehler C., Guisan A., 2012. Climatic niche shifts are rare among terrestrial plant invaders. Science 335:1344-1348.

Phatak S.C, 1992. An integrated sustainable vegetable production system. HortScience 27:738-741.

Reichard S., White P., 2001. Horticulture as a pathway of invasive plant introductions in the United States. Bioscience 51:103-113.

Richardson D.M., Allsopp N, D'Antonio C.M., Milton S.J., Rejmanek M., 2000. Plant invasions – the role of mutualism. Biological Reviews 75:65-93.

Ruiz-Colmenero M., Bienes R., Eldridge D.J., Marques M.J., 2013. Vegetation cover reduces erosion and enhances soil organic carbon in a vineyard in the central Spain. Catena 104:153-160.

San Emeterio L., Arroyo A., Canals R.M., 2004. Allelopathic potential of *Lolium rigidum* Gaud. on the early growth of three associated pasture species. Grass and Forage Science 59:107-112.

Sanz-Elorza M., Dana E.D., Sobrino E., 2006. Invasibility of an island area in NE Spain by alien plants. Acta Oecologica 29:114-122.

Speziale K.L., Ezcurra C., 2011. Patterns of alien plant invasions in northwestern Patagonia, Argentina. Journal of Arid Environments 75:890-897.

Teasdale J.R., 1996. Contribution of cover crops to weed management in sustainable agricultural systems. Journal of Production Agriculture 9:475-479.

Thebaud C., Abbott R.J., 1995. Characterization of invasive *Conyza* species (*Asteraceae*) in Europe: quantitative trait and isozyme analysis. American Journal of Botany 82:360-368.

Travlos I.S., 2010. Legumes as cover crops or components of intercropping systems and their effects on weed populations and crop productivity. *In: Advances in Food Science and Technology* (Ed. A.J. Greco), Vol.1, pp. 151–164. Nova Science Publishers, Inc., Hauppauge, New York.

Travlos I.S., 2013. Responses of invasive silverleaf nightshade *(Solanum elaeagnifolium Cav.)* populations to varying soil water availability. Phytoparasitica 43:41-48.

Travlos I.S., Chachalis D., 2010. Glyphosate-resistant hairy fleabane (*Conyza bonariensis*) is reported in Greece. Weed Technology 24:569-573.

Travlos I.S., Chachalis D., 2012. Relative competitiveness of glyphosate-resistant and glyphosate-susceptible populations of hairy fleabane (*Conyza bonariensis* L.). Journal of Pest Science 86:345-351.

Travlos I.S., Chachalis D., 2013. Assessment of glyphosate-resistant horseweed (*Conyza canadensis* L. Cronq.) and fleabane (*Conyza albida* Willd. ex Spreng) populations from perennial crops in Greece. International Journal of Plant Production 7:665-676.

Vilà M., Siamantziouras A.S.D., Brundu G., Camarda I., Lambdon P., Medail F., Moragues E., Suehs C.M., Traveset A., Troumbis A.Y., Hulme P.E., 2008. Widespread resistance of Mediterranean island ecosystems to the establishment of three alien species. Diversity and Distributions 14:839-851.

Williams D.G., Mack R.N., Black R.A., 1995. Ecophysiology of introduced *Pennisetum setaceum* on Hawaii–the role of phenotypic plasticity. Ecology 76:1569-1580.

Williamson M., 1996. Biological Invasions. Chapman and Hall, London

Yannitsaros A., 1997. Species of *Conyza* Less.in Greece. P. 22 in Proceedings of 10th Hellenic Weed Science Conference, Thessaloniki, December, 16-18.

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RESEARCH ABOUT EXPLORING OF NEW WHEAT AND RYE GERMPLASM FROM TRANSYLVANIA TO BREEDING FOR PRODUCTIVITY, IN BRAILA PLAIN CONDITIONS

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Abstract

The paper presents the results of research caring out in the years 2014 and 2015 who were tested seven local populations of Transylvania, in the climatic conditions of Braila Plain. The seed was received from the Suceava Gene Bank, with the purpose of studying their potential in terms of regional production, breeding, acclimatization and hybridization use in breeding the varieties zoned. We studied the coincidence both flowering and morphology in correlation with yields obtained. They were also made some hybridization, so that in the coming years to study characters of the F1 generation. Productions were between 3733 kg/ha (A3) and 7952 kg/ha (A7) for wheat and between 3524 kg/ha (C1) and 6807 kg/ha (C3), the best results were recorded at variants A7 (Baisoara 1) – 7952 kg/ha and A1 (Vima Mare) – 6792 kg/ha for wheat and at variants C3 (SVGB-5106) – 6807 kg/ha and 6 (SVGB-16510) – 6373 kg/ha for rye. Thousand grain mass, the highest values were recorded for variant A1 (Vima Mare) – 45.73 g wheat and C4 variant (SVGB-16116) – 36.04 g, while the highest values of hectolitre mass were recorded at variant A6 (Baisoara) – 78.2 kg/hl for wheat and at variant C4 (SVGB-16116) – 69.3 kg/ha for rye.

***Key words**: wheat, rye, breeding, production.*

INTRODUCTION

Wheat is the most important cereal, providing food to more than 40% of the population, but is used in animal feed, due to much higher nutritional value than maize. Also, rye is increasingly appreciated bakery, especially when mixed with wheat, and lately tends to introduce new varieties of triticale, which may become an alternative wheat variety for baking (Nădășan, 2014). From the genetic standpoint, the production capacity in wheat, rye and triticale is a complex character, strongly influenced by environmental conditions and having a reduced stability. Genetic determinism of production capacity is polygenic type, effects additivity dominant super-dominant or epistasis, which involve inclusive and modificatory oligo-genes or gene amplification effect, inhibiting or reducing (Madoșă, 2005). We can say that genetic determinism form two components of production capacity, one morphological and physiological another, which are influenced by environmental conditions at a rate of 50-60%. It is therefore very important genetic stability of the components production, the TGV characters with high stability, density and number of spikelets on the ear. A stable middle ear length shows, no. of grain from the ear, and the smallest number of genetic stability is represented by fertile tillers grain weight per ear, number of grains per ear and number of grains in the plant. All these characters were studied in the 7 local populations of wheat and seven rye local populations in the crop years 2014-2015 and 2015-2016.

In the same time, there were performed hybridizations using inter- and intra- parent material that presented coincidence on the blossoming, and seeds obtained represent biological material of F1 generation to study next year. The research objectives were: O1-study of biological material which comes from the north and west of the country on regional adaptability to climatic conditions; O2 - Observing the flowering coincidence and choice of the parents for hybridization; O3 - Making hybridization between plants elite, chosen from each experimental variant; O4 - Evaluation of production; O5 - Keeping hybrid seeds for later study obtained hybrids.

Requirements of a new variety of wheat for conditions of our country, are: maximum production capacity - over 10 t/ha, the high protein content - over 15-17%, dry gluten content - over 10 - 12%, compared flour/bread - 1.00/1.35, active resistance to climatic stresses and phytopathogenic, intensification favourable reaction conditions (Leonte, 2010).

MATERIALS AND METHODS

The biological material used was represented by seven local populations of wheat and seven local populations of rye, purchased from Gene Bank of Suceava and 4 registered varieties of wheat, a variety of barley and two varieties of triticale, for comparison and testing by hybridization (Table 1).

Table 1. Biological material used in experience and experimental factors

Factor A		Factor B		Factor C	
A1	VIMA MARE	B1	SVGB-10264	C1	LITERA
A2	ACMARIU 1	B2	SVGB-16113	C2	BOEMA
A3	AGRIS	B3	SVGB-5106	C3	IZVOR
A4	VALEA BRADULUI 1	B4	SVGB-16116	C4	GLOSA
A5	SARMAS 1	B5	SVGB-5093	C5	CARDINAL
A6	BAISOARA	B6	SVGB-16510	C6	ODA
A7	BAISOARA 1	B7	SVGB-16770	C7	STIL

Experience occurred in crop years 2014 - 2015 and 2015 - 2016, with basic applied technologies. There were made observations about rising, density, number of fertile tillees, plant height, ear length, no. spikelets/ear, no. kernel/ear, no. kernels/spikelet, no. kernels/plant, grains mass/ear, grains weight/plant, production at standard humidity of 14%, the weight of a thousand grains and hectolitre mass.

RESULTS AND DISCUSSIONS

Number of fertile tillees per plant has shown that local populations of wheat from Transylvania have a degree of tillees much higher than varieties approved (Figure 1), the highest number of tillees on the plant being registered at A2 variant (Acmariu 1) with four tillees/plant, followed by a solution of A3 (Agris) with three tillees/plant, and the variant A1 (Vima Mare) with two tillees/plant.

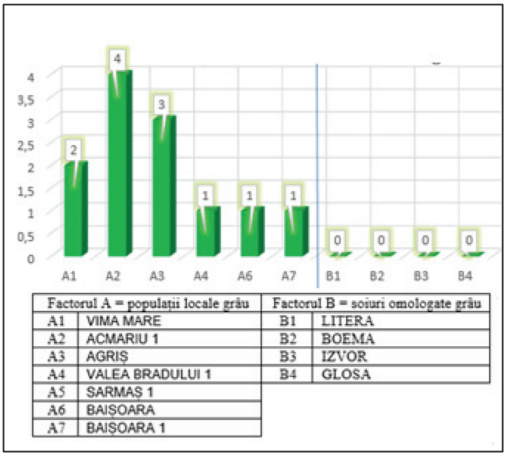


Figure 1. The graph for the average number of fertile tillees at local populations and approved varieties of winter wheat and rye

The highest average number of fertile tillees was obtained at variant C1 (SVGB- 10264) - 7 brothers/plant followed by variant C7 (SVGB-16770) - 6 tillees/plant and variant C5 (SVGB-5093) 5 tillees/plant (Figure 2).

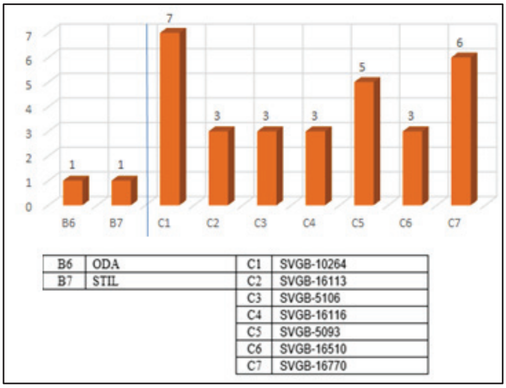
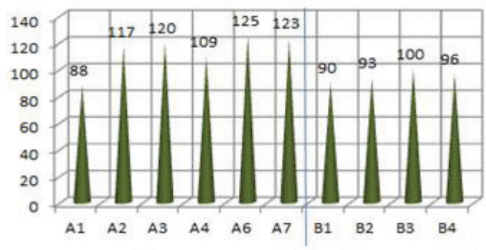


Figure 2. The graph for the average number of fertile tillees per plant at local populations of rye and triticale varieties

For the average height of the plant at winter wheat, the highest values were recorded throughout the local populations in Transylvania, compared to varieties zoned, the highest values being the variant A6 (Baisoara)

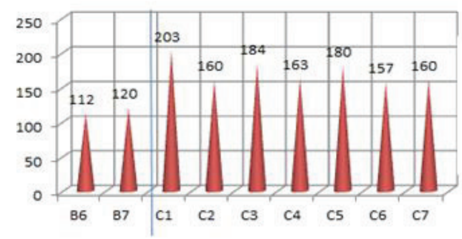
125 cm, followed in descending order by variant A7 (Baisoara 1) – 123 cm, variant A3 (Agris) – 120 cm, and variant A2 (Acmariu 1) - 117 cm (Figure 3).



Factorul A = populații locale grâu		Factorul B = soiuri omologate grâu	
A1	VIMA MARE	B1	LITERA
A2	ACMARIU 1	B2	BOEMA
A3	AGRIȘ	B3	IZVOR
A4	VALEA BRADULUI 1	B4	GLOSA
A5	SARMAȘ 1		
A6	BAIȘOARA		
A7	BAIȘOARA 1		

Figure 3. Height average of plant wheat at local populations compared to zoned varieties approved

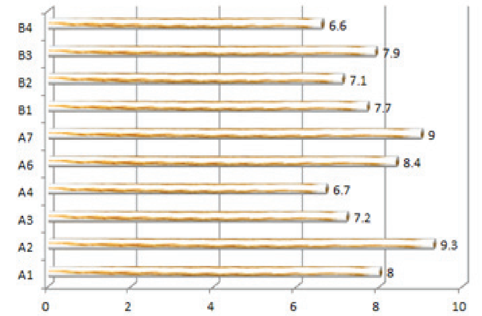
Regarding the average height of the rye and triticale plants studied, the highest value was recorded in variant C1 (SVGB - 10264) - 203cm, followed in descending order by variant C3 (SVGB-5106) – 184 cm and variant C5 (SVGB-5093) - 180 cm. The variant with the lowest height was C6 (SVGB-16510) – 157 cm (Figure 4).



B6	ODA	C1	SVGB-10264
B7	STIL	C2	SVGB-16113
		C3	SVGB-5106
		C4	SVGB-16116
		C5	SVGB-5093
		C6	SVGB-16510
		C7	SVGB-16770

Figure 4. Average height of local plant populations of rye and triticale varieties

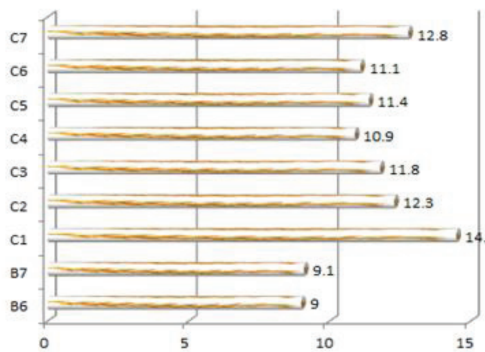
Determinations regarding the average length of the matures ear within local populations of wheat in Transylvania, compared to approved zoned varieties, showed that local populations are potentially very high, the highest values being recorded of variants A2 (Acmariu 1) – 9.3 cm, followed by the A7 variant (Baisoara 1) – 9 cm and A6 (Baisoara) – 8.4 cm (Figure 5).



A1	VIMA MARE	B1	LITERA
A2	ACMARIU 1	B2	BOEMA
A3	AGRIȘ	B3	IZVOR
A4	VALEA BRADULUI 1	B4	GLOSA
A5	SARMAȘ 1		
A6	BAIȘOARA		
A7	BAIȘOARA 1		

Figure 5. Average length of the ear to local populations compared with approved wheat varieties

For rye, the highest average length of the ear was registered at variant C1 (SVGB-10264) – 14 cm, followed by C7 (SVGB-16770) – 12.8 cm and C2 (SVGB-16113) – 12.3 cm (Figure 6).



B6	ODA	C1	SVGB-10264
B7	STIL	C2	SVGB-16113
		C3	SVGB-5106
		C4	SVGB-16116
		C5	SVGB-5093
		C6	SVGB-16510
		C7	SVGB-16770

Figure 6. The graph of the average length of the ear to local populations of rye and triticale varieties

Measurements on the number of spikelets at local populations wheat studied ranged from the minimum of 14 (variant A1 - Vima Mare) and a maximum of 19 (variant A7 - Baisoara 1), while the varieties approved zoned value in the spikelets number was between 13.3 B4 (Glosa) and 14.7 (the letter B1 - Litera and B3 - Izvor) (Figure 7).

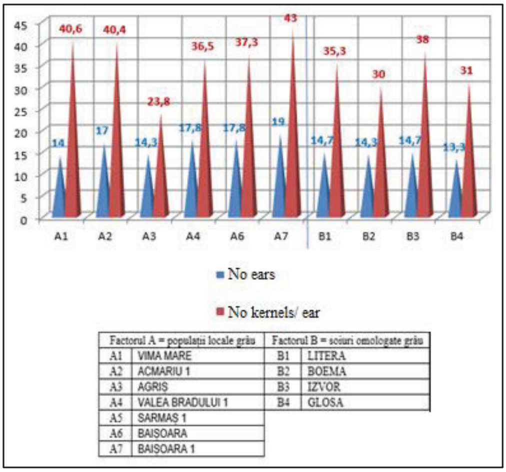


Figure 7. Average values of ear number and kernels number per ear of the local populations of wheat, compared with approved varieties zoned

In the same time, the average number of grains per ear maximum was 45.0, the solution A7 (Baisoara 1), followed in descending order of variant A1 (Vima Mare - 40.6) and A2 variant (Acmariu 1 to 40.4) while the varieties approved, the maximum on the number of grains per spikelets was obtained at B3 variant (variety Izvor – 38.0), followed in descending order of variants B1 (variety Litera - 35.3) and B4 (variety Glosa - 31).

At rye, the highest number of spikelets was recorded in variant C1 (SVGB-10264) - 35.9, followed by C2 variant (SVGB-16113) - 33.8 and C7 variant (SVGB-16770) - 31.9. The number of kernels per ear largest was recorded at C3 solution (SVGB-5106) - 57.5, followed by C7 variants (SVGB-16770) - 55.4 and C6 (SVGB - 16770) - 55 (Figure 8).

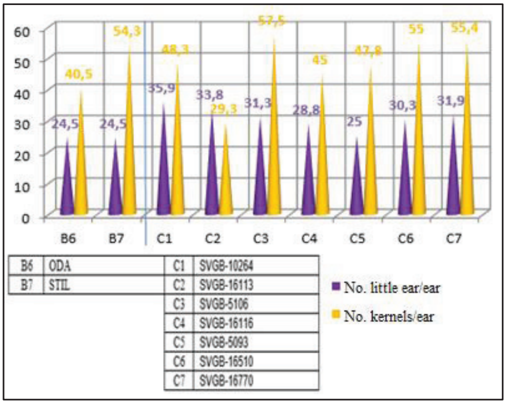


Figure 8. The number of kernels per ear

Measurements on the average number of grains per plant local populations of wheat, compared to the approved varieties, emphasized that all local wheat populations from Transylvania are more productive than approved varieties zoned due to the increased number of siblings fertile, the highest value being 202 kernels/plant to variant A2 (Acmariu 1), followed by A1 variant (Vima Mare) - 122 kernels/plant and A3 (Agris) - 95 kernels/plant (Figure 9).

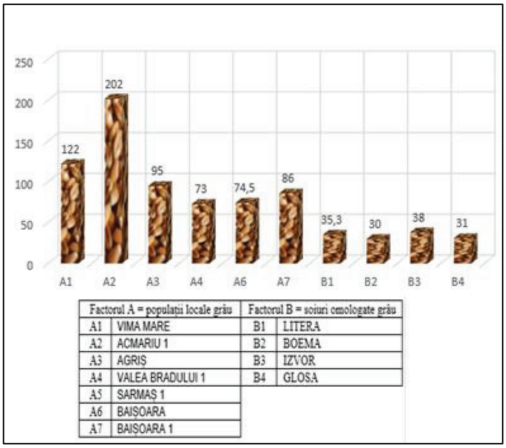


Figure 9. The graph of the average number of kernels / plant at local populations wheat from Transylvania, compared to zoned varieties approved

The highest values of the average number of kernels per plant at rye were obtained by C7 variant (SVGB - 16770) - 388 kernels/pl. and C1 (SVGB - 10264) - 386 kernels/plant (Figure 10).

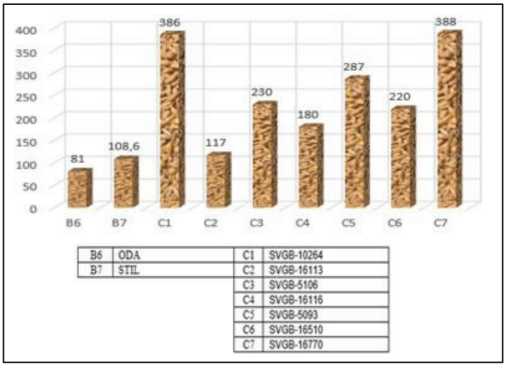


Figure 10. The graph of the average number of kernels per plant at approved varieties of triticale and rye local populations in Transylvania

Regarding the average weight of grains per ear and plant wheat the experimental variations, the highest values were obtained variants A1 (Vima Mare) – 2.202 g/spike and 6.606 g/plant followed by A2 variant (Acmariu 1) – 1.536 g/spike and 7.684 g/plant (Figure 11), while rye experimental variants, the highest values were obtained C7 variants (SVGB-16770) – 2.063 g/spike and 14.444 g/plant and C1 (SVGB-10264) - with 1.333 g/spike and 10.67 g/plant (Figure 12).

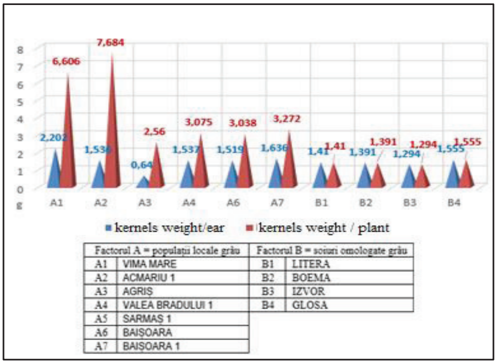


Figure 11. Graph for the average weight of kernels per ear and plant at wheat local populations from Transylvania comparative to zoned varieties

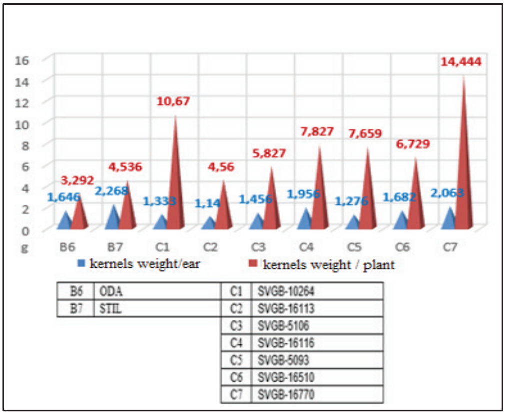


Figure 12. The graph of the average kernels mass per ear and per plant for varieties of triticale and rye local populations from Transylvania

The highest yields experimental variants of wheat, compared with the average experience were obtained variants A7 (Baisoara 1) - 7952 kg/ha and A1 (Vima Mare) - 6792 kg/ha, while varieties approved zoned, the highest production was achieved by Glosa variety - 6989 kg/ha (Figure 13).

Experimental variants rye highest production compared with the average experience was obtained experimental variant C3 (SVGB - 5106) – 6807 kg/ha, followed by the variety of triticale Oda - 6695 kg/ha and the local population C6 (SVGB - 16510) - 6373 kg/ha (Figure 14).

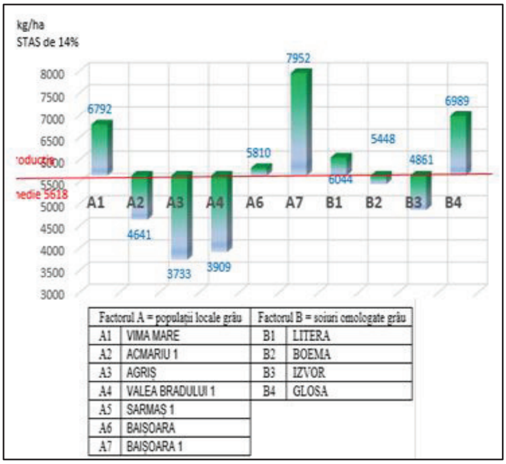


Figure 13. Average yield of wheat obtained experimental variant, compared to the zoned varieties

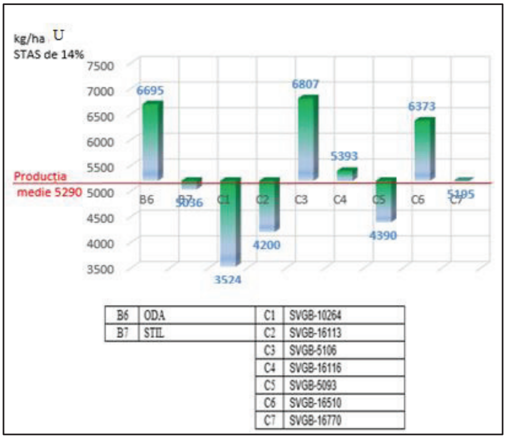


Figure 14. Average yield obtained in experimental variants of triticale and rye, compared with the average of experience

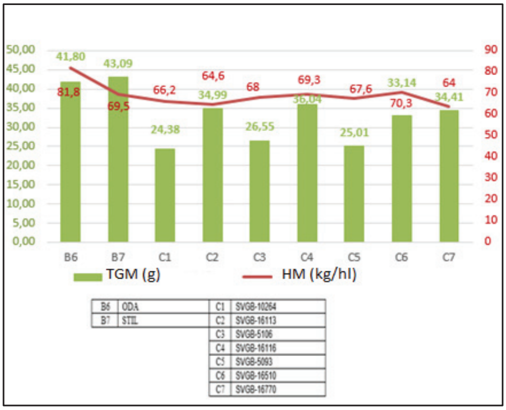


Figure 16. The graph of the average values of thousand grain weight (TGW) and hectolitre mass (HM) obtained by local populations rye from Transylvania and triticale varieties zoned

The determinations of thousand grains mass showed that local populations A1 (Vima Mare) 45.73 g and A3 (gooseberry) 43.99 g have the highest values compared to approved varieties zoned, while determinations of the hectolitre mass recorded higher values at zoned approved varieties, the highest value being the variety Glosa (82.2 kg/hl), and from local populations of wheat, the highest value of hectolitre mass was obtained by A6 variant (Baisoara) (78.2 kg/hl) (Figure 15).

For rye, the higher thousand grain weight and hectolitre mass was obtained by C4 variant (SVGB - 16116) 36.04 g, respectively 69.3 kg/hl (Figure 16).

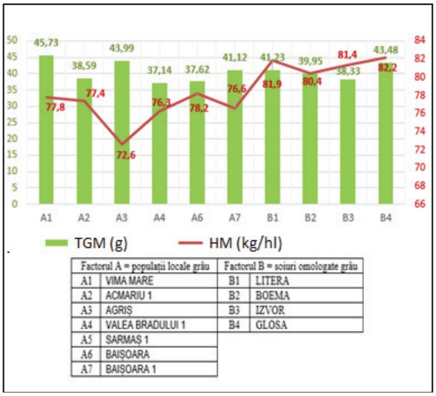


Figure 15. The graph of the average values of a thousand grain weight (TGW) and hectolitre mass (HM) of local populations wheat from Transylvania, compared to zoned varieties

CONCLUSIONS

Local populations of wheat and rye in Transylvania is a very precious biological material from genetically, standing out elements of productivity in wheat variants A7, A1, A2 and A6, and the rye variants C3, C6 and C4. The objectives of improving both the wheat and the rye is pursuing a complex, for increasing production capacity, limiting environmental conditions, with stability harvest mechanization technology adapting and improving the quality of the harvest.

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REFERENCES

Leonte C., Simioniuc D., Cretu L., Tardea Gh., 2010. Genetica si Ameliorarea plantelor.

Madoşă E., 2000. Ameliorarea plantelor agricole, Editura Marineasa, Timişoara.

https://health.gov/dietaryguidelines/2015/resources/2015-2020_Dietary_Guidelines.pdf

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EFFECTS OF NITROGEN FERTILIZATION ON MINERAL CONTENT OF SMOOTH BROMEGRASS (*Bromus inermis* Leyss.)

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Abstract

This study aimed to determine the effects of five nitrogen doses (0, 40, 80, 120 and 160 kg.ha^{-1}) on mineral content of smooth bromegrass (Bromus inermis Leyss.). Nitrogen, phosphorus, potassium, calcium, magnesium and tetany ratio were determined in this research. Nitrogen rates significantly affected all components determined in smooth bromegrass. Nitrogen applications increased N, P, K and tetany ratio but decreased Ca and Mg concentrations. The highest N, P, K concentrations and tetany ratio were obtained from 160 kg ha^{-1} N treatment, while the lowest values were obtained from control treatment.

***Key words**: calcium, nitrogen, smooth bromegrass, tetany ratio.*

INTRODUCTION

Smooth bromegrass (*Bromus inermis* Leyss.) is a high-yielding grass but requires longer recovery periods than other grasses. It is best adapted to well drained soils and is an excellent choice for drought prone areas (Undersander et al., 1996). Because of its highly developed root system, smooth bromegrass is resistant to temperature extremes and drought. It grows best on deep, well-drained silt or clay loam but may also establish itself in sandier soils.

Grasses need nitrogen more than many plant groups need it. Organic matter and nitrogen deficiency could be removed by fertilization in agricultural areas including dry farming in Turkey (Serin et al., 1999; Koc et al., 2004). The nutrient contents of the forage have an important role in animal feeding. The factors influencing the nutritive value of forage are many, and the degree to which they are interrelated may vary considerably from one area to another. These factors may include, alone or in combination, plant type, climate, season, weather, soil type and fertility, soil moisture, leaf to stem ratio, and physiological and morphological characteristics, and may change depending on whether the plants are annuals, perennials, grasses or legumes (Turk et al., 2009).

The most important disease for livestock is grass tetany caused by mineral matter imbalance in feeds. N and K fertilizing used to enhance rangeland yield has increased the risk for tetany by increasing K/Ca+Mg ratio up to 2.2 (Elkins et al., 1977). Because, there is an antagonistic relationship between K and Mg. The yield decrease or mortality in livestock fed by feeds which are rich in K can be observed due to the fact that Mg is blocked. The concentrations of Ca, Mg and K are important for ruminants and must be higher than 3.1, 1 and 6.5 g kg^{-1} for beef cattle, respectively (NRC, 1984).

The objective of this research was to determine the effects of nitrogen doses on mineral content of smooth bromegrass.

MATERIALS AND METHODS

The research was conducted at Isparta (37°45′N, 30° 33′E, altitude 1035 m) located in the Mediterranean region of Turkey, between 2014 and 2016 years. The major soil characteristics, based on the method described by Rowell (1996) were as follows: the soil texture was clay-loam (clay: 31.2%, silt: 45.1%, sand:23.7%); organic matter was 1.1% by the Walkley-Black method; total salt was 0.3%; lime was 7%;sulphur was 12 mg kg^{-1}; extractable P by 0.5N $NaHCO_3$ extraction was 3.3 mg kg^{-1}; exchangeable K by 1N NH_4OAc was 119 mg kg^{-1}; pH was 7.1 in soil saturation extract. Soil type was a calcareous fulvisol. Total precipitation was 177 mm in 2015 (March–June) and 210 mm in 2016. The long-term average is 208 mm. Average temperature was 13.9°C in 2015 and 12.7°C in 2016. The long- term average is 12.8°C.

The experiments were evaluated in a randomized complete block design with three replications. Sowing was done by hand on 15 March in 2014. Seeding rates were 25 kg ha^{-1}. Plot sizes were 2.1x 5 m = 10.5 m^2. Smooth bromegrass fertilized at the rates of 0, 40, 80, 120 and 160 kg N ha^{-1}. Calcium ammonium nitrate 26% was used as fertilizer. Herbage was not harvested during the growing season of 2014 due to the establishment year. All plots had been harvested only once every year (50% flowering stage of smooth bromegrass). Samples taken from each plot were dried at room temperature then dried in an oven at 65°C till they reached constant weight.

After cooling and weighing, the samples were ground for mineral contents analyses. Nitrogen content was calculated by the Kjeldahl method (Kacar and İnal, 2008); K, Ca and Mg contents of samples were determined using an atomic spectrophotometer after digesting the samples with $HClO_4$:HNO_3 (1:4); P content was determined by vanadomolybdophosphoric yellow colour method (Kacar and İnal 2008). Tetany ratios (K: (Ca + Mg)) were calculated on a milliequivalent basis (Cherney and Marten 1982).

The data were analyzed together using the Proc GLM (SAS 1998). Means were separated by LSD at the 5 % level of significance.

RESULTS AND DISCUSSIONS

The results of variance analysis showed that N, P, K, Ca, Mg and tetany ratios in smooth bromegrass were influenced significantly by nitrogen treatments (Table 1).

Table 1. Results of Analysis of Variance Traits Determined

	df	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium	Tetany ratio
Years	1	*	ns	ns	ns	ns	ns
Block	2	*	ns	*	ns	ns	ns
Nitrogen	4	**	**	**	*	**	**
N x Year intr.	4	ns	ns	ns	ns	ns	Ns

df: degrees of freedom, *P<0.05 and **P<0.01.

Increasing N fertilization rates resulted in an increase in N concentration of smooth bromegrass (Table 2). 160 kg ha^{-1} nitrogen treatments had the highest N concentration (19.23 g kg^{-1}) followed by the 120 kg ha^{-1} nitrogen dose (17.78 g kg^{-1}). The lowest N concentration (14.32 g kg^{-1}) was obtained from control treatment. Nitrogen content of forage is one of the most important criteria for forage quality evaluation (Holechek et al., 1989; Vogel et al., 1993). These results are in agreement with those reported by Jacobsen et al. (1996) and McCaughey and Simons (1998).

Table 2. The N, P, K, Ca, Mg concentrations and tetany ratios of smooth bromegrass at different nitrogen doses

Nitrogen fertilization	N (g kg^{-1})	P (g kg^{-1})	K (g kg^{-1})	Ca (g kg^{-1})	Mg (g kg^{-1})	Tetany ratio
0	14.32 e	3.18 d	13.12 e	5.45 a	4.55 a	1.31 e
40	15.81 d	3.37 c	14.89 d	4.69 b	4.22 b	1.67 d
80	16.53 c	3.62 b	16.11 c	4.62 b	4.08 c	1.85 c
120	17.78 b	3.79 a	17.34 b	4.63 b	3.85 d	2.04 b
160	19.23 a	3.82 a	18.41 a	4.49 c	3.62 e	2.27 a

Application of N fertilization increased phosphorus concentration from 3.18 g kg^{-1} to 3.82 g kg^{-1} in present study. Similar results were reported by Albayrak and Türk (2011).

Nitrogen treatments significantly increased K concentration of smooth bromegrass (Table 2). K concentration in control plots was 13.12 g kg^{-1}, while it increased up 18.41 g kg^{-1} in 160 kg ha^{-1} N treatments. All treatments had higher K concentration than recommended daily requirement (6.5 g kg^{-1}) for beef cattle (NRC, 1984).

The highest Ca concentration (5.45 g kg^{-1}) was obtained from control treatments, while the lowest Ca concentration (4.49 g kg^{-1}) was obtained from 160 kg ha^{-1} N treatments. All fertilizer treatments exceeded the Ca concentration of 3.1 $g.kg^{-1}$ recommended for beef cattle (NRC, 1984). Similar results were reported by Albayrak and Türk (2011).

The highest Mg concentration (4.55 g kg^{-1}) was obtained from control treatments, while the lowest Mg concentration (3.62 g kg^{-1}) was obtained from 160 kg ha^{-1} N treatments. A linear decrease in Mg concentration was seen with N fertilization rates, as has been reported in other studies (Smith, 1975; Rominger et al., 1976; James et al., 1995; Ball et al., 2001). The determined Mg level in this study was higher than the recommended daily requirements of 1 g kg^{-1} for beef cattle (NRC, 1984).

Tetany values, changed from 1.31 to 2.27 with increasing N rates. Forage and animal scientists are aware of the importance of the concentrations of Ca, Mg, K and K/(Ca+Mg) ratio in diets for ruminants. A ratio between K and Ca+Mg of more than 2.2, expressed on an equivalent basis, has been considered to be an indicator of potential grass tetany (Kemp and t'Hart, 1957; Ward, 1966; Elkins et al., 1977; Mayland and Grunes, 1979). Kidambi et al. (1989) reported that both Ca and Mg had negative association with K in grasses. Tetany (K/Ca+Mg) is associated with Mg deficiency in the blood. There is an antagonistic relationship between K and Mg. In present study, means of K/(Ca+Mg) ratio exceeded the critical 2.2 level in 160 kg ha^{-1} N treatments. The ratios in other nitrogen treatments were less than the critical level. Mayland and Hankins (2001) reported that high N and K doses increases the risk of contracting grass tetany in early spring. Grass tetany causes yield decrease or mortality in livestock. The application of Mg fertilizer can decrease risk of grass tetany (Rayburn, 2005).

CONCLUSIONS

Smooth bromegrass has adequate mineral content for ruminant animal requirements for production in the Mediterranean region of Turkey. Nitrogen applications increased N, P, K and tetany ratio but decreased Ca and Mg concentrations. The highest N, P, K concentrations and tetany ratio were obtained from 160 kg ha^{-1} N treatment, while the lowest values were obtained from control treatment. The highest Ca and Mg concentrations were obtained from control treatment, while the lowest values were obtained from 160 kg ha^{-1} N treatment.

REFERENCES

Albayrak S., Turk M., 2011. Effects of fertilization on forage yield and quality of crested wheatgrass (*Agropyron cristatum* L. Gaertn.). Bulg. J. Agric. Sci., 17: 642-648.

Ball D.M., Collins M., Lacefield G.D., Martin N.P., Mertens D.A., Olson K.E., Putnam D.H., Undersander D.J., Wolf M.W., 2001. Understanding Forage Quality, American Farm Bureau Federation Publication, 1-01, Park Ridge, IL.

Cherney J.H., Marten G.C., 1982. Small grain crop forage potential: I. Biological and chemical determinants of quality and yield. *Crop Science*, 22: 227-231.

Elkins C.B., Haaland R.L., Honeland C.S., 1977. Tetany potential of forage species as affected by soil oxygen. Proceedings of the XIII International Grassland Congress, 18-21 May. Pp. 1505-1507.

Holechek J.L., Estell R.E., Kuykendall C.B., Valdez R., Cardenas M., Hernandez C.N., 1989. Seeded wheatgrass yield and nutritive quality on New Mexico big sagebrush range. Journal of Range Management, 42: 118-122.

Jacobsen J.S., Lorbeer S.H., Houlton H.A.R., Carlson G.R., 1996. Nitrogen fertilization of dry land grasses in the Northern Great Plains. Journal of Range Management,49: 340-345.

James D.W., Hurst C.J., Tindall T.A., 1995. Alfalfa cultivar response to phosphorus and potassium deficiency: Elemental composition of the herbage. *J. Plant Nutr.*, 18, 2447.

Kacar B., Inal A., 2008. Bitki Analizleri. *Nobel Yayınları* . Ankara, 892p.

Kemp A., T'Hart M.L., 1957. Grass tetany in grazing milking cows. *Neth. J. Agric. Sci.*, 54, 17.

Kidambi S.P., Matches A.G., Gricgs T.C., 1989. Variability for Ca, Mg, K, Cu, Zn, and K/(Ca +Mg) ratio among 3 wheat grasses and sainfoin on the southern high plains. *Journal of Range Management,* 42: 316-322.

Koç A., Gokkus A., Tan M., Comakli B., Serin Y., 2004. Performance of tall fescue and lucerne-tall fescue mixtures in highlands of Turkey. New Zealand J. of Agric. Research, 47: 61-65.

Mayland H.F., Grunes D.L., 1974. Shade-induced grass-tetany prone chemical changes in Agropyron desortorum and Elymus cinereus. J. Range Manage., 27, 198-201.

Mayland H.F., Hankins J.L., 2001. Mineral Imbalances and Animal Health: A Management Puzzle Anti-Quality Factors in Eangeland and Pastureland Forages, Idaho Forest, Wildlife and Range Experiment Station University of Idaho, Moscow, ID 83844-1130, pp. 54-62.

McCaughey W.P., Simons R.G., 1998. Harvest management and N-fertilization effects on protein yield, protein content and nitrogen use efficiency of smooth bromegrass, crested wheatgrass and meadow bromegrass. Canadian Journal of Plant Science, 78: 281-287.

NRC, 1984. Nutrient Requirements of Domestic Animals, No. 4, Nutrient Requirements of Beef Cattle, Washington : NAS : NRC, revised edn. 6.

Rayburn E.B., 2005. Forage Management, West Virginia University, Extension Service.

Rominger R.S., Smith D., Peterson L.A., 1976. Yield and chemical composition of alfalfa as influenced by high rates of K topdressed as KCl and K2SO4. Agron. J. 68:573–577.

Rowell D.R., 1996. Soil science: methods and applications. Harlow, Longman.

SAS Institute, 1998. INC SAS/STAT users guide release 7.0. Cary, NC, USA.

Serin Y., M. Tan A., Koc and A. Gokkus, 1999. The effect of N applied at different seasons and doses on seed yield and some yield components of smooth bromegrass (*Bromus inermis* Leyss.) and relationships among the characteristics. Turkish J. of Agric. and Forestry, 23:257-264.

Smith D., 1975. Effects of potassium topdressing a low fertility silt loam soil on alfalfa herbage yield and composition and on soil K values. *Agron. J.*, 67, 60.

Turk M., Albayrak S., Yuksel O., 2009. Effects of fertilisation and harvesting stages on forage yield and quality of hairy vetch. New Zealand J. of Agric. Research,52: 269-275.

Undersander D., Casler M., Cosgrove D., 1996. Identifying pasture grasses. Cooperative Extension Publications, A3637, 58p.

Vogel K.P., B.C. Gabrielsen J.K., Ward B.E., Anderson H.F., Mayland and R.A. Masters, 1993. Forage quality, mineral constituents, and performance of beef yearlings grazing two crested wheatgrasses. Agronomy Journal,85: 584-590.

Ward G.M., 1966. Potassium metabolism of domestic ruminants A review. *J. Dairy Sci.*, 49, 268-276.

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PRODUCTIVITY AND QUALITY OF BULGARIAN LAVENDER VARIATIES

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Abstract

Bulgarian lavender varieties / Lavandula vera / are well known to the world aromatic, chemical and pharmaceutical industry. Specific climatic conditions characterized by cold winters, short springs and hot summers are very favourable for rapid growth and development of lavender plants. Genetic material created under these conditions was demonstrated with varieties: Raya, Hemus, Hebar and Karlovo, the potential of which in the form of the amount of harvested flowers varies from 560 to 690 kg/da in that with high content of essential oil in the range of 1.9 to 2.6 percent. Bulgarian lavender oil is high quality and is in direct competition with French oil.

Key words*: variaties, productivity, quality, essential oil.*

INTRODUCTION

In recent years, Bulgaria has reached a leading position in the world production of quality lavender essential oil from 200 t in 2015 to 250 t in 2016, compared to the production per capita it is leading in the world ranking. It is the high quality of Bulgarian lavender oil which determines its application in the global perfume and cosmetics industry. Quantities produced in other countries except France have a lower quality indicators based on the higher content of camphor and are used for the production of fresheners mainly.

MATERIALS AND METHODS

During the period 2013-2015 in the region of Plovdiv and experimental base AU - Plovdiv, field trials have been carried out to establish specific productive features and detailed qualitative parameters of Bulgarian lavender production. The results for the varieties are compared to the quality criteria of Bulgarian lavender oil. Lavender oil is volatile due to the free alcohols (Nematian A. et al., 2014). Increased rate of some ingredients determines the quality of the oil. A basic method for the preparation of essential oil is steam distilled with steam temperature over 140°C and pressure of 4-5 atmospheres (Jablonský M. et al., 2016). While growing lavender preferably a light soils with alkaline reaction (Cordovilla M. et al., 2014), (Dallev M. & Ivanov I., 2015). Chemical composition and its main components influencing the quality of essential oil and its price (Kara N. and Baydar H., 2013), (Danh L. et al., 2013).

RESULTS AND DISCUSSIONS

The results for productivity, presented as average values according to different varieties during the research period, are as follows: Hemus 6.3 $t.ha^{-1}$, essential oil 2%, yield 49.2, late-flowering variety, Hebar 6.4 $t.ha^{-1}$, essential oil 1.9%, yield 52.8, medium flowering variety, Raya 6.9 $t.ha^{-1}$, essential oil 1.9%, yield 52.8 suitable for dry flower. The volume of essential oil of reaches 180 l/ha.

The results for the varieties are compared to the quality criteria of Bulgarian lavender oil with the following main parameters: 1.8-cineole, % - 1.6- 4.2, cis-Ocimene + trans-Ocimene, % - 2-4 8.4 linalool, % - 16.1- 42.5, camphor, % - up to 0.5, lavandulol, % - 0.8- 2.7, terpinen-4-ol, % - 4-5- 8.7 linalyl acetate, % - 24.7- 51.6 lavandulyl acetate, % - more than 4.5. For Hemus the main ingredients are 1,8-cineole, % - 3.9, cis-Ocimene + trans-Ocimene, % -4.8, linalool, -33.9%, camphor, % - up to 0.4, lavandulol, % - 0.9, terpinen-4-ol, % -0.3, linalyl acetate, % - 39.6, lavandulyl acetate, % - over 3.4. For Hebar the main ingredients are

1,8-cineole, % - 1.1, cis-Ocimene + trans-Ocimene, -12.6 %, linalool, -28.5 %, camphor % - to 0.4 lavandulol, % - 0.2 terpinen 4-ol, -0.2%, linalyl acetate, % - 36.9, lavandulyl acetate, % - over 3.9. For Raya the main ingredients are 1,8-cineole, % - 2.3, cis-Ocimene + trans-Ocimene, -6.0%, linalool, -38.4%, camphor, % - to 0.6, lavandulol, % - 0.4, terpinen-4-ol, -0.5%, linalyl acetate, % - 36.2, lavandulyl acetate, % - more than 5.4.

Average essential oil content in % for the period according to different varieties: Hemus- 1.8%, Hebar- 2.8%, Raya- 2.9%.

The average values of biometric identifiers for the research period by varieties are as follows: Hemus- height – 52 cm, bush diameter - 59.5 cm, number of inflorescences- 302, length of spike - 5.3 cm, number of flower nodes - 4.7, number of flowers in 1 node - 8.3 length of the flower stem - 21.8 cm. Hebar- height – 55 cm, bush diameter - 80.0 cm, number of inflorescences - 456, length of spike - 4.9 cm, number of flower nodes - 4.5, number of flowers in 1 node - 6.5 length of the flower stalks - 21.3 cm. Raya- height - 51 cm, bush diameter - 70.0 cm, number of inflorescences- 413, length of spike - 4.9 cm, number of flower nodes - 4.2, number of flowers in 1 node - 5.9 length of the flower stem - 15.8 cm (Table 2).

Table 1. Variability of biometric parameters 2013 - 2015 years

Bush diameter, cm									
	2013			2014			2015		
Var	min	max	aver	min	max	aver	min	max	aver
1	45	60	53	55	85	66b	45	70	59c
2	60	80	72	70	80	77a	70	86	80b
3	65	85	73	60	90	78a	60	80	70c
Number of inflorescences									
	2013			2014			2015		
Var	min	max	aver	min	max	aver	min	max	aver
1	79	138	111	250	331	277	210	404	302
2	211	368	275	330	451	401	340	546	456
3	170	240	200	410	723	580	195	615	413

Table 2. Variation in the content of essential oil 2013 - 2015 years

Content of essential oil, %									
	2013			2014			2015		
Var	min	max	aver.	min	max	aver	min	max	aver
1	1,2	2.5	2.0	1.2	2.2	1.6	1.3	2.5	1.8
2	2,1	3.2	2.7	1.9	2.6	2.3	2.2	3.2	2.8
3	2,2	3.6	3.1	2.3	3.3	2.6	2.3	3.6	2.9

Demonstrated indicators characterize to the greatest extent the productive capacity of Bulgarian lavender varieties, and their quality characteristics provoke demand on the world market of essential oils.

In recent years, in Bulgaria's neighboring countries there has been an increased interest in this culture and Bulgarian varieties are mainly preferred in the cultivated lavender areas.

Chemical composition and its main components influencing the quality of essential oil and its price. In the Table 1 and 2; 1. Hemus, 2. Hebar, 3. Raya, Variaties.

Table 3. Variation of the main constituents of the essential oil

Hemus						
Main content	2013		2014		2015	
	min.	max.	min.	max.	min.	max.
1,8-cineole, %	2.2	3.3	2.0	3.7	2.9	3.9
cis-β-ocimene, %	1.9	2.3	1.2	1.9	1.8	2.4
trans-β-ocimene, %	1.4	2.0	0.6	1.2	0.9	2.4
cis-β-ocimene + trans-β-ocimene, %	3.3	4.3	1.8	3.1	2.8	4.8
linalool, %	38.6	41.0	29.7	31.1	31.2	33.9
camphor, %	0.1	0.2	0.4	0.6	0.3	0.4
lavandulol, %	0.8	1.1	0.8	1.5	0.6	0.9
terpinen-4-ол, %	3.9	4.5	2.1	2.8	0.2	0.3
linalylacetate, %	2.8	28.7	31.6	32.9	36.8	39.6
lavandulylacetate, %	2.5	3.2	2.0	2.9	2.8	3.4

Table 4.Variation of the main constituents of the essential oil

Hebar						
Main content	2013		2014		2015	
	min.	max.	min.	max.	min.	max.
1,8-cineole, %	1.8	2.3	3.0	4.5	0.7	1,1
cis-β-ocimene, %	5.9	6.5	1.7	2.4	6.7	7.2
trans-β-ocimene, %	5.4	6.0	1.5	2.4	4.8	5.4
cis-β-ocimene + trans-β-ocimene, %	11.3	12.5	3.2	4.8	11.5	12.6
linalool, %	28.5	28.8	28.0	28.5	26.9	28.5
camphor, %	0.3	0.5	0.4	0.6	0.2	0.4
lavandulol, %	1.0	2.6	0.8	1.2	0.1	0.2
terpinen-4-ол, %	1.1	1.6	2.9	3.8	0.1	0.2
linalylacetate, %	29.5	30.8	28.2	28.7	33.9	36.9
lavandulylacetate, %	2.9	3.2	3.4	3.6	3.3	3.9

Table 5. Variation of the main constituents of the essential oil

Raya						
Main content	2013		2014		2015	
	min.	max.	min.	max.	min.	max.
1,8-cineole, %	1.0	1.7	1.9	2.9	1.2	2.3
cis-β-ocimene, %	1,7	2.1	1.6	2.3	2.8	3.1
trans-β-ocimene, %	1.0	1.8	0.2	0.3	2.1	2.9
cis-β-ocimene + trans-β-ocimene, %	2.7	3.9	1.8	2.6	4,9	6.0
linalool, %	33.9	37.0	32.9	34.1	32.2	38.4
camphor, %	0.1	0.2	0.1	0.2	03	0.6
lavandulol, %	1.0	1.3	0.5	0.8	0.2	0.4
terpinen-4-ол, %	0.9	1.4	2.1	3.4	0,2	0,5
linalylacetate, %	28.9	35.7	32.8	34.5	28.9	36.2
lavandulylacetate, %	3.6	5.2	4.2	5.2	3.7	5.4

CONCLUSIONS

The greatest amount of lavender is obtained from a variety Druzhba.

Variety Hemus synthesized the greatest amount linalylatcetate 39.6%, followed by 36.9% Hebar variety and variety Sevtopolis by 36.2%. Linalilatsetat is the most important ingredient that significantly affects the quality of lavender oil.

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Bulgarian lavender varieties Hemus, Hebar and Raya show high productivity and very good quality in different agro-meteorological conditions of each year, which allows us to recommend them for growing in Bulgaria's neighboring countries.

REFERENCES

Cordovilla M.P., Bueno M., Aparicio C., Urrestarazu M., 2014. Effects of salinity and the interaction between thymus vulgare and lawandula angustifolia on growth, ethylene production and essential oil contents.. Journal Of Plant Nutrition, 37(6), 875. doi:10.1080/01904167.2013.873462.

Dallev M., Ivanov I., 2015. Study of body for surface tillage in heavy soils with low humidity. Scientific Papers-Series A, Agronomy, 58, 45-48.

Danh L., Han L., Triet N., Zhao J., Mammucari R., Foster N., 2013. Comparison of Chemical Composition, Antioxidant and Antimicrobial Activity of Lavender (Lavandula angustifolia L.) Essential Oils Extracted by Supercritical CO, Hexane and Hydrodistillation. Food & Bioprocess Technology, 6(12), 3481. doi:10.1007/s11947-012-1026-z.

Jablonský M., Ramajová H., Ház A., Sládková A., Škulcová A., Čížová K., 2016. Comparison of different methods for extraction from lavender: yield and chemical composition. Key Engineering Materials, 68831. doi:10.4028/www.scientific.net/KEM.688.31.

Kara N.C., Baydar H.C., 2013. Effect of different additives added to distillation water on essential oil content and quality of lavender. Suleyman Demirel University Journal Of Agriculture (Turkey), (2).

Nematian A., Shariati M., Vieira C., 2014. Effects of different drying methods on, volatile oil content and composition of lavander (Lavandula officinalis L.). Advances In Environmental Biology, 351.

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DETERMINATION OF CUTTING PROPERTIES OF SAGE (*Salvia officinalis* L.) AT DIFFERENT HARVESTING TIME

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Abstract

The time required to harvest plant crops is important to the plant properties. It is affected by design of the harvest equipment and the desire for high-quality products with low energy consume. In this study, we determined the cutting properties of sage (Salvia officinalis L.) at different harvesting time to be applied to the design of mechanization applications. Cutting properties of sage (Salvia officinalis L.) (an important medicinal aromatic plant) harvested on 15, 22, 30 July and 7 August, 2013 (H1, H2, H3 and H4, respectively) were measured at the bottom and top sections of the stalk. Measurements included maximum force, bioyield force, shearing force, bending stress, shearing stress, shearing energy, and shearing deformation.

The highest force (50.02 N) was at H4 on the bottom section, and the lowest was at H1 on the top. Maximum values for bioyield force, shearing force, and bending stress were at H4 on the bottom section, and corresponding minimum values were at H1 on the top section. Shearing stress decreased at successive harvest dates for both stalk sections. Strength measurements for bottom sections of the stalk were greater than those for top sections. When reduced harvesting force is needed because of harvester design or harvest procedures, harvesting near the top of the stalk is recommended.

Key words: *harvest time, sage (Salvia officinalis L.), mechanization means, cutting properties, stalks strength.*

INTRODUCTION

The Genus *Salvia* L. (sage) of the family *Lamiaceae* comprises nearly 900 species spread widely throughout the world. Salvia is represented in Turkey by 94 taxa belonging to 89 species with 50% endemism. In Turkey, commercial *Salvia* species belong to the following groups: camphor/1.8-cineole group: *S. fruticosa*, pinene group: *S. tomentosa*, and thujone group: *S. officinalis* 1. Sage is well known as a common medicinal and aromatic plant widely used in food, perfumery, herbal medicine and products. (Baser, 2002; Hohmann et al., 2003; Wang et al., 1998).

In this study, we determined the cutting properties of sage (*Salvia officinalis* L.) at different harvesting time to be applied to the design of mechanization applications. Cutting properties of sage (*Salvia officinalis* L.) (an important medicinal aromatic plant) harvested on 15, 22, 30 July and 7 August, 2013 (H1, H2, H3 and H4, respectively) were measured at the bottom and top sections of the stalk. Measurements included maximum force, bioyield force, shearing force, bending stress, shearing stress, shearing energy, and shearing deformation.

MATERIALS AND METHODS

For this study, sage (*Salvia officinalis* L.) plants were harvested by hand from the experimental field in Suleyman Demirel University, Isparta, Turkey. Sage (*Salvia officinalis* L.) was harvested on four different data, i.e. July 15 (H1), July 22 (H2), July 30 (H3) and August 7 (H4), in 2013. The total height of the sage (*Salvia officinalis* L.) stalk was approximately 600 mm. The portion defined as the top section was where budding began, i.e., the uppermost section from approximately 100 mm below the apex of the plant. The portion designated as the bottom section was defined as the portion of the plant from the soil surface up to a height of 100 mm.

Top and bottom sections of stalks were combined with other portions of the plants for some evaluations. Stalks damaged during cutting were discarded. Diameter and cross-sectional area of the experimental samples were measured before the bending and shearing tests.

Moisture content of the plants was determined at harvest time. Specimens were weighed and dried in an oven at 102°C for 24 h and then reweighed (ASABE, 2006).

A universal testing machine (LF Plus, UK) with a 500 N load cell and a computer-aided cutting and bending apparatus (Figures 1 and 2) was used to measure the strength characteristics of the sage (*Salvia officinalis* L.) stalks. All the tests were carried out at a speed 0.8 mm s^{1}, and data were recorded at 10 Hz. All data were analyzed by nexgen software program.

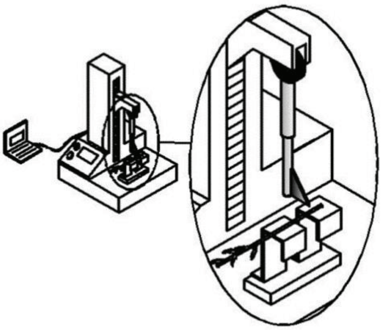

Figure 1. Cutting system

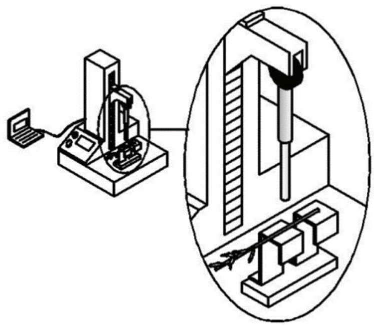

Figure 2. Bending system

The bending force was determined with load cell that produced force × time data up to failure of the sage (*Salvia officinalis* L.) stalk (Figure 2). Force-deformation curves were calculated from the test data by the software.

The shearing forces on the load cell with respect to knife penetration were recorded by computer (Ozbek, 2009).

The shearing stress in $N.mm^2$ was calculated using the equation of Shahbazi et al. (2012):

$$\tau = \frac{F_{s\max}}{A}$$

Where Fsmax is the maximum shearing force of the curve in N, and A is the area of the stalk at the deformation cross-section in mm^2.

The shearing tests were conducted with 0.8 $mm.s^1$ knife speed progressy (Simonton, 1992). Bioyield force, shearing force, bending stress, shearing stress, and shearing deformation were calculated from the force-deformation curves at the inflection point as defined by ASAE Standard (1985).

S368.1 (ASAE Standards, 1985) was obtained from all curves.

The energy of shearing was determined as the area under these curves (Chen et al., 2004; Srivastava, 2006).

All measured characteristics were analyzed against three years and four harvesting times and two stalk sections Comparisons between treatments of means were used in Duncan’s multiple range test ($p < 0.05$).

RESULTS AND DISCUSSIONS

The average stalk diameter, stalk length, and moisture content at the four harvest dates are shown in Table 1.

The strength measurements of sage (*Salvia officinalis* L.) stalks are given in Table 2.

The diameter of sage (*Salvia officinalis* L.) stalks decreased from the bottom to the top of plant, suggesting that the strength characteristics may vary due to cross-sectional area.

Table 1. Physical characteristics of sage (*Salvia officinalis* L.) at four harvest dates

Average length (mm)	Harvest date[a]	Moisture content (%, dry weight basis)	Diameter (mm)			
			bottom	standard deviation[b]	top	standard deviation[b]
600	H1	61.5	3.06[a]	0.34	2.30[a]	0.23
	H2	43.0	2.81[b]	0.54	2.16[b]	0.34
	H3	29.8	2.76[c]	0.65	2.14[b]	0.54
	H4	13.5	2.61[d]	0.33	1.79[c]	0.22

Table 2. Average strength characteristics of sage (*Salvia officinalis* L.)

Harvest date[1]	Maximum force (N)	Bioyield force (N)	Shearing force (N)	Bending stress (MPa)	Shearing stress (MPa)	Shearing energy (J)	Shearing deformation (mm)
	Bottom section						
H1	30.60[d]	24.48[d]	17.04[b]	2.29[d]	4.50[a]	0.40[a]	41.87[a]
H2	36.45[c]	29.16[c]	17.08[b]	2.57[c]	3.05[b]	0.25[b]	28.81[b]
H3	39.29[b]	31.43[b]	17.69[b]	3.06[b]	2.88[c]	0.25[b]	24.33[c]
H4	50.02[a]	40.01[a]	23.62[a]	3.64[a]	2.42[d]	0.16[c]	22.16[d]
Mean	39.09	31.27	18.86	2.89	3.21	0.27	29.29
Standard deviation	3.65	2.25	2.87	3.12	1.04	0.001	3.12
	Top section						
H1	17.09[d]	13.67[c]	7.47[b]	2.97[d]	3.93[a]	0.15[a]	39.67[a]
H2	20.40[c]	16.32[b]	10.56[a]	3.21[c]	3.03[b]	0.11[b]	24.46[b]
H3	21.62[b]	17.30[b]	10.78[a]	5.83[b]	2.93[c]	0.09[c]	22.34[c]
H4	26.25[a]	21.00[a]	10.87[a]	6.17[a]	2.05[d]	0.06[c]	19.92[d]
Mean	21.34	17.07	9.92	4.55	2.99	0.01	26.60
Standard deviation	5.22	2.12	1.54	4.18	2.32	0.001	2.12

Maximum force was evaluated as a function of harvest date (H1, H2, H3 and H4) and stalk sections. Maximum force increased with increasing harvest date and was lower at the top section of the stalks than at the bottoms. The effect of harvest date on the maximum force applied to the stalk sage (*Salvia officinalis* L.) plants was statistically significant ($P < 0.05$). Leblicq et al., 2015 and Ince et al. (2005) were reported similar results. These similar results are decreasing the moisture content with increasing the maximum force. The highest maximum force (50.02 N) was observed at the H4 harvest date on the bottom stalk section, and the lowest maximum force was observed at the H1 harvest date on the top section. The higher moisture level of the plants at the H1 harvest date may be responsible for the low observed force (Table 1). The smaller size of the top section compared with the bottom section may also have contributed to the lower maximum force.

The bioyield force increased at successive harvest data. This may be attributable to decreased moisture level in the stalk with increased harvest data, causing the texture of the stalk tissue to become more rigid. This result is similar reported on other plant species (Chen et al., 2004; Ince et al., 2005). For both stalk sections, the harvest date had a significant effect on the bioyield force ($P < 0.05$). The maximum bioyield force of 40.01 N was observed at H4, and the minimum bioyield force of 13.67 N was at H1.

Shearing force is one of the most important plant characteristics affecting plant harvesting. If the weight of the plant is known, the shearing force and the shearing height can be used to determine the speed of the blade to be used in harvesting (Igathinathane et al., 2010; Taghijarah et al., 2011). The maximum shearing force was observed at H4 at the bottom section of the stalks. The minimum shearing force was at H1 on the top section. For both stalk sections, the harvest date had a significant effect on the shearing force ($P < 0.05$). The bending stress value is also used to determine the speed of the cutting unit of the harvesting machine. This was in agreement with the literature (Ince et al., 2005; Galedar et al., 2008; Shahbazi et al., 2012). The effect of harvest data on bending stress was significant ($p < 0.05$), and varied between 4.68 and 13.72 MPa. The maximum bending stress was observed at H4 in the top section of the stalk.

The shearing stress values decreased at successive harvest date. The maximum shearing stress value (4.50 MPa) was observed at H1 on the top section of the stalk. The minimum shearing stress (2.05 MPa) was observed at H4 on the bottom section of the stalk. The effect of harvesting time on shearing stress was significant ($P < 0.05$). These results were similar to those of Ozbek et al. (2009).

The shearing energy varied between 0.06 and 0.40 J. These results were similar to Yu et al. (2014) and Lien et al. (2015). The shearing energy values observed for the bottom section of the stalks were greater than the values observed for the top section), and the effect of harvest date on shearing energy was significant ($P < 0.05$).

Deformation has an important place among the strength characteristics of the plant. The maximum shearing deformation (41.87 mm) was observed at H1 on the bottom, and the minimum (19.92 mm) was observed at H4 on the top section of the stalk.

CONCLUSIONS

In this study, the effect of harvest date and stalk section on stalk strength properties of sage (*Salvia officinalis* L.) was determined. Maximum force, bioyield force, shearing force, bending stress, shearing stress, shearing energy, and shearing deformation were examined at four different harvest data and on two different sections of the plant stalk.

The strength characteristics of the bottom section of the plant were greater than the corresponding values for the top section.

With regard to bending stress, the top section of the stalk had higher values than the bottom section. This due to the more elastic structure of the top section.

The maximum force, bioyield force, shearing force, and bending stress values all increased with increasing time, whereas the shearing stress, shearing energy, and deformation values decreased with later harvesting dates.

These experiments have demonstrated that harvest data and harvesting height of the plant were important factors in decreasing the shearing energy required to harvest sage (*Salvia officinalis* L.) plants. Therefore, when reduced force is necessary due to harvester design or harvest methodology, harvesting near the top of the plant is recommended.

REFERENCES

Asabe Standards., 2006. Moisture measurement e Forages.. St. Joseph, MI: American Society of Agricultural and Biological Engineers (ASABE). S358.2.

Asae Standards., 1985. Compression test of food materials of convex shape. St. Joseph, Mich.: American Society of Agriculture Engineering. S368.1.

Baser K.H.C., 2002. Aromatic biodiversity among the flowering plant taxa of Turkey. Pure Appl. Chem. 74: 527-545.

Chen Y., Gratton J. L., Liu L., 2004. Power requirements of hemp cutting and conditioning. Biosyst. Eng., 87 (4): 417–424.

Galedar M. N., Jafari A., Mohtasebi S. S., Tabatabaeefar A., Sharifi A., O'dogherty M. J., Rafiee S., Richard G., 2008. Effect of moisture content and level in the crop on the engineering properties of alfalfa stems. Biosyst. Eng, 101, 199-208.

Hohmann J., Redei, D., Mathe, I., Blunden, G., 2003. Phenylpropanoid glycosides and diterpenoids from Salvia officinalis. Biochem. Syst. Ecol. 31: 427-429.

Ince A., Uğurluay S., Güzel E., Özcan M. T.. 2005. Bending and shearing characteristic of sunflower stalk residue. Biosyst. Eng. 92, 175–181.

Igathinathane C., Womac A.R., Sokhansanj S., 2010. Corn stalk orientation effect on mechanical cutting. Biosyst. Eng., 107: 97-106.

Lien C.C, Liu H.W., 2015. Shear characteristics of napier grass stems. Appl. Eng. Agric., 31 (1): 5-13.

Leblicq T., Vanmaercke S., Ramon H., Saeys S., 2015. Mechanical analysis of the bending behaviour of plant stems. Biosys. Eng., 129: 87-99.

Ozbek O., Seflek A. Y., Carman K., 2009. Some mechanical properties of safflower stalk. Appl.Eng.Agric., 25: 619–625.

Shahbazi F., Nazarigaledar M.., 2012. Bending and Shearing Properties of Safflower Stalk. J. Agric. Sci.Techn., 14: 743-754.

Simonton W., 1992. Physical properties of zonal geranium cuttings. Trans. ASAE, 35(6): 1899-1904.

Srivastava A. K., Goering C. E., Rohrbach R. P., Buckmaster D. R. (2006). Engineering principles of agricultural machines (2nd ed.). American Society of Agricultural and Biological Engineers, St. Joseph, USA, p. 185.

Taghijarah H., Ahmadi H., Ghahderijani M., Tavakoli M., 2011. Shearing characteristics of sugar cane (Saccharum officinarum L.) stalks as a function of the rate of the applied force. Austr. J. Crop Sci., 5(6): 630-634.

Yu M., Igathinathane C., Hendrickson J., Sanderson M., Liebig M., 2014. Mechanical shear and tensile properties of selected biomass stems. Trans. of the ASABE, 57 (4): 1231-1242.

Wang M., Shao Y., Huang T.C., Wei G.J., Ho C.T., 1998. Isolation and structural elucidation of aroma constituents bound as glycosides from sage (Salvia officinalis). J. Agric. Food Chem. 46: 2509-2511.

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PERFORMANCE OF A HYDRAULIC JET AGITATION SYSTEM WITH DIFFERENT JET NOZZLE SIZES IN THE SPRAYER TANK

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Abstract

Consumption of wettable powders (WP) and water-soluble granules (WSG) have increased in last years in the pesticide market. Main problems faced with these kinds of pesticides are the requirement of continuous mixing due to sedimentation in sprayer tanks. To solve this problem, usage of hydraulic jet agitators in sprayer tanks have increased in last years. However, position of agitator in tank, mixing pressure and technical specifications of hydraulic jets are important for an effective agitation. In this study, we determined the agitation performances of a hydraulic jet in a 400 L sprayer tank by using one jet nozzle at 3 different jet nozzle sizes (orifice size: 1.0, 1.5 and 3.0 mm) and 3 different agitating pressures (3, 6 and 8 bar). Kaolin clay and Cooper oxide chloride were used as a tracer material for simulating WP and WSG solutions in the tank. And, International ISO 5682-2:1997 (E) Standard has been used for sampling method in the tank level. To measure the rate of tracer material in the tank, turbimetric and drying method were used and results were comparted with reference solution concentrations to determinate of deviation rates. As a result, deviation rates of all agitation configuration used in this research were higher than the defined acceptable limits in ISO 5682-2:1997 (E) at all measurements in the sprayer tank.

Key words: *sprayer tank agitation, turbidimeter, wettable powder, water-soluble.*

INTRODUCTION

The use of agricultural chemicals is one of the indispensable elements in decreasing crop losses caused by diseases, harmful and weeds in agricultural production. Each year, 3 million tons of pesticides are used in the world and 45 thousand tons of pesticides are used in our country. Although pesticides are classified according to their formulation types, the usage rates of especially wettable powder formulations (WP) have increased in recent years and reached 17% of the total pesticide used in Turkey. Unlike other formulations, the wettable powder (WP) is required to be mixed effectively and continuously in the tank during spray application, since it is delivered to the target with the water in the tank. If the proper agitation is not achieved during the pesticide application, the pesticide liquid componentswill fall bottom of the tank and a rate of application of a pesticide that is not in proper conditions arises. This problem is especially important for sprayers with large tank capacity (Ozkan and Ackerman, 1999). Pneumatic, hydraulic and mechanical agitators are used in the sprayer tanks, either individually or in combination with both agitators (Brusselman et al., 2010) For sprayers produced in Turkey, mostly hydraulic jet type agitators are preferred (Bolat et al., 2012). The agitators in the sprayers produced in Turkey are usually located perpendicular to the sprayer tank bottom and provide a flow towards the top of the pressurized fluid tank exiting the agitator. However, this type of sprayer tank agitators cannot provide a sufficient level of agitating within the tank. In a study conducted in Cukurova region of Adana/Turkey, where intensive chemical consumption is high in Turkey, agitation system mistakes of the existing sprayers were determined and found to be 90% in the sprayers (Bayat et. al., 1999). These locally produced sprayers with a high level of agitator failure cause pesticide application at different concentrations on the same field surface and pesticide applications cause heterogeneous pesticide distribution. Pesticide applications with these sprayers cause very high or very low spraying activities. In recent years, some R & D studies have been conducted on pesticide tank mixing technologies in USA and EU countries and the successful results obtained from these studies have been transferred to practice. The performance of the agitators used depends on the sprayer tank shape and size, agitator design and location, mixing pressure and formulation of pesticide (Uçar et al., 2000; Zeren and Bayat, 1999). In particular, the agitator performance is directly influenced by the location of the agitator in the tank, and the hydraulic jet sprayer has been found to be more effective when placed at an inclination of 2.5-5 cm above the basin and 30° relative to the basin (Uçar, 1998). The international ISO 5682-2: 1997 (E) standard is used to determine the performances of the agitators in the sprayer tanks (Anonymus, 1997). According to this standard, in order to determine the activity of the agitator, agitatation of the wettable powder and the specified Copper oxide chloride and water should be put in the recommended concentration in the tank, and samples taken from the tank should be dried at certain temperatures (105-110°C) for evaluation. In recent years, however, measurement instruments (Turbidimeters), which are a new technology in turbidity measurements and which can produce results in a very short time, have also started to be used (Ozkan and Ackerman, 1999). These turbidimeter measurements of the samples are made according to the optical sampling method and the results can be recorded in the digital environment.

The main objective of this study was to compare the performance of the hydraulic jet agitator with different nozzle orifice diameters (1.0 mm, 1.5 mm and 3.0 mm) in three different agitating fluid pressures (3, 6 and 8 bars) in conjunction with ISO 5682-2: 1997 (E) standard as measured by Turbidimetric and Drying methods.

MATERIALS AND METHODS

A field sprayer with a tank capacity of 400 liters was used for the measurements made within the scope of the research. Agitating with a hydraulic jet placed perpendicular to the tank bottom was performed in the sprayer tank. The efficacy tests were carried out in 3 different jet nozzle orifices (Type A: 1.0 mm, Type B: 3.0 mm and Type C: 1.5 mm) and 3 different pressures (3, 6 and 8 bar) were determined. In determining agitating performance, the samples taken are in accordance with the international ISO 5682-2: 1997 (E) standard for Turbidimetric and Drying methods.

Samples taken according to this standard were carried out in 4 stages;

Stage 1: The Jet type tank agitator was operated for 10 minutes while the tank was in full position and samples were taken at three different elevation levels (10%, 50% and 90% full) of the tank.

Stage 2: The hydraulic jet agitator was run for 16 minutes after stopping for 10 minutes and the samples taken in the first stage were repeated.

Stage 3: At the time of unloading the filled storage by means of the nozzles, samples were taken at 8 different storage height levels (every 50 liters).

Stage 4: Sampled from the residual liquid in the bottom of the emptied tank.

An experiment was setup in order to be able to take samples at stage 1 and stage 2 from the sprayer tank and not to disturb the sprayer concentration (Figure 1). Here, a series of plastic hoses fitted at three different heights (90%, 50%, and 10% sampling levels) of the tank and other mounted glass beakers was used. The glass beaks, which is connected parallel to each other, were connected to a vacuum pump (KNF Neuberger D-79112 Freiburg) to suck the samples. Thus, samples were able to be taken from the tank simultaneously. In addition, a separate pressure gauge is fitted on the agitation line in addition to the existing system on the pump in order to be able to follow the pressure in the hydraulic agitator in the test setup.

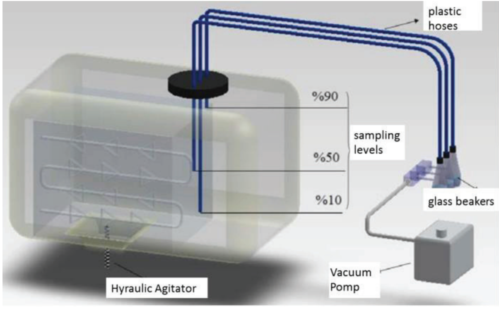

Figure 1. The experimental setup established for sampling in the tank

Turbidimetric and Drying methods were carried out separately in determining the mixing performances with the same sampling methods for the liquid concentrations taken from the tank.

Drying Test Measurements (Classical Method)

In this method, wettable powders of Copper oxychloride (Cu2 (OH) 3Cl) were used in the tank and the samples were dried in a drying cabinet (oven) for 24 hours and at a temperature of 105-110 °C (Figure 2). In the determination of the mixing tests, the samples were taken in four steps according to the international ISO 5682-2: 1997 (E) standard.
The measurements made in this method were recorded by weighing before and after drying, so that the absolute percentage deviation from the initial concentration of each sample was calculated using the formula given in Equation 1, by determining the amount of dry matter.

$$MS(\%) = \left| \frac{NK - BK}{NK} \right| x100 \qquad \text{(Eq. 1)}$$

Where:
MS - Absolute deviation rate (%);
NK - Sample Concentration;
BK - Initial Concentration.

Figure 2. Drying process of the samples

Turbidimetric Test Measurements

Measurements on the samples obtained by this method were carried out in accordance with the international ISO 5682-2: 1997 (E) standard as in the drying method. However, in this method, Kaolin clay, which is a wettable powder, is used in the tank. In this method, measurements were made with Turbidimeter (HF Micro 1000) and calibration kits were used in different measurement ranges (0.02 - 10 and 1000 NTU) (Figure 3).

Figure 3. Turbidimeter Device (HF Micro 1000) and calibration kits

Turbidimetric measurements are obtained in the Nephelometric Turbidimeter Unit (NTU). The turbidity measurements made by this method are used to determine the initial concentration value in the tank and to determine the turbidity reading ranges. The measured turbidity values of the existing calibration kits of the device are shown in as shown in Table 1, turbidity measurements with calibration kits (0.02 - 10 and 1000 NTU) were determined to be measurable at a concentration range of 0.02 - 0.6 g/l solution concentration.

Table 1. Average turbidity value for different solution concentration (NTU)

Solution concentration (g/l)	Average turbidity value (NTU)
0.02	64.325
0.06	72.725
0.1	146
0.2	293
0.3	424.5
0.4	573.5
0.5	779.75
0.6	1086.75

The measurements for each selected concentration were made in 4 replicates and the average turbidity values measurable in the turbidity measurements were calculated as: 64.3 to 1086.7 NTU.

The regression equation determined by solution concentrations and the corresponding graph are given in Figure 4.

RESULTS AND DISCUSSIONS

In the scope of the study, the percentages of deviations of each of the first and second stage agitators at the agitator pressures of 3, 6 and 8 bar are given in Table 2 and Table 3.

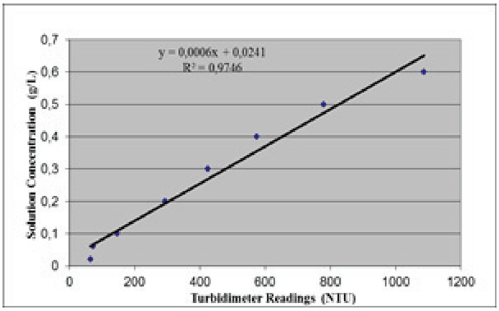

Figure 4. Regression graph and equation for solution concentrations

Equation (2) given below is used to determine the mixing performance (%) in the turbidimetric method.

$$KP = \frac{SBD - ÖBD}{SBD} \times 100 \qquad \text{(Eq.2)}$$

Where:
KP - Mixer performance (%);
SBD - The initial turbidity value (NTU);
ÖBD - Measured turbidity value.

When Table 2, the results of the first stage evaluating the agitator efficacy tests, is examined, it is seen that the type A mixer produces the lowest percentage of deviation (18.4%) to the first concentration value similarly in both methods at 6 bar pressure.

ISO 5682-2: 1997 (E) specifies that an effective mixing should be in the range of 0.95-1.05% acceptable for the first concentration (Anonymous, 1997).

Accordingly, it can be said that, in terms of the results of the first stage, the deviation rates obtained in the three types of mixers and their associated pressure levels are considerably higher than the initial concentration and form an inefficient mixing process.

According to the results of the second stage, the lowest measured deviation rate was measured with a Type A mixer and a pressure of 8 bar with 18.8% (Table 3).

Similar to the first step here, the difference with respect to the initial concentration in all three types of mixers is well above the acceptable limits.

The third stage (reduced storage levels) where the mixer performances were determined consisted of samples taken every 50 liters during discharge of the liquid from the reservoir through the nozzles.

Figure 5 shows the drying rate and Figure 6 shows the deviation rates calculated by Turbidimetric method.

Table 2. First Stage (after initial operation) Deviation Rates (%)

Agitator types	Deviation rates from initial concentration (%)					
	Drying Method			Turbidimetric Method		
	3 bar	6 bar	8 bar	3 bar	6 bar	8 bar
A	24.2	18.4	19.4	28.5	16.1	22.1
B	21.6	22.8	23.6	24.2	20.3	21.9
C	24.6	20.1	19.2	27.5	19.2	24.5

Table 3. Deviation Rates in the Second Stage (after 16 hours of operation)

Agitator types	Deviation rates from initial concentration (%)					
	Drying Method			Turbidimetric Method		
	3 bar	6 bar	8 bar	3 bar	6 bar	8 bar
A	29.3	22.0	18.8	28.3	23.2	23.6
B	26.4	26.6	24.8	28.2	21.7	21.8
C	28.1	24.7	24.1	26.6	22.0	23.3

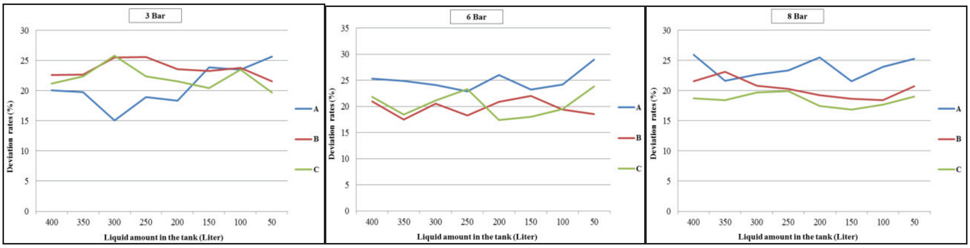

Figure 5. Deviation rates (%) occurring in the third stage of the drying process (reduced storage levels)

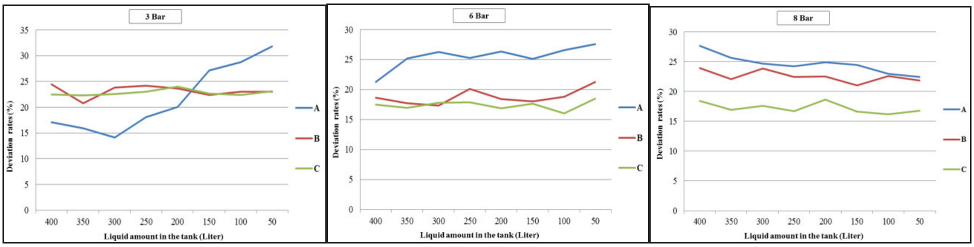

Figure 6. Turbidimetric method deviations in the third stage (reduced storage levels) (%)

As can be seen from Figure 5 and Figure 6, high rates of deviations above the predicted deviations of the entire liquid levels of the depot are obtained by both the drying method and, if necessary, by the turbidimetric method.

This results in the fact that no mixer is effective at the desired level throughout the spraying in the sprayer storage. Drug applications with mixers with such high deviation rates have reached heterogeneous and inadequate biological activity values overall field surface and lead to unsuccessful results in the formulation. In particular, the low level of mixer mistakes during application is very important in terms of spraying success. The sedimentation of the medicine in the warehouse takes place mostly while the medication is in progress.

Therefore, the reduction of mixer mistakes and their problems will increase the success of spraying, thus providing human and environmental health and country economy (Bolat et al., 2013).

The deviation rates of the samples taken from the bottom of the tank the fourth stage in which the mixing performances are tested, are given in Figure 7.

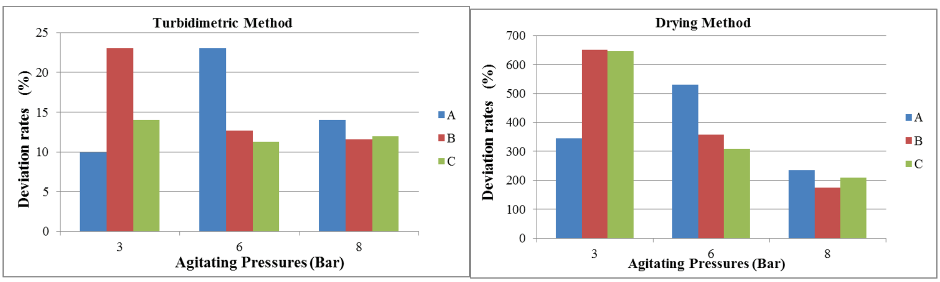

Figure 7. Deviation rates in the fourth stage (tank bottom region) (%)

In Figure 7, when the calculated deviation rates of the samples taken from the bottom of the tank are examined, it is seen that the deviation rates calculated by both methods are at high levels. As can be seen from this, the wettable powder substance was found to collapse to the bottom of the tank due to insufficient agitating.

In terms of the results obtained from the mixing test measurements made, the results of both measurement methods used were close to each other. This shows that both evaluation methods can be used safely in mixing performance. Although the International ISO 5682-2: 1997 (E) standard used in mixing tests does not recommend a drying method, the Turbidimetric method has proven to be a more preferable method in terms of ease of measurement, instantaneous results and high sensitivity. Furthermore, the performance of the mixer at different pressures and jet nozzle bore diameters in terms of the results obtained in the mixing tests performed did not reach the expected levels of mixing performance. For this reason, it has been determined that mixer designs which enable more effective mixing should be done by performing R & D studies in the domestic production of sprayer tanks.

ACKNOWLEDGEMENTS

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REFERENCES

Anonymous, 1997. Equipment for crop protection spraying equipment part 2: test methods for hhydraulic sprayers. Int. Standard ISO 5682-2. Int. Org.for Standard, Switzerland.

Bayat A., Yarpuz. N., Soysal A., 1997. Tarla Pülverizatörleri İle Yapılan İlaç Uyg. Doğruluk Düzeyinin Saptanması. Tarımsal Mek. 17. Ulusal Kong. s.537-546. TOKAT.

Bolat A., Bayat A., Ucar T., 2012. Pülverizatör Deposu İlaç Karıştırma Sistemleri. 27. Tarımsal Mekani-zasyon Ulusal Kongresi Bildiri Kitabı. S. 265-270. Samsun.

Bolat A., Bayat A., Ucar T., 2013. Hidrolik Jet Karıştırıcılı Depoya Sahip Pülverizatörlerde Karıştırıcı Et-kinliğinin Turbidimetrik Yöntemle Saptanması. 1. Bitki Koruma Ürünleri ve Makinaları Kongresi Bildiri Kitabı Cilt III. S. 185-194. Antalya.

Brusselman E., Moens M., Steurbaut W., Nuyttens D., 2010. Effect of agitation systems on the viability and the displacement of entomopathogenic nematodes in spray tank. Aspect of Applied Biology 99.

Ozkan H.E., Ackerman K.D., 1999. Instrumentatıon for Measuring Mixture Variabılıty. American So-ciety of Agricultural Engineers Vol 15(1) 19-24.

Ucar T., 1998. Simulation and experimental study of jet agitation effects on agrochemical mixing in sprayer tanks. Doktora Tezi. The Ohio State University.

Ucar T., Ozkan H.E., Fox R.D., Brazee R.D., Derksen R.C., 2000. Experimental Study of Jet Agitation Ef-fects on Agrochemical Mixing in Sprayer Tanks. Journal of Agricultural Eng. Research, 75(2), 195-207.

Zeren Y., Bayat A., 1999. Tarımsal Savaş Makinaları. Cukurova Univ. Ziraat Fak. Yayınları. Yayın No. 108.

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ANALYSIS OF LONG-TERM TEMPERATURE DATA USING MANN-KENDALL TREND TEST AND LINEAR REGRESSION METHODS: THE CASE OF THE SOUTHEASTERN ANATOLIA REGION

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Abstract

Nature has been adversely affected by increasing industrialization – especially after the latter half of the last century – when accelerating technological development, unplanned urbanization, incorrect agricultural policies, deforestation, and the excessive and unsuitable use of energy have acted as factors to increase the release of gases into the environment. The global warming effect of greenhouse gases has had a negative impact on the meteorological and hydro-meteorological parameters, such as the temperature and precipitation, which are the main elements of a region's climate. In particular, sudden changes occurring in air temperature lead to major changes in the design of air conditioning systems, energy analysis, and heating- and cooling-load calculations such as degree-day. Various energy-forecasting methods are being developed for air-conditioning systems in buildings, animal shelters and controlled environmental agriculture structures. Accurate and easily accessible climatic data are extremely important in terms of analysing the accuracy and energy efficiency of air conditioning systems. In this study, the trends and changes over a long period of daily maximum, minimum and mean temperature data were analyzed using the Mann-Kendall trend test and linear regression analysis, and comments have been made about nine provinces in the Southeastern Anatolia Region of Turkey. As a result of these analyses, it has been concluded that maximum temperatures of the provinces of Adıyaman, Gaziantep, Mardin, Şanlıurfa, the mean temperatures of the provinces of Adıyaman, Batman, Gaziantep, Kilis, Mardin, Siirt, Şanlıurfa and Şırnak, and the minimum temperatures in the provinces of Gaziantep, Kilis show statistically significant rising trends.

Key words*: climate change, Linear Regression Analysis, Mann-Kendall Trend Test, Southeastern Anatolia Region, temperature.*

INTRODUCTION

Climate parameters that have a variable structure constantly differ in their temporal and spatial aspects. A majority of the Earth exhibits changes within short or long periods due to the nature of its own climate. A short-term climate change shows a difference in an annual measurement of any climate parameter from the long-term mean (Gardner et al., 1996; Karabulut and Cosun, 2009).

Temperature, the main climate factor, has a significant role in the identification of global climate variability. The changes that occur in temperature are important in understanding the general climate structure. Therefore, in recent years, studies on climate change have focused on the trend analyses of the temperature parameter (Kadıoglu, 1997; Turkes et al., 2008; Karabulut and Cosun, 2009).

Human factors are believed to have contributed to climate change from the mid-19th century. They have led to an increasing deterioration of ecological balance, along with rising population and developing technology. Changes associated with natural causes have advanced slowly for many years and the change has now become palpable. The biggest impacts of climate change will occur in countries in the middle and high altitudes. Turkey is among the countries that will be greatly affected by this change due to its geographical location (Karabulut et al., 2008).

The increases identified by Sensoy et al. (2005), that occurred in Turkey's mean, maximum and minimum temperature series –

particularly in the spring and summer after the cold year of 1992 – suggested that temperatures in Turkey are tending to rise, while the number of frost and icy days falls, along with daily temperature range. They indicated that cool nights decrease as hot nights increase, and that both maximum and minimum temperatures are rising. The difference between daily maximum and minimum temperatures diminishes because of global warming in many regions throughout the world (Tecer et al., 2004; Cosun and Karabulut, 2009).

As in other countries, various studies related to climate change that specifically focus on trend analysis are also being carried out in Turkey. These trend analyses carried out on temperature demonstrate the existence of statistically significant increases throughout the country (Partal and Kahya, 2006; Ozkul et al., 2008).

The aim of this study is to examine the trends of the daily maximum, minimum and mean temperature values of the nine provinces located in the Southeastern Anatolia Region – where agricultural activities are concentrated and where the hottest geographical areas in the country are found – by using Linear Regression Analysis (LRA) and the Mann-Kendall Trend Test (MKT).

MATERIALS AND METHODS

The Southeastern Anatolia Region (SAR), which includes Turkey's important reservoirs in terms of water resource potential: the valleys of the Euphrates and Tigris rivers, was selected in the study. There are nine provinces in the region, and the long-term daily maximum, mean and minimum temperature values were obtained from the General Directorate of Meteorology of these provinces. The LRA and MKT techniques utilized in this study are simple and commonly used methods.

Linear Regression Analysis (LRA)

Linear regression analysis is a non-parametric test that determines the relationship between two or more dependent and independent variables that have a causal link. This test analyses whether a linear relationship and trend exists between variables with a 95% confidence interval (Haan, 1977; Hamdi et al., 2009; Singh et al., 2015). The Linear regression equation is shown in equation 1:

$$Y = a + bX \tag{1}$$

Here, Y indicates a dependent variable, X indicates an independent variable, and a and b indicate a constant values. The significance of the linear regression test is tested with a 95% confidence interval using α (significance levels such as 5%, 1%) and Student t-test (Haan, 1977; Sneyers, 1990; Bulut et. al., 2006).

Mann-Kendall Trend Test (MKT)

The MKT is very commonly used because it is not affected by deficient and erroneous measurement in a data series such as hydro-meteorological data. It is non-parametric and facilitates trend determination. The MKT statistic (u(t)) is calculated. Equations 2 and 3 below are used to calculate the MKT statistic:

$$t = \sum_{i=1}^{n} n_i \tag{2}$$

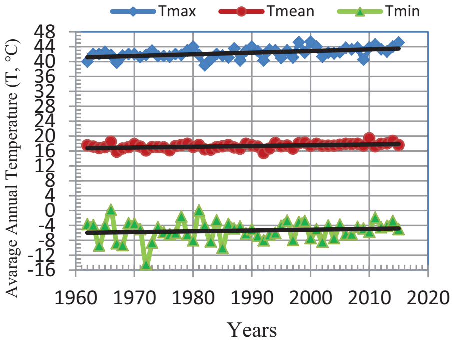
$$u(t) = \frac{\left(t - E(t)\right)}{\sqrt{\mathrm{var}(t)}} \tag{3}$$

The u(t) value, calculated as a result of the test, is directly compared with the table value (t_{Critic}) of the 95% confidence interval ($t_{\alpha/2,(n-2)}$) in the Student-t distribution, and the existence of a trend in the variables is identified (Mann, 1945; Kendall, 1975; Sneyers, 1990; Partal and Kahya, 2006; Safari, 2012; Ahmed et al., 2014; Soydan et al., 2015).

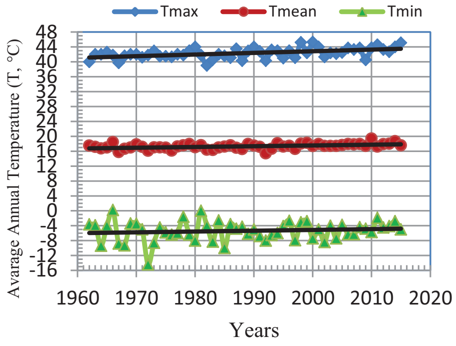
RESULTS AND DISCUSSIONS

Long-term daily maximum, mean and minimum temperature values of the nine provinces are illustrated in Figure 1, by years, to examine the potential climatic changes in the study field.

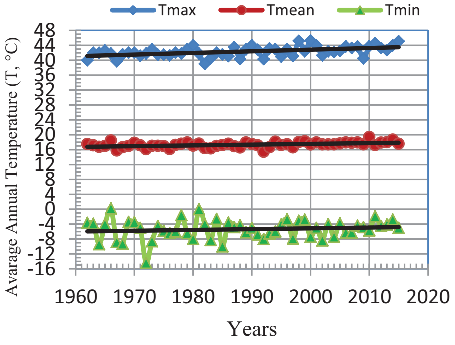
Adıyaman



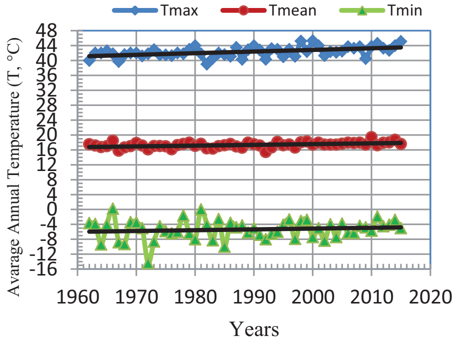
Batman



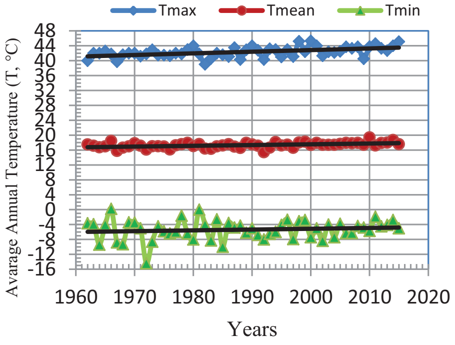
Diyarbakır



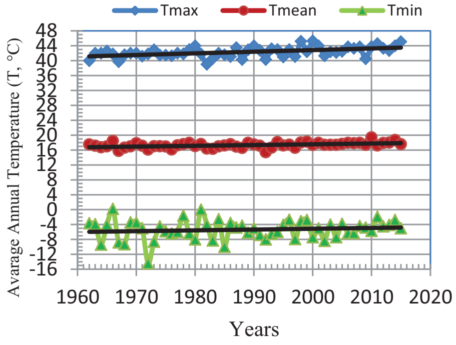
Gaziantep



Kilis



Mardin



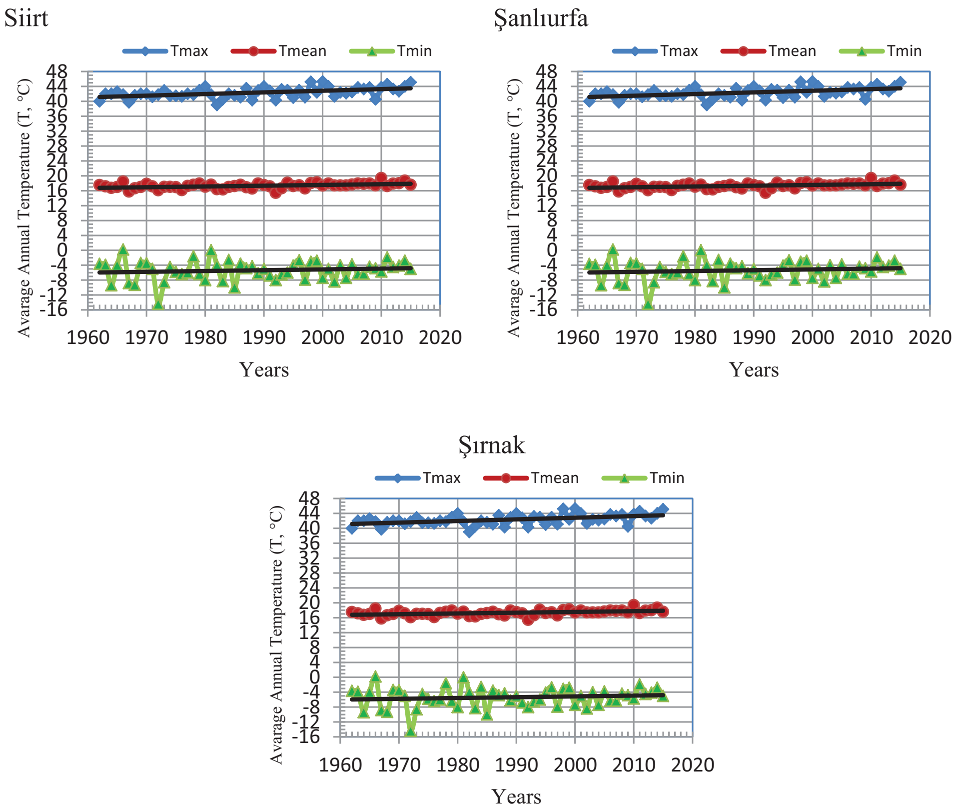


Figure 1. Visual changes in long-term daily maximum (T_{max}), mean (T_{mean}) and minimum (T_{min}) temperature values

Figure 1 indicates that the trends of the temperature series generally agree with one another. Depending on the potential climatic changes in the region, significant rising trends have occurred in the regional provinces of Adıyaman for maximum and mean; in Gaziantep for maximum, mean and minimum; in Mardin for maximum and mean temperatures; in Şanlıurfa for maximum and mean temperatures; in Kilis for mean and minimum temperatures, and in Batman, Siirt and Şırnak for mean temperatures.
These results agree with the predictions made by Turkes et al. (2002) with the 1975–2005 annual and seasonal maximum, mean and minimum temperature increases. The geographical position of the region supports the rising trend along with long-term temperatures. In another study that examined temperature and precipitation values through trend analysis (Bahadir, 2011), the southern part of Turkey was said to be particularly sensitive to climatic changes. It indicates that the rising trend in temperature will continue and be occasionally severe in the future in the provinces of the Southeastern Anatolia project field. Therefore, our findings are compatible with these predictions.
In order to demonstrate the statistical significance of the trends in long-term annual daily maximum, mean and minimum temperature values of the provinces in the study area, a linear regression analysis was carried out in a first phase, and an MKT was conducted in a second phase. The linear analysis equations and features of the provinces, by years, are illustrated in Tables 1, 2, and 3.

Table 1. Linear regression analysis features of long-term daily maximum temperatures

Weather Station	Regresion Coefficient (b)	Correlation Coefficient (r)	t value	t_{critic}	p value	Trend No	Trend Inceases	Trend Decreases
Adıyaman	0.0440	**0.494**	**+ 4.100**	±2,0036	**0.000**		**X**	
Batman	- 0.0161	0.170	- 1.260	±2,0054	0.212	X		
Diyarbakır	- 0.0043	0.055	- 0.400	±2,0054	0.689	X		
Gaziantep	0.0264	**0.302**	**+ 2.330**	±2,0054	**0.024**		**X**	
Kilis	0.0132	0.045	+ 1.050	±2,0054	0.296	X		
Mardin	0.0280	**0.371**	**+ 2.940**	±2,0054	**0.005**		**X**	
Siirt	0.0017	0.010	+ 0.140	±2,0054	0.887	X		
Şanlıurfa	0.0219	**0.084**	**+ 2.020**	±2,0054	**0.049**		**X**	
Şırnak	0.0209	0.195	+ 1.330	±2,0162	0.189	X		

Table 2. Linear regression analysis features of long-term daily mean temperatures

Weather Station	Regresion Coefficient (b)	Correlation Coefficient (r)	t value	t_{critic}	p value	Trend No	Trend Increases	Trend Decreases
Adıyaman	0.0205	**0.451**	**+ 3.640**	±2,0036	**0.001**		**X**	
Batman	0.0291	**0.503**	**+ 4.270**	±2,0054	**0.000**		**X**	
Diyarbakır	- 0.00332	0.071	- 0.510	±2,0054	0.615	X		
Gaziantep	0.0299	**0.552**	**+ 4.870**	±2,0054	**0.000**		**X**	
Kilis	0.0201	**0.474**	**+ 3.960**	±2,0054	**0.000**		**X**	
Mardin	0.0275	**0.552**	**+ 4.500**	±2,0054	**0.000**		**X**	
Siirt	0.0211	**0.391**	**+ 3.120**	±2,0054	**0.003**		**X**	
Şanlıurfa	0.0235	**0.491**	**+ 4.140**	±2,0054	**0.000**		**X**	
Şırnak	0.0380	**0.608**	**+ 5.080**	±2,0162	**0.000**		**X**	

Table 3. Linear regression analysis features of long-term daily minimum temperatures

Weather Station	Regresion Coefficient (b)	Correlation Coefficient (r)	t value	t_{critic}	p value	Trend No	Trend Increases	Trend Decreases
Adıyaman	0.0218	0.130	+ 0.960	±2,0036	0.344	X		
Batman	0.0006	0.010	+ 0.010	±2,0054	0.991	X		
Diyarbakır	- 0.0402	0.130	- 0.980	±2,0054	0.332	X		
Gaziantep	0.0932	**0.470**	**+ 3.910**	±2,0054	**0.000**		**X**	
Kilis	0.0704	**0.422**	**+ 3.420**	±2,0054	**0.001**		**X**	
Mardin	0.0180	0.105	+ 0.780	±2,0054	0.441	X		
Siirt	0.0305	0.141	+ 1.050	±2,0054	0.300	X		
Şanlıurfa	0.0297	0.217	+ 1.640	±2,0054	0.107	X		
Şırnak	0.0242	0.126	+ 0.850	±2,0162	0.402	X		

In Tables 1, 2 and 3, the statistical significance of the trend equations calculated for each province was analysed with correlation coefficient (r), a Student-t test and 5% probability (p) values.

The statistical significance of these trends has been determined to vary between + 4.100 and + 2.020 at daily maximum temperatures (Table 1), between + 5.080 and + 3.120 at daily mean temperatures (Table 2) and between + 3.910 and + 3.420 at daily minimum temperatures (Table 3). Moreover, in the long-term mean temperature changes of the provinces, it has been determined to vary between + 0.0440 and + 0.0219 at maximum temperatures, between + 0.0380 and + 0.0211 at mean temperatures and between + 0.0932 and + 0.0704 at minimum temperatures. The values given were listed to illustrate the important provincial trends. The values of the other non-trend provinces were not taken into account.

As a result of these analyses, it has been concluded that maximum temperatures of the provinces of Adıyaman, Gaziantep, Mardin, Şanlıurfa, the mean temperatures of the provinces of Adıyaman, Batman, Gaziantep, Kilis, Mardin, Siirt, Şanlıurfa and Şırnak, and the minimum temperatures in the provinces of Gaziantep, Kilis show statistically significant rising trends.

Moreover, in terms of the long-term annual average temperature-change values (linear regression analysis) of the regional provinces, the daily maximum temperatures were determined to vary between $+0.0219^{o}C\ 56^{-1}years^{-1}$ (for Şanlıurfa) and $+0.0440^{o}C\ 54^{-1}years^{-1}$ (for Adıyaman); the daily mean temperatures varied between $+0.0201\ ^{o}C/56$ years (for Kilis) and $+0.0380^{o}C\ 46^{-1}years^{-1}$ (for Şırnak) and daily minimum temperatures varied between $+0.0704^{o}C\ 56^{-1}years^{-1}$ (for Kilis) and $+0.0932^{o}C\ 56^{-1}years^{-1}$ (for Gaziantep).

Mann-Kendall Trend Test (MKT)

The changes in the long-term daily maximum, mean and minimum temperature values of the nine provinces in the study were analysed using the Mann-Kendall Trend Test. The result is illustrated in Tables 4, 5 and 6.

Table 4. MKT results of long-term daily maximum temperatures

Weather Station	Monitoring Period (n)	MKT Value ($u(t)$)	t_{critic}	Trend No	Trend Inceases	Trend Decreases
Adıyaman	54	**+ 3.812**	±2,0036		**X**	
Batman	56	- 0.452	±2,0054	X		
Diyarbakır	56	+ 0.028	±2,0054	X		
Gaziantep	56	**+ 2.474**	±2,0054		**X**	
Kilis	56	+ 0.905	±2,0054	X		
Mardin	56	**+ 2.940**	±2,0054		**X**	
Siirt	56	+ 0.283	±2,0054	X		
Şanlıurfa	56	**+ 2.587**	±2,0054		**X**	
Şırnak	46	+ 1.278	±2,0162	X		

Table 5. MKT results of long-term daily mean temperatures

Weather Station	Monitoring Period (n)	MKT Value ($u(t)$)	t_{critic}	Trend No	Trend Increases	Trend Decreases
Adıyaman	54	**+ 2.678**	±2,0036		**X**	
Batman	56	**+ 4.000**	±2,0054		**X**	
Diyarbakır	56	**- 0.608**	±2,0054	X		
Gaziantep	56	**+ 4.396**	±2,0054		**X**	
Kilis	56	**+ 3.732**	±2,0054		**X**	
Mardin	56	**+ 4.226**	±2,0054		**X**	
Siirt	56	**+ 3.449**	±2,0054		**X**	
Şanlıurfa	56	**+ 3.944**	±2,0054		**X**	
Şırnak	46	**+ 4.232**	±2,0162		**X**	

Table 6. MKT results of long-term daily minimum temperatures

Weather Station	Monitoring Period (n)	MKT Value ($u(t)$)	t_{critic}	Trend No	Trend Increases	Trend Decreases
Adıyaman	54	+ 0.828	±2,0036	X		
Batman	56	+ 1.060	±2,0054	X		
Diyarbakır	56	- 0.862	±2,0054	X		
Gaziantep	56	**+ 3.718**	±2,0054		**X**	
Kilis	56	**+ 3.152**	±2,0054		**X**	
Mardin	56	+ 1.484	±2,0054	X		
Siirt	56	+ 1.060	±2,0054	X		
Şanlıurfa	56	**+ 2.149**	±2,0054		**X**	
Şırnak	46	+ 1.240	±2,0162	X		

The MKT values calculated in Tables 4, 5 and 6 were analyzed against a 5% ($p<0.05$) significance level.

According to the MKT u(t) results statistically significant rising trends have occurred, respectively (see Tables 4, 5 and 6) in the provinces of Adıyaman (+3.812) Mardin, Şanlıurfa and Gaziantep (+2.474) where they vary between +3.812 and +2.474 in maximum temperature, in Şırnak (+4.232), Gaziantep, Mardin, Batman, Şanlıurfa, Kilis, Siirt and Adıyaman (+2.678) where they vary between +4.232 and +2.678 in mean temperatures, and in Gaziantep (+3.718) and Şanlıurfa (+2.149) where they vary between +3.718 and +2.149 in minimum temperatures. The values given were listed to illustrate the important provincial trends. The values of the other non-trend provinces were not taken into account.

CONCLUSIONS

The trend values calculated for long-term daily maximum, mean and minimum temperature values of every meteorology station in the region were analyzed with a 5% ($p<0.05$) level of significance using bidirectional t distribution. It has been determined that there is a statistically significant trend in the long-term maximum temperatures, mean temperatures and minimum temperatures of the provinces in the study area. The geographical location of the Southeastern Anatolia Region, internal migration, unplanned urbanization, deforestation, erroneous agriculture policies and industrialization are believed to be associated with these trends. The province most severely affected by the climatic change in the region is Gaziantep (changes at maximum, mean and minimum temperatures). The change in Gaziantep was found to be +2.64 ^{o}C 56^{-1}years^{-1} for maximum temperatures, +2.99 ^{o}C 56^{-1}years^{-1} for mean temperatures and +9.32 ^{o}C 56^{-1}years^{-1} for minimum temperatures.

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REFERENCES

Ahmed S.I., Rudra, R, Dickinson T., Ahmed M., 2014. Trend and periodicity of temperature time series in Ontario. American Journal of Climate Change, 3-5 September, 272-288p.

Bahadir M., 2011. Güneydoğu Anadolu Proje (GAP) alanında sıcaklık ve yağışın trend analizi. Uluslararası Sosyal Araştırmalar Dergisi, 4(16): 46-59. (in Turkish)

Bulut H., Yesilata B., Yesilnacar M.İ., 2006. Atatürk Baraj gölünün bölge iklimi üzerine etkisinin trend analizi ile tespiti. GAP V. Mühendislik Kongresi Bildiriler Kitabı, 26-28 Nisan 2006, 79-86s. (in Turkish)

Cosun F., Karabulut M., 2009. Kahramanmaraş'ta ortalama, minumum ve maksimum sıcaklıkların trend analizi. Türk Coğrafya Dergisi, 53: 41-50. (in Turkish)

Gardner R.H., Hargrove W.G., Turner M.G., Romme W.H., 1996. Climate change, disturbance and landscape dynamics, global change and terrestrial ecosystems. Cambridge University Press, 149-172.

Haan C.T., 1977. Statistical Methods in Hydrology, The Iowa State University Press, Ames, USA.

Hamdi M.R., Abu-Allaban M., Al-Shayeb A., Jaber M., Momani N.M., 2009. Climate change in Jordan: A comprehensive examination approach. American Journal of Environmental Sciences, 5(1): 58-68.

Kadıoglu M., 1997. Trend surface air temperature data over Turkey. Journal of Hydrology, 89: 128-144.

Karabulut M., Sarıyildiz F., Korkmaz H., Gürbüz M., 2008. Göksun'da yağış ve sıcaklıkların trend analizleri. 100. Yılında Göksun Sempozyumu, 23-24 Ağustos, Kahramanmaraş. (in Turkish)

Karabulut M., Cosun F., 2009. Kahramanmaraş ilinde yağışların trend analizi. Coğrafi Bilimler Dergisi, 7 (1): 65-83. (in Turkish)

Kendall M.G., 1975. Rank Correlation Methods, Charles Griffin, London.

Mann H.B., 1945. Nonparametric tests against trend. Econometrica. 13(3): 245-259.

Ozkul S., Fıstıkoglu O., Harmancıoglu N., 2008. İklim değişikliğinin su kaynaklarına etkisinin büyük menderes ve gediz havzaları örneğinde değerlendirilmesi, TMMOB 2. Su Politikaları Kongresi, 309-322. (in Turkish)

Partal T., Kahya E., 2006. Trend analysis in turkish precipitation data. Hydrological Processes. 20: 2011-2026.

Safari B., 2012. Trend analysis of the mean annual temperature in Rwanda during the last fifty-two years. Journal of Environmental Protection, 3: 538-551.

Singh D., Gupta R.D., Jain S.K., 2015. Study of daily temperature ındices over Sutlej Basin, N-W Himalayan Region, India, Global NEST Journal, 17(2): 301-311.

Sneyers R., 1990. On the statistical analysis of series of observations, WMO Technical Note 143, WMO No: 415, TP-103, Genva, World Meteorological Organization, pp:192.

Soydan N.G., Gümüş V., Şimşek O., Gerger R., Ağun B., 2015. Seyhan havzası aylık ortalama akım ve yağış verilerinin trend analizi. VIII. Ulusal Hidroloji Kongresi 8-10 Ekim, 330-339s, Şanlıurfa. (in Turkish)

Sensoy S., Demircan M., Alan İ., 2005. 1970-2004 Yılları arası Türkiye iklim indisleri trendleri, Devlet

Meteoroloji İşleri Genel Müdürlüğü, www.meteor.gov.tr/FILES/iklim/turkiye_iklim_indisleri.pdf (in Turkish)

Tecer L., Okutan H., Cerit O., 2004. İklim Değişimi: 1975-2001 Periyodunda Rize yağış ve sıcaklık trendlerinin analizi, 1. Ulusal Çevre Kongresi Bildiriler Kitabı, 355-365. (in Turkish)

Türkes M., Sumer U., Demir, I., 2002. Türkiye'nin günlük ortalama, maksimum ve minimum hava sıcaklıkları ile sıcaklık genişliğindeki eğilimler ve değişiklikler. 11-13 Nisan, Klimatoloji Çalıştayı Bildiriler Kitabı, 89-106, Izmir. (in Turkish)

Türkes M., Koc, T., Saris F., 2008. Spatiotemporal variability of precipitation total series over TURKEY, International Journal of Climatology. 29(8): 1056-1074.

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SPECIES OF PLANTS OF THE OLTEŢ RIVER BASIN

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Abstract

The Olteţ River Basin is an area with varied flora, due to natural factors represented by geomorphological formations, differences in altitude, latitude and climatic conditions. From the altitude of 1548 m in the upper part, at the beginning of the basin, to the 88 m in its lower part at Fălcoiu, where the river flows into the greater Olt river, there are altitudes of 905 m in the Olteţ Gorges at Polovragi and of 411 m in the hills of the Getic Plateau which is crossed by the Olteţ. In this article are presented the floral elements identified in the territory researched over many years, starting with the year 2007 and several data about the condition of populations. Observations of the number of individuals/the abundance and factors which can endanger the existence of some species have shown that there are changes taking place within the floral inventory.

Key words*: flora, ganera, species, vegetation, the Olteţ River Basin.*

INTRODUCTION

Spontaneous plant species of the Olteţ River Basin, regardless of what plant formations they are found in, are a component which needs and is worth the attention of researchers in this field.

The floral research conducted shows that there are common species which have a great number of individuals with a high frequency, but also cases of genres with few species which have a small number of individuals.

The floral composition of the vegetation in some points in the Basin has shown annual variations in many respects, especially as regards the entry or absence of entry into vegetation of some species.

Out of the great number of species found in the territory researched, this article presents 25 plant species from 21 genres, mentioned as spontaneous or rare in the literature.

MATERIALS AND METHODS

For observation of the species there were made field trips, in itinerary and stationary in some places, in the past years. Some plants have been harvested, pressed and placed on paper sheets in herbarium.

Those quoted as rare or vulnerable, as well as those existing in a small number of individuals, have been photographed. Determination was made using the special determiner devices. During the field trips all important aspects about each plant were written down in the field notebook.

Discussions were held with the local people to identify the place by the name given by these people, the popular name of the plant and the degree to which some of the plants were being used.

RESULTS AND DISCUSSIONS

The plant species identified in the territory researched have established the localization by the name of the locality, the popular name of the place and its coordinates by Google Earth. Aspects about the number of individuals are also presented, as well as the degree of damage by natural or anthropogenic factors.

Some of the descriptions are accompanied by photos of the plants, which were taken on the field.

***Angelica* L.**

Angelica arhangelica L. – Polovragi, upstream of the Olteţ Gorges, 45012′57.20″ N, 230 46′ 23.41″ E, alt. about 649 m, a very small number of individuals, some of which were damaged by the upstream flood, 21 VII 2014 (Figure 1).

Figure 1. *Angelica arhangelica*, the Olteţ Gorges (photo: M. Burduşel, July, 2014)

***Azolla* Lam.**
Azolla filiculoides Lam. (*A. caroliniana* Willd. non auct.) – Fălcoiu, stagnant waters from former irrigation channels, 44013′52.90″N, 24022′54. 86″E, alt. about 86 m, a small number of individuals, the channels are being clogged, 27 VIII 2009. This species is quoted by Gh. Popescu (1996) in the Corabia- Orlea-Potelu area, localities at a great distance from Fălcoiu (Figure 2).

Figure 2. *Azolla filiculoides*, Fălcoiu (photo: M. Burduşel, August 2009)

***Cerastium* L.**
Cerastium dubium (Bastard) Guepin (*Cerastium anomalum* Waldst. & Kit) – Tetoiu, in cultis abbandonatis 44043′46.03″N, 23055′26.10″E, alt. about 244m, a very small number of individuals, 3 IV 2008, leg. Maria Burduşel, det. G. Negrean and Maria Burduşel.

***Cynoglossum* L.**
Cynoglossum hungaricum Simonk. – Tetoiu in meadow „La Perieţeanu„ 440 43′ 40.14″ N, 230 55′ 13. 18″ E, alt. about 221 m, small number of individuals, of which few are reaching maturity as the plants are destroyed by the animals grazing in the area, 13 VI 2012 (Figure 3).

Figure 3. *Cynoglossum hungaricum*, Tetoiu (photo: M. Burduşel, June 2012)

***Cyperus* L.**
Cyperus serotinus Rottb. (*Juncellus serotinus* (Rottb.) C. B. Clarke; Duvaljouvea serotina (Rottb.) Palla) – Fălcoiu, a dike flooded area of the Olteţ River, 44013′55. 94″N, 24022′49.82″E, alt. about 86 m, a very small number of individuals, 14 VIII 2014.

***Corydalis* Vent.**
Coridalis solida (L.) Clairv. subsp. *Slivenensis* (Velen.) Hayek – Călui in Cerăt Forest, 44026′06.70″N, 24004′30.77″ E, alt. about 160 m, a very small number of individuals relative to the individuals from the solida subsp., 2 IV 2009.

***Doronicum* L.**
Doronicum hungaricum (Sadl.) Rchb. – Călui in Cerăt Forest, 44026′06.70″N, 24004′30.77″ E, alt. about 160 m, a small number of individuals, 28 IV 2010.

Figure 4. *Doronicum hungaricum*, Călui (photo: M. Burduşel, April 2010)

Echinops L.
Echinops exaltatus Schrad. (*E. commutatus* Jur.) – Tetoiu, in Chirca, the edge of the oaktree forest, 44043′41.13″ N, 23055′37.31″ E, alt. about 257 m, very small number of individuals, 23 VII 2011.

Erythronium L.
Erythronium dens-canis L. subsp. *niveum* Baumg. - Zătreni ,in Făget - Beechtree Forest, 44o47′31.38″N, 23051′07.12″ E, a small number of individuals, picked up as ornamental plants,10 III 2015.

Equisetum L.
Equisetum ramosisimum Desf. - Tetoiu in Lunca Olteţului – riverside, at the water well, 44043′29.32″N, 23054′37.17″ E, alt. about 211m, small number of individuals, 11 VI 2010.

Fritillaria L.
Fritillaria orientalis Adams (*F. montana* Hoppe; *F. tenella* M. Bieb.) – the Olteţ Gorges, at the bridge, 45012′20.98″ N, 23046′41.63″ E, a very small number of individuals, 14 IV 2010.

Gallium L.
Galium kitaibelianum Schult- Polovragi upstream of the Olteţ Gorges, 45012′57.20″ N, 230 46´ 23.41″ E, alt. about 649 m, a very small number of individuals at the edge between the pasture land and forest, 18 VII 2013.

Kickxia Dumort.
Kickxia elatine (L.) Dumort. subsp. *elatine* – Tetoiu, in cultis abbandonatis, at Perieţeanu, 44043′46.03″ N, 23055′ 26.10″ E, alt. about 244 m, a small number of individuals, 22 VII 2012.
Kickxia elatine (L.) Dumort. subsp. *crinita* - Tetoiu, in cultis abbandonatis, at Perieţeanu, 44043′46.03″ N, 23055′ 26.10″ E, alt. about 244 m, a very small number of individuals, 22 VII 2012.

Lathyrus L.
Lathyrus sphaericus Retz. – Irimeşti in the meadow, 44038′ 49.58″ N, 23055′ 26.77″ E, alt. about 191 m, a small number of individuals on the reduced areas of unpopulated pastures, 21 VI 2015.

Leontopodium (Pers.) R.Br.
Leontopodium alpinum Cass. – Polovragi in the Olteţ Gorges, 45011′48.83″ N, 23047′00.85″ E, alt. cca 680 m, a very small number of individuals on the rocky formations beside the grotto; there is grazing land in the area, 24 VII 2011.

Melittis L.
Melittis melissophyllum L. subsp. *melissophyllum* – Tetoiu in the Chirca Forest, 44043′41.13″ N, 23055′ 37.31″ E, alt. about 257 m, a small number of individuals; the forest is being exploited, 18.VI.2014 (Figure 5).

Figure 5. *Melitis melissophyllum*, Tetoiu (photo: M. Burduşel, June 2014)

Ornithogalum L.
Ornithogalum boucheanum Ascherson, E+M, Fălcoiu in the acacia tree forest of Dobrosloveni, 44012′10.77″ N, 24020′59. 72″ E, alt. about 107 m, a small number of individuals, 2 IV 2017.
Ornithogalum pyramidale L. – Tetoiu in the grasslands, near the Drumul Satului (Village Road), 44043′44.25″ N, 230 55′34.08″ E, alt. about 259 m, a small number of individuals, 3 VI 2010.
Ornithogalum umbellatum L. – Polovragi, a glade in the beechtree forest, 45011′55.84″N, 2 047′09.84″ E, alt. cca 705 m, a small number of individuals, 12 V 2009.

Ranunculus L.
Ranunculus constantinopolitanus (DC) D,Urv. – Călui in the Cerăt Forest, 44026′06.70″ N, 24 04′30.77″ E, alt. cca 160 m, a small number of individuals, 16 IV 2009; Fălcoiu in the Razem

Forest, 44013′10.60″N, 24 22′35.80″E, alt about 88 m, a great number of individuals in some places in the forest, 2 IV 2016 (Figure 6).

Figure 6. Forest image with *R. constantinopolitanus*, Fălcoiu. (photo: M. Burduşel, April 2016)

Saxifraga **L.**

Saxifraga tridactylites L. – Polovragi in the Olteţ Gorges, at the Grotto, 45011′48.83″ N, 23047′00. 85″ E, alt. about 680 m, a very small number of individuals exposed to grazing, 28 IV 2007 (Figure 7).

Figure 7. *Saxifraga tridactylites*, the Olteţ Gorges (photo: M. Burduşel, April 2007)

Sedum L.

Sedum sexangulare L. – Fălcoiu, the dike area of the Olteţ River at the confluence with the Olt River, 44013′54.75″ N, 240 22′50.88″ E, alt. about 86 m, a great number of individuals, 6 VII 2010 (Figure 8).

Figure 8. *Sedum sexangulare*, Fălcoiu (photo: M. Burduşel, July 2010)

Veronica **L.**

Veronica orchidea Crantz (*V. spicata* L. subsp. *orchidea* (Crantz) Hayek) – Tetoiu pasture Dealul Viilor (Vineyard Hill), 440 43′53.23″ N, 230 55′55.17″ E, alt. about 303 m, a very small number of individuals, destroyed by grazing, 6 V 2008 (Figure 9).

Figure 9. *Veronica orchidea* ((photo: M. Burduşel, May 2008)

Veronica triphyllos L. – Fălcoiu on the outer side of the dike, 44013′52.90″ N, 240 22′54.86″E, alt. about 86 m, a great number of individuals, exposed to grazing, 27 III 2011.

In order to evaluate the abundance of some of the species, we have agreed that a number smaller than 10 individuals of a population should be considered a very small number and between 10 and 50 idividuals should be considered a small number. The species with over 50 individuals in a population are Ranunculus constantinopolitanus, in the Razem Forest, Fălcoiu and Sedum sexangulare,which have been quoted as having a great number of individuals.

CONCLUSIONS

The aspects presented here offer information about the spontaneous plant species in the Olteţ River Basin, with respect to their diversity, abundance and degree of endangerment. Depending on these data measures can be established to limit the decrease in the number of individuals from some species. In this article we can find partial results from the vast research. Introduction of the photos is meant to facilitate determination of the species and the access to knowing them by the beginner students of this field.

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REFERENCES

Dihoru Gh., Dihoru Alexandrina, 1994. Plante rare, periclitate şi endemice în Flora României - Lista roşie - Red list of rare, endangered and endemic plants in the Flora of Romania. Acta Bot. Horti bucurest. /1993-1994/: 173-197.

Negrean G., 2001. Lista roşie a plantelor din România existente în pajişti (inclusiv endemite şi subendemite) - Red list of the plants in the meadows of Romania (including endemites and subendemites) Pp. 30-58. In: Gheorghe Coldea, Gavril Negrean, Ion Sârbu & Anca Sârbu. 2001. Ghid pentru identificarea şi inventarierea pajiştilor seminaturale din România. - A Guidebook for identification and inventory of the semi-natural meadows in Romania, Bucureşti Edit. alo. 58 pp.

Oltean M., Negrean G., Popescu A., Roman N., Dihoru G., Sanda V., Mihăilescu S., 1994. Lista roşie a plantelor superioare din România. – Red list of superior plants in Romania, In: M. Oltean (coord.), Studii, sinteze, documentaţii de ecologie – Studies syntheses, research in ecology,Acad. Română, Institutul de Biologie, Nr. 1: 1

Păun M., Popescu Gh., 1971. Flora spontană din cursul superior al văii Olteţului, - Spontaneous flora of the upper course of the Olteţ River Valley -Comunicări de Botanică, Bucureşti, XII.

Păun M., 1965. Contribuţii la flora raionului Balş, regiunea Oltenia - Une contribution à la connaissance de la flore du district de Balş, region d'Oltenie. Bul. Şti., Inst. Agron. 7: 27-59. /listă 467 spp, 4 hybr, 17 subsp, 57 var, 2 forme, coronime, B: 18, R: fr rs/.

Păun M., 1965. Contribuţii la flora raionului Balş, regiunea Oltenia - Une contribution à la connaissance de la flore du district de Balş, region d'Oltenie. Bul. Şti., Inst. Agron. Craiova 7: 27-59.

Popescu Gh., 1979. Noutăţi floristice şi de vegetaţie din Oltenia – New floral and plant findings in Oltenia, Studii şi cercetări de Biologie, Edit. Academiei Republicii Socialiste România,T. 31, Nr. 1, 13 pag.

Săvulescu T. et al., 1952, 1976. Flora R.P.R.-R.S.R., Vol. I-XII, Edit. Academiei Române, Bucureşti

Păun M. 1969. Vegetaţia acvatică din împrejurimile oraşului Balş – Aquatic vegetation in the surroundings of Bals, Comun. Bot. 10: 201-222.

Păun M., Popescu G., 1975. Date asupra vegetaţiei cursului superior al Olteţului - Quelques notes sur la végétation du cours superieur de la rivière Olteţ. Lucr. Şti., Volum Omagial, 25 ani Învăţământ. Superior Agronomic în Oltenia (1948-1973), Universitatea Craiova. /1975/: 138-143. /de la Negovanul şi Curmătura Olteţului la Polovragi, listă & descr. 8 asoc, câteva spp, B: 8, R: fr/.

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INFLUENCE OF GEOGRAPHICAL FACTORS ON THE FATTY ACID PROFILE AND OIL YIELD OF *Olea europaea* L.

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Abstract

Olive tree is important oil sources for Mediterranean countries. For their excellent nutritional quality, olives and olive oil have always been essential component of the diet in many Mediterranean civilizations. Geographical factors such as slope, aspect, lithology, geology and elevation influence plant growth, development and subsequently main primary and secondary metabolite production, secretion and accumulation. Because of geographical factors and cultivated olive cultivars which indicate high genetic diversity in Turkey influence the fatty acid composition. This may result in a standardization problem in terms of olive production and their fatty acid composition. Geographical Information System (GIS) has been increasingly performed to analyze the influence of location on the growth and distribution of plants. In the present work changes in olive oil content and its fatty acid composition were discussed with the extent of varying geological and environmental factors. Herein, there was a weak relation between slope and major fatty acids except linoleic acid. Among the tested parameters, oil yield was more pronounced with varying slope percentage. There was a higher correlation with respect to the elevation than slope effect concerned with fatty acid compositions. With respect to the aspect and lithology, higher oil yields and fatty acid compositions were obtained in the south and southeast aspect and basaltic soils

Key words: *fatty acid, geographical information system, GIS, Olea europaea L., olive*.

INTRODUCTION

Geographical Information System (GIS) has a great concerned system of managing, analyzing, and displaying all forms of geographically referenced information. Since the disciplines of the plant sciences and geography are intertwined, GIS has been increasingly performed to analyze the influence of location on the growth and distribution of plants. The key role of GIS has gained an interest for the study of plants in fields ranging from agriculture to ecology (Morgan, 2011). Soil, topography and climatic factors are the nonliving components affecting plant growth and development and consequently the biochemical and physiological indices of plants at all levels as well as determine the extent where the genetic factors are up or down regulated or expressed (Bareja, 2011).
Traditionally, plants have been extensively used for medicinal, nutritional, flavoring, cosmetically and industrial purposes. Of those plants, *Olea europaea* L. (olive) belonging to the *Oleaceae* family is of the most important crops especially in Mediterranean countries. On plantation which they cover around 8 million hectares on the worldwide (Guinda et al., 2004) and its fruit and oil have a major agricultural importance in Turkey. Besides its fruits as table olive, its fatty oil is characterized with distinguished fatty acid composition, of which medicaly importance has been proven by a number of studies (Leon et al., 2004; Matson and Grundy, 1985). Moreover, the oil obtained from olive fruits have essential key roles for reactive oxygen species (ROS) which are associated with pathology of some diseases including diabetes, cardiovascular, cancer, age related, and neurological disorders has been well documented (Chacraborty et al., 2009; Ishii, 2007; Burhans and Weinberger, 2007; Polidori et al., 2007; Halliwell and Guteridge, 1999; Soholm, 1998).
Plant growth may be positively or adversely affected in growing area by a number of

factors. Since the important property of olive oil and the odor as well as flavors association with oil quality have been found to be correlated with fatty acid composition (Maestro and Borja, 1990; Leon et al., 2004). In the present study, variation in the oil yield and fatty acid compositions was examined with geographical factors. Also, the size of variation by geographical conditions where the sampling done, and evaluations were compared based on the regression and linear trend analysis.

MATERIALS AND METHODS

Geographic Information System (GIS)

The sampling sites were mapped with the tools of geographic information systems (GIS). A GIS-based map can clarify and combine the geographical or environmental condition relation-effects on biochemical contents of a plant. In this context, slope, lithology, geology, aspect and digital elevation model (DEM) maps of the sampling sites were composed. Herein, the relatively experimental laboratory results were discussed applying the power of new technologies with the ever-increasing vast of geospatially- based data. Fatty acid changes, essential to human health, were under discussion with the extent of varying geological and environmental factors in the present work.

Sampling site and method

The olive fruits were sampled in the Kilis Yaglik cv. that approximately the same aged trees from Kilis district of southeastern part of Turkey. Fruits were also harvested in the same ripening period (mid-December 2012) from the same position on the sampled trees. The detailed information concerning the topographical and geographical data of experimental sites of the region is collectively present in Figure 1.

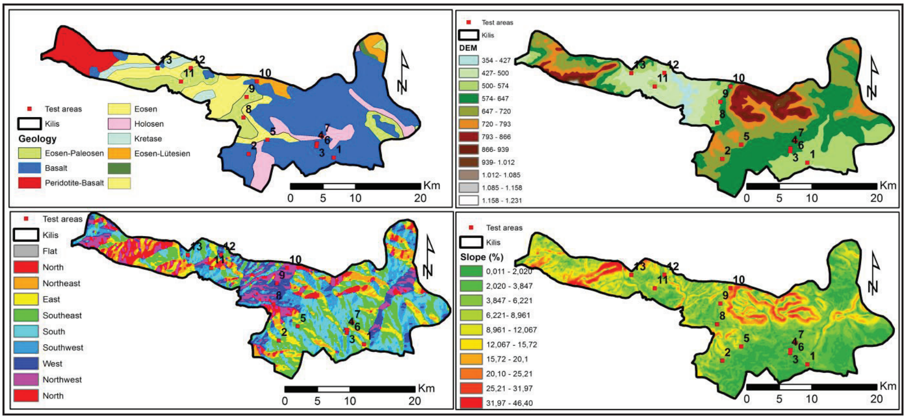

Figure 1. The topographical and geographical data of experimental sites of the region

Oil extraction and fatty acid composition analysis

The oils were extracted from olive fruits (each 10 g sample) with n-hexane for four hours using a Soxhalet Extraction Apparatus (Thermal). Then the solvent was evaporated under reduced pressure and temperature using a Rotary Evaporator (Heidolph). 0.5 g of olive oil was added 10 ml n-heptanes into a screw-capped tube for esterification. The fatty acid analyses were conducted according to the official method COI/T.20/Doc.no.24 2001. 0.1 g of olive oil was taken into screw-capped tube. 2 ml n-heptanes were added to it and shaken. After 0.2 ml methanolic potassium hydroxide was added for esterification, tubes were vigorously shaken for 30 sec. after the vials were closed. The supernatant of the solution was taken followed after one hour of incubation at room temperature. Then, the supernatant was put in 2 ml vials for injection.

GC-FID analyses of fatty acids methyl esters was carried out on a Shimadzu Gas Chromatography (GC-2010 series) equipped with an Supelco SP 2380 fused silica capillary column (100 m, 0.25 mm i.d., 0.2 µm film thickness). Helium was used as carrier gas, at a flow rate of 3 mL/min. The injection and detector

temperature were 140 ºC and 240 ºC, respectively. The oven temperature was held isothermal at 140 ºC for 5 min, then raised to 240 ºC at 4 ºC /min and held isothermal at 240 ºC for 15 min. Injection volume of Diluted samples [1/100 (v/v) in n-heptanes] of 1.0 µL were injected automatically in the split mode (1/100).
The identification of the constituents was based on comparison of the GC-retention times with those of available analytical standards (Larodan Fine chemicals, mixture of 37 components of fatty acids methyl esters). Peak area was used to obtain the percentage of individual fatty acid.

RESULTS AND DISCUSSIONS

This study was designed to examine the effects slope, aspect, elevation and lithology of locations on the oil yield and some major fatty acid components of the oil of olive fruits collected from different orchards in Kilis province of Turkey. In this context, 13 locations for sampling were chosen and the numerical and geographical information concerned with sampling sites were represented and, the oil yields and their fatty acid components were numerically and empirically demonstrated in Table 1.

Table 1. Geographical and topographical properties, and oil yields with their fatty acid compounds for each location

Longitude	Latitude	Location	Oleic acid	Linoleic Acid	Palmitic acid	Stearic acid	Oil yield	Slope (%)	Aspect	Elevation	Lithology
37.21	36.68	1	67.45	11,02	13.28	4.32	22.14	2.93	East	528	Basaltic
37.06	36.69	2	69.96	9.19	12.84	4.06	26.88	1.86	East	673	Basaltic
37.18	36.70	3	67.17	11.18	13.95	4.47	21.63	2.95	South	560	Basaltic
37.18	36.70	4	68.86	10.17	13.16	4.09	22.53	1.84	South	580	Basaltic
37.10	36.71	5	66.24	12.69	13.17	4.29	30.16	4.25	Southeast	645	Basaltic
37.19	36.71	6	65.46	11.55	14.66	3.94	18.4	4.21	South	609	Basaltic
37.19	36.71	7	68.89	10.19	13.09	4.17	24.08	4.21	South	610	Basaltic
37.06	36.74	8	66.08	12.71	13.83	3.28	25.88	4.19	Southwest	557	Eosen Marn
37.06	36.77	9	67.29	11.55	14.44	2.99	25.78	7.41	West	586	Eosen Marn
37.08	36.79	10	68.72	10.50	13.45	3.41	28.75	11.8	Northwest	591	Eosen Limestone
36.95	36.79	11	68.96	8.75	13.53	4.36	14.62	8.96	South	460	Eosen Limestone
36.97	36.81	12	66.91	12.07	13.81	3.67	29.37	5.77	West	454	Eosen Limestone
36.91	36.81	13	67.88	10.67	13.16	4.34	18.23	8.97	South	513	Kretase Limestone

Effects of slope
The slope of the collections where we sampled olive fruits ranged from 1.86-11.88 %.
The inclination of land effects on oleic acid, linoleic acid, palmitic acid, stearic acid, which are the major fatty acid components of olive oils and oil yield were represented in Figures 2-6 with R^2=0.1356, R^2=0.018, R^2=0.1313, R^2=0.1313 and R^2=0.2872, respectively.
Even though weak correlation was obtained among slope effects on the mentioned parameters, we can deduce that linoleic acid comprising the essential portion of olive oil was not significantly found to be affected. Among the tested parameters, oil yield was more pronounced with varying slope percentage (R^2=0. 2872) (Table 2).

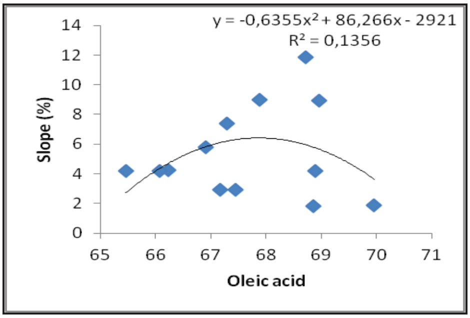

Figure 2. The effects of slope on oleic acid content

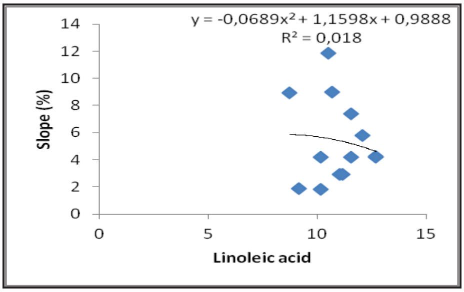

Figure 3. The effects of slope on linoleic acid content

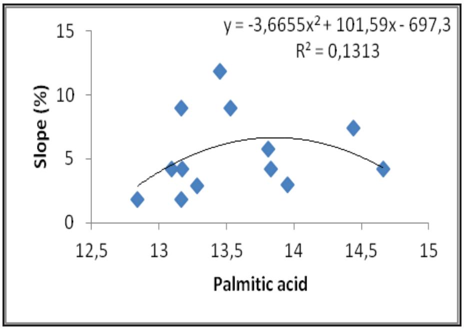

Figure 4. The effects of slope on palmitic acid content

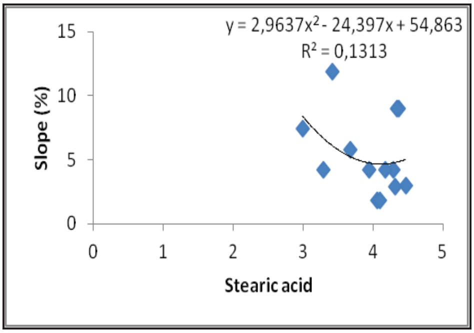

Figure 5. The effects of slope on stearic acid content

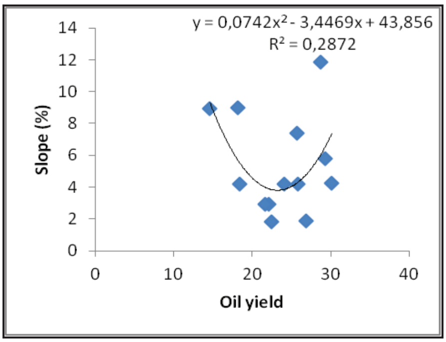

Figure 6. The effects of slope on oil yield

Effects of elevation

Locations ranged in elevation from 454 to 673 m herein. The altitude of location effects on oleic acid, linoleic acid, palmitic acid, stearic acid, which are the major fatty acid components of olive oils and oil yield were represented in Figures 7-11 with R^2=0.3342, R^2=0.0034, R^2=0.4977, R^2=0.0233 and R^2=0.2574, respectively. Herein, it was demonstrated that there was a moderate correlation between elevation and palmitic acid. However, the impacts of slope were attenuated with the elevation.

There was a higher correlation with respect to the elevation than slope effect concerned with fatty acid component herein however; the lower correlation was obtained in elevation effect than slope impact. Linoleic acid (R^2=0.0034) and stearic acid (R^2=0.0233) were determined to be less correlated to the varying elevation. (Table 2)

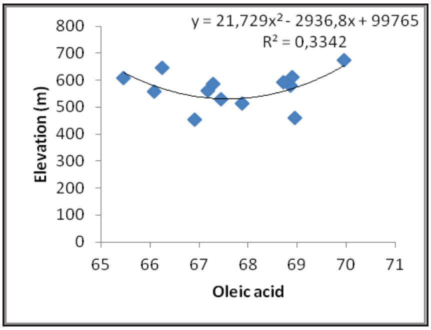

Figure 7. The effects of elevation on oleic acid content

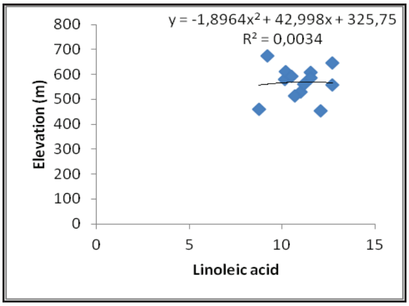

Figure 8. The effects of elevation on oleic acid content

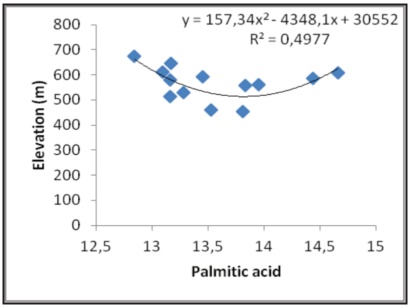

Figure 9. The effects of elevation on palmitic acid content

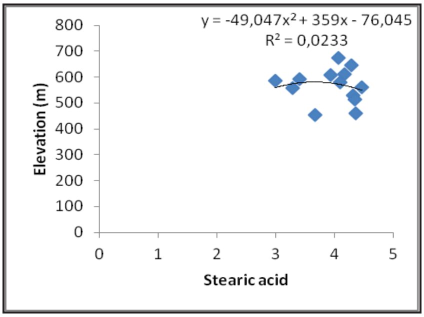

Figure 10. The effects of elevation on stearic acid content

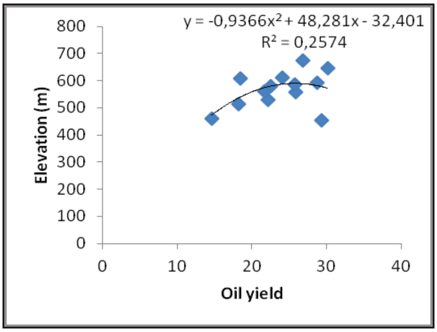

Figure 11. The effects of elevation on yield

Table 2. Relationship between topographical properties and oil yields and fatty acids

TP	Fatty acids and oil yield	RE	DC (R^2)
Slope	Oleic acid	$y = -0.635x^2 + 86.266x - 292$	0.1356
	Linoleic Acid	$y = -0.068x^2 + 1.159x + 0.98$	0.0180
	Palmitic acid	$y = -3.66x^2 + 101.59x - 697.3$	0.1313
	Stearic acid	$y = 2.963x^2 - 24.397x - 54.86$	0.1313
	Oil yield	$y = 0.074x^2 - 3.45x + 43.85$	0.2872
Elevation	Oleic acid	$y = 21.729x^2 - 2936.8x + 997$	0.3342
	Linoleic Acid	$y = -1.89x^2 + 42.99x + 325.7$	0.0034
	Palmitic acid	$y = 157.34x^2 + 434.1x + 305$	0.4977
	Stearic acid	$y = -49.047x^2 + 359x - 76.04$	0.0233
	Oil yield	$y = -0.936x^2 + 482x - 32.401$	0.2574

Effects of aspect

Aspect have a strong and significant influence on temperature through the affecting the angle of sun-lights reaching and contacting with the ground. Consequently, microclimates of the regions are strongly influenced by the aspect of a slope. Of 13 test areas in the present work, east (2), south (6), southeast (1), southwest (1), northwest (1) and west (2) aspects were determined (Table 1). Aspect as a climate factor is significantly influenced by temperature and precipitation elements. In fact, plant species diversity and frequency in Turkey differ on the slopes of the mountains overlooking the sea than on the slope overlooking the mountains inland. This is an important aspect factor of influence on the vegetation. The highest oil yield was determined in the southeast aspect orchids above 600 m elevation having basaltic soils. Interestingly, eosin-limestone soils at different aspects also gave higher oil yield with major fatty acid compositions. However, of tested 13 areas, oil yield and its major fatty acid compositions varied significantly depending aspects correlatively elevation and soil type.

Effects of lithology

Marly surfaces are composed of easily friable rocks. Therefore, erosion severely occurs on bare surfaces, causing decline in mineral content and soil thickness. In the present study, olive trees locating on different rock types were determined higher oil yields and fatty acid components were obtained in basaltic soils. Volcanic rock basalt has rich mineral content. Basalt rock reacts are dissolved and physically disintegrated after reaction with water. Then basaltic soils are formed from the rocks. Nevertheless, lithology ought not to be considered lonely for oil yield and its fatty acid composition variation. The slope or inclination of a land can be defined as the percentage change in its elevation over a certain distance (Bareja, 2011). Plant growth and consequently biochemical indices of a plant are influenced by the steepness of a slope through differential incidence of solar radiation, wind velocity and soil type (Bareja, 2011) and availability of water and nutrients (Casado et al., 1985; Montalvo, 1992; Maggi et al., 2005) and therefore on each slope, *Olea europaea* L. faces different environmental challenges as a heterogeneous environments resulted from slope habitats (Maggi et al., 2005). Biology of organisms at all levels was reported to be affected with the varying the microclimatic conditions on the slopes (Nevo, 1997, 2001; Auslander et al., 2003). Herein, it was addressed that sharp microclimatic differences may stress plants (Moller and Swaddle, 1997; Auslender et al., 2003) and consequently production and release of secondary metabolite between slopes. Slope positions were associated with less variability in previous reported papers (Maggi et al., 2005). Plant biomass was significantly correlated (r=0.65 and 0.70) in the report by Kapolka and Dollhopf (2001). However, up to our best knowledge, no data have been proposed concerned with biochemical components of oils and oil yield.

The elevation or altitude of the land affects plant growth and development primarily through temperature effect (Bareja, 2011). Altitudinal gradients effects on plant growth through photosynthetic rate have been of interest to plant physiologists and ecologists (Billings et al., 1961; Körner and Diemer, 1987; Friend et al., 1989; Terashima et al., 1995; Bowman et al., 1999; Sakata and Yokoi, 2002; Kumar et al., 2005). In considering the impacts of elevation on plant growth and related parameters, altitudinal gradients affect not only temperature gradients but partial pressure of carbon dioxide in air and its effect on photosynthesis, resulting variations on plant phenology and growth (Heegaard, 2002; Fernandes-Calvo and Obeso, 2004; Fujimura et al., 2010).

CONCLUSIONS

The consequences of the study reveal that oil yields and fatty acid profile of the oils were influenced by the different ecological and topographical conditions, supplying additional information about the climatic conditions and its impact on the oil quality. Herein, there was a weak relation between slope and major fatty acids except linoleic acid.

Among the tested parameters, oil yield was more pronounced with varying slope percentage. There was a higher correlation with respect to the elevation than slope effect concerned with fatty acid compositions. With respect to the aspect and lithology, higher oil yields and fatty acid compositions were obtained in the south and southeast aspect and basaltic soils.

Ever increasing need for productive uses of land and natural resources under global climate changings directed researchers to assess to find new computer based technologies or agricultural techniques for sustainable crop production and higher yield regarding with desired secondary and primary metabolite content.

In the light of the present study, this information may help to understand topography and to predict the best plantations for crops.

REFERENCES

Auslander M., Nevo E., Inbar M., 2003. The effects of slope orientation on plant growth, developmental instability and susceptibility to herbivores. Journal of Arid Environments 55: 405-416.

Bareja B.G., 2011. The abiotic factors affecting plant growth and development include topography and soil. Crop Farming Review (http://www.cropsreview.com /abiotic-factors.html; access date: 25/02/2017)

Billings W.D., Clebsch E.E.C., Mooney H.A., 1961. Effect of low concentrations of carbondioxide on photosynthesis rates of two races of Oxyria. Science 133: 1864.

Bowman W.D., Keller A., Nelson M., 1999. Altitudinal variation in leaf gas exchange, nitrogen and phosphorus concentrations, and leaf mass per area in populations of *Frasera speciosa*. Arct Antarct. Alpine Res 31: 191-195.

Burhans W.C., Weinberger M., 2007. DNA replication stress, genome in stability and aging. Nucleic Acids Res 35:7545-7556.

Casado M.A., Miguel J.M., Sterling A., Galiano E.F., Pineda F.D., 1985. Production and spatial structure of Mediterranean pastures in different stages of ecological succession. Vegetation 64(2):75-86.

Chakraborty A., Ferk F., Simic T., Brantner A., Dusinska M., Kundi M., Hoelzi C., Nersesyan A., Knasmüller S., 2009. DNA-protective of sumach (Rhus coriaria L.), a common spice: Results of human and animal studies. Mutation Research/Fundamental and Molecular Mechanisms of Mutagenesis 661(1): 10-17.

Fernández-Calvo I.C., Obeso J.R., 2004. Growth, nutrient content, fruit production and herbivory in bilberry *Vaccinium myrtillus* L. along an altitudinal gradient. Forestry 77(3): 213-223.

Friend A.D., Woodward F.I., Switsur, V.R., 1989. Field measurements of photosynthesis, stomatal conductance, leaf nitrogen and δ 13 C along altitudinal gradients in Scotland. Functional Ecology 117-122.

Fujimura S., Shi P., Iwama K., Zhang X., Gopal J., Jitsuyama Y., 2010. Effect of altitude on theresponse of net photosynthetic rate to carbondioxide increase by spring wheat. Plant Production Science 13(2): 141-149.

Guinda A., Albi T., Camino M.C.P., Lanzo´n A., 2004. Supplementation of oils with oleanolic acid from the olive leaf (*Olea europaea* L). European Journal of Lipid Science and Technology 106: 22–26.

Halliwell B., Gutteridge J.M.C., 1999. Free radicals in biology and medicine (3rd ed.). Oxford: Oxford University Press.

Heegaard E., 2002. A model of alpine species distribution in relation to snow-melt time and altitude. Journal of Vegetation Science 13: 493-504.

Ishii N., 2007. Role of oxidative stress from mitochondria on aging and cancer. Cornea 200(26):S3-S9.

Kapolka N.M., Dollhopf D.J., 2001. Effect of slope gradient and plant growth on soil loss on reconstructed steep slopes. International Journal of Surface Mining, Reclamation and Environment 15 (2): 86-99.

Körner C., Diemer M., 1987. In situ photosynthetic responses to light, temperature and carbondioxide in herbaceous plants from low and high altitude. Funct. Ecol 1: 179-194.

Kumar N., Kumar S., Ahuja, P.S., 2005. Photosynthetic characteristics of *hordeum, triticum, rumex, and trifolium* species at contrasting altitudes. Photosynthetica 43: 195-201.

Leon L., Uceda M., Jimenez A., Martin L.M., Rallo L., 2004. Variability of fatty acid composition in olive (*Olea europaea* L.) progenies. Spanish Journal of Agricultural Research 2(3): 353-359.

Maestro D., Borja P., 1990. La calidad del aceite de oliva la composicion y maduracion de la aceituna. Grasas y Aceites 41:171–178

Maggi O., Persiani A.M., Casado M.A., Pineda F.D., 2005. Effects of elevation, slope position and livestock exclusion on microfungi isolated from soils of Mediterranean grasslands. Mycologia 97(5): 984–995.

Matson F.M., Grundy S.M., 1985. Comparison of effects of dietary saturated, mono unsaturated and poly unsaturated fatty acids on plasma lipids and lipoproteins in man. Journal of Lipid Research 26: 194-202.

Møller A.P., Swaddle J.P., 1997. Asymmetry, Developmental Stability, and Evolution Oxford University Press, Oxford

Montalvo J., 1992. Estructura y funcio´n de pastizales mediterra´neos [doctoral dissertation]. Madrid, Spain: Universidad Complutense.

Morgan B.J., 2011. Geographic Information Systems for the Plants Sciences. Arnoldia 69 (1): 14-22.

Nevo E., 1997. Evolution in action across phylogeny caused by microclimatic stresses at “Evolution Canyon” Theoretical Population Biology 52:231–243

Nevo E., 2001. Evolution of genome–phenome diversity under environmental stress Proceedings of the National Academy of Sciences 98: 6233–6240

Polidori M.C., Griffiths H.R., Mariani E., Mecocci P., 2007. Hall marks of protein oxidative damage in neurodegenerative diseases: Focus on Alzheimer’s disease. Amino Acids 32:553–559.

Sakata T., Yokoi Y., 2002. Analysis of the O_2 dependency in leaf level photosynthesis of two *Reynoutria japonica* populations growing at different altitudes. Plant, Cell & Environment 25(1): 65-74.

Soholm B., 1998. Clinical improvement of memory and other cognitive functions by *Ginkgo biloba*: Review of relevant literature. Adv Ther 15:54–65.

Terashima I., Masuzawa T., Ohba H., Yokoi Y., 1995. Is photosynthesis suppressed at higher elevations due to low CO_2 pressure? Ecology 76: 2663-2668. Figure 3. View from a Dairy Farm in the NE part of Romania.

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PARTICULARITIES OF COGNITIVE DEVELOPMENT OF THE STUDENTS FROM THE AGRICULTURAL SPECIALITIES IN THE CONTEXT OF INITIAL TRAINING

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Abstract

The paper aimed to present the role and impact of International Fund for Agriculture on the development of the rural areas of the Republic of Moldova. Till the present the rural development are on the law level. The farmers were facing significant problems in running the business and a lot of poor people still lived in rural areas. These people could potentially be employed only in Agriculture as other economic activities are less developed in the rural areas.
The Rural Financial Services and Agribusiness Development Project (RFSADP) is the fifth International Fund for Agricultural Development (IFAD) program in Moldova and became effective on July 4, 2011. The implementation of the RFSADP was divided into four main components, to address various issues identified for reducing the poverty in rural areas. Each component and subcomponent describes a certain approach to improve business development in rural areas, with focus on agriculture and to improve the quality of lives for the people in rural areas.
International Fund for Agriculture Development provided funding, consultancy and organized a set of activities to target poor people in rural areas to improve their living, to increase their knowledge about the most recent technologies in agriculture and to provide practical information about how to run their business and increase output.

Key words: *rural development, project management, investment projects.*

INTRODUCTION

Today agricultural higher education is an indisputable prerequisite for the innovative development of the economy of any country of the world.
Expanding opportunities for agricultural education institutions and strengthening their research potential in the Republic of Moldova are current problems. Theoretical and practical knowledge, acquired by students in agricultural technologies, ensure their employment in food and commerce sector, marketing and other fields, thus completing the deficit of qualified employers existing in these sectors.
That's why, *cognitive development and the implementation of new technologies*, which constitute a true revolution in the republic's agriculture, largely dependend on the quality of education and contemporary specialist's knowledge. In this respect, the graduates from agricultural specialties of the State Agrarian University of Moldova are highly appreciated as specialists, most of them having their own businesses and actively contributing to the economic development of the country. However, one of the major problems of agricultural higher education remains training and personal development of the contemporary student; its importance has grown considerably in recent years, due to the pace at which changes take place in the contemporary society, between the two phenomena there is a strong interrelation.

MATERIALS AND METHODS

The material used to make this study consisted of research, analysis and the interpretation of the data both from specialty literature and from scientific studies. In this study the student agronomist and his cognitive development have an important place.
The information was gathered while studying the specialty scientific literature and other sources. In terms of theoretical and scientific aspect, the article was written in the context of complex and systematic approach to the concepts of cognitive development and its social effects.

RESULTS AND DISCUSSIONS

Educating the youth in the spirit of responsibility for their future is necessary because it is not fair from the point of view of the society and of the individual that the whole care for the formation of the young should fall on the educational agents, with family, school and society, the educated person is accountable to the society for what he will become in the future. This statement demonstrates once again that the factors of professional and socio-cultural development of the students in higher education institutions largely belong to the student himself. So, the training of a specialist, regardless of faculty and specialty, must be performed with his direct participation: the teacher issues the information needed for training young specialist and the student accumulates and processes this information, thus creating and refining his own personality.

In the curricula of Agronomy specialty of the total of 5400 hours (180 ECTS) 2700 hours are reserved for the initiation into specialty disciplines, while the same number of 2700 hours are reserved for individual study. All study subjects reserve the right to form professional skills that will help ensure the final studies and integration in professional field.

The potential European Qualifications Framework (EQF) is designed as a set of tools that meets the individual needs of citizens, it has principles and common procedures, providing guidelines, developed under the Work Programme „Professional Education and Training for cooperation in the fields of quality assurance, validation, guidance and career guidance and in the field of key competences". The key objective of the EQF is to support lifelong learning and to ensure that learning outcomes are valued and used properly.

Cognitive competence (use of theory and concepts, of capacities for knowledge acquired tacitly and informally through experience) is one of the elements of the competence defined in EQF, along with functional competences, personal competences and ethical competences that improve knowledge development of agroalimentary field for the graduate of this specialty.

Such university courses as Plant Cultivation, Agricultural Consulting, Environmental Protection etc. prepare the future agronomist to get sound knowledge of the business, which makes him distinct from an amateur by such specific topics as: basic biological laws of plants growth and development, methods of influence of human behaviour and engagement in consultancy etc. that aim to form skills to use the most advanced methods of individual and group counselling, they form the skills of modelling advanced technologies and processes, of quantitative and qualitative increasing of agricultural production. The same competence is also developed by socio-humanity and general disciplines. The contents of the Course „Professional Ethics" gets the student acquainted with such notions as the Code of ethics of the worker in the agrifood system, the focus of this discipline is to develop ethical competence. The humanity subjects provide personal development of the student.

An important aspect of personality development of any hard-working young man is the ability of self-government, which is the product of self-education and an advanced form of organization and management of own forces and knowledge in relation to the society. A guide for developing these skills is directing by university teachers for individual work. In these conditions there can be reduced the youth social passivity, lack of motivation, lack of social responsibility for the quality of the received education etc.

For the period of youth, the vast majority of authors distinguish two categories of tasks *traced by personal development*. The first category relates to the sphere of social relations which meets the needs for affiliation and privacy of the person. Here can be mentioned social skills for interaction and cooperation with others, focusing on the relations within the couple in love and the married couple.

Another category relates predominantly to *the formation and development of the skills specific to professional activity*, including the abilities necessary for economic independence, financial resources management, professional role shaping and professional achievements. Thus, the maturation of a person is the effect of the new roles that the person assumes in interpersonal relations and in vocational training, youth is seen as a period of important decisions relating to these areas.

Psychologically, subjectively, the person lives as a teenager, although he has exceeded this stage of his evolution. He is a late teenager, having a certain stability of feelings and reactions. He slowly leaves the world of the same age group of teenagers where he felt really himself, away from family and school. He is still present in the group, but he chooses his teammates against other criteria, of which the most important is the inclusion of the opposite sex partner. In fact, he participates in group where he can congeal relationships with girls and boys for a university, scientific or social activity. This stage of age is characterized by the formation of such personality traits as:

- *emphasizing the conscious reasons of the behaviour (desires, tendencies grow faster than the will and character; following this law, the person acts under the motivations of moment and then analyses the consequences);*
- *activity and life orientation towards a goal;*
- *autonomy;*
- *perseverance;*
- *self-control;*
- *initiative*.

It is a period of self-analysis and self-esteem. The self-esteem takes place by comparing the ideal *ego* with the real one. But the ideal *ego* is not verified yet and may be accidental, and the real *ego* is not yet rated multilaterally by the person himself. Here occurs, therefore, an objective contradiction. That is why we often see mood changes.

Another problem of this age is **self-education** - human activity oriented to changing, transforming his own personality. Self-discipline at this age is carried out by means of various tools and techniques, the most common being autoresponsability or independent formulation of the formation of attributes; self-report or the retrospective of the past and the successful deeds during that period; self-analysis or reflexive processes that allow the student to know the causal regularities of success and failure, which serve as the basis for the advancement of new requirements to himself; self-control or fixing, permanent record of personal behaviour and states in order to avoid unwanted actions and deeds. Self-assessment is the product of all the acts of self-knowledge.

From the point of view of *cognitive development*, agronomy students, like other students, develop their ability to identify problems to solve, to analyse their component parts, to develop strategies. They have a rational thinking which requires information changing and reorganizing. At their age, students are able to understand scientific theories, to critically examine them and to build new visions. The potential of thought and intelligence is expressed in-depth study of a certain domain and in the exposure of what they perceived and assimilated from the teacher - highly qualified specialist, basic court confirming the level of education and understanding of the issues of a science. It is specific for the student to orient to the profession consisting of: motivation for choosing profession, value orientations in the professional field, profession conceptions, social mounting for further study. Based on these characteristics, the contemporary students can be conventionally divided into 3 groups:

1. *Students with positive guidance for the profession*, they keep this guidence until the end of the studies - 68%;
2. *Students who have not clearly determined motivation and a definite attitude,* they do not possess full information about the profession, they are not active - 20%;
3. *Students with a negative attitude towards their specialty*, their views on specialty are amorphous, vague, they are not active across the entire training period ~10-12%.

The student is interested in knowing the environment and the society. He seeks the answers to the questions that arise from the examination of facts and ideas. He shows a great intellectual curiosity, not always focused on his specialty study. According to diagram, while getting older, the student is at the postconventional level. As Kohlberg demonstrated, only 10% of young people have proven they are at this stage of moral judgment. Students tend to express very severe examination of moral behaviour, primarily the behaviour of the teachers. Less prominently than in adolescence, students adopt a particularly harsh critical attitude when it comes to the violation of the moral norms, as the young men understand them.

At this age period, the young man is preoccupied with the establishment of an intimate relationship with another person. It is a relevant problem of this age, some even marrying during the studies. Friendship relations are vital. According to Erikson, privacy associated with isolation is essential in this age period. The student, like other congeners, experiences intimate friendship being focused on one person, but in the context of group relationships.

Although the student has obtained social maternity (the ability of the young to acquire the social roles necessary for life in the society), he still feels himself a teenager, so he doesn't consider himself an adult and does not assume adult responsibilities. The student continues to be dependent on his family, though he makes efforts to live outside the parental home. In many cases this fact is explained by financial dependence. The relations with family members pass to a new level and become cooperative, parents representing closed persons.

Another aspect of the status change is that young people experience tension between themselves and the society, trying to maintain a balance between protecting their personality and effective involvement in the society. For the student preparation at higher level, deepening the study in a domain, reflexivity on what he learns, writing papers on the topics requested by the teachers are the ways of self-assertion, without being directly linked to the society, that can be indifferent or insignificant. At the same time, he wants the product of its work to have social value. It is obvious that the student is the person who always tends to change.

CONCLUSIONS

As a result of the above said, we can conclude that the primary mission of university agricultural education is to form, through interdisciplinary studies, highly qualified specialists, able to organize and lead productive business in the food sector.

In addition to the skills specific for the domain mentioned above, future graduates must also hold key competences of personal development: interpersonal and professional communication, knowledge of informational technologies, ability to lead and work in teams etc. This will ensure adaptability, mobility and flexibility on the labour market, success and the growth of personal and professional satisfaction being guaranteed.

Unlike other young people, the student's tension between himself and the world is more complex. He lives with the feeling that he could change the world. The future intellectual person is formed as a result of this balance between self and the social.

REFERENCES

Barna A., 1995. Self-discipline. Theoretical and methodological problems. E.D.P. Bucharest.

Bernat S., 2003. Efficient learning technique. Publisher P.U.C., Cluj-Napoca.

Cretu D., Nicu A., 2004. Pedagogy and Psychology elements. Publishing House "Lucian Blaga", Sibiu.

Pâslaru Vl., 2003. The positive principle of education. Civitas, Chisinau.

Siebert Horst, 2001. Constructivist pedagogy. European Institute Publishing House, Iași.

Thomas S., 1983. Self-discipline. Sense and success. Scientific and Encyclopedic Publishing House, Bucharest.

Joiţa E., 2002. Cognitive Education. Polirom Publishing Hous, Cluj-Napoca.

Neacsu I., 1990. Effective learning methods and techniques. Military Publishing House, Bucharest.

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FRUITS VARIABILITY OF *Hibiscus trionum* L. WEED

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Abstract

The plant fruit system consists of bi-layered calyx, capsule 5-partitioned, with hairs and o lot of seeds. From determinations resulted in a 10-11 extern bracteoles and intern calyx of 16 mm height and 12 mm width. The capsule weighted 160 mg, had a length of 10 mm, width of 7 mm, and the hairs were 2.5 mm in length. One capsule were formed 26 seeds, which had an average weight of 91 mg, a length of 1.9 mm, width 1.6 mm, and the TSW 3.5 g. Between different characters have been established all correlations. Among the negatives were noted between the number of seeds from a capsule with: seed dimensions (r = -0.266^{00} for length, r = -0.373^{000} for width, and thousand seeds weight (TSW) (r = -0.362^{000}). Positive correlations were evident between calyx width with capsule weight (r = 0.285) and between seed dimensions with TSW (r = 0.253** for length, r = 0.235*** for width). Overall plant proved enough large variability that demonstrate high ability to adapt and compete in the agricultural field.*

Key words: *Hibiscus trionum, calyx, capsule, seeds, variability*.

INTRODUCTION

Weeds in agricultural fields meet a new stage in their evolution (Teo-Sherrell et al., 1996). Given the reduction of chemical control, there is a readjustment to their new conditions. New measures of control is recommended large for morphological variability studies. The higher their expression, plant is better suited (Chirilă et al., 1986). From a practical standpoint, for effective control investigations are necessary a new complex of investigations. A weed known in agricultural fields is *Hibiscus trionum* L. [pro syn. *Hibiscus dissectus* Wall., *Hibiscus versicarius* Cav., *Ketonia trionum* (L.) Scop., *Trionum annuum* Medik., bladder hibiscus, bladder ketmia, flower-of-an-hour, modesty, puarangi, rosemallow, shoofly, venice mallow, HIBTR code Bayer]. *H. trionum* is Asia, Africa and Australia (Craven et al., 2011). In the US was introduced as an ornamental plant (Chandler et al., 1974). We can meet over flower gardens in Eastern Europe. It is an annual summer plant with medium to small port, and from the armpit of leaves develop stems with flowers. Flowering occurs in mid-summer to early autum about 1-2 months. Flowering lasts one day in sunny and remains open for a few hours (Figure 1). During anthesis style and stigma are erect and receptive to receive pollen from other plants. In the absence of pollen, self-pollination occurs. Since the out-crossing seems to be preferable to self-pollination, it could contribute to a greater success of the plant in other walks of life. *H.trionum* containing 28 chromosomes in diploid form. Rarely met tetraploid and very rare hexaploid plants (Murray et al., 2008).

Figure 1. *H. trionum*, flower-of-an-hour

Figure 2. *H. trionum* fruit characteristics

The fruit which they form have a short branch. Each fruit is based on a thin circle there are several spreading bracts that are slender. Follow sepals that make up the calyx, of pale green, membranous, translucent, net-nerve, hirsute and spikes, overgrown around the cup. The capsule of 15 to 20 mm in length, is ovoid in shape, black, with a plurality of simple bristles spread out- Figure 2.

At maturity capsule opens in 5-valve and releases lots of seeds (Westra et al., 1996). Seeds are rough, dull brown or grey, in kidney or heart- shape.

The seed medium size is 2-3 mm. By performing measurements in different conditions of vegetation, it might bring some new elements to describe this species of weed.

In this study it was analyzed on a mature plant, the number of spreading bracts, height and width of calyx, weight of coated calyx capsule. The capsules were measured as length, width and length hairs.

Seeds were determined by total number from a capsule, seeds weight, seed length, seed width, and absolute seed weight - thousand seeds weight (TSW).

MATERIALS AND METHODS

Measurements were performed in the third decade of august, past two years. Plants were chosen for several spring crops like maize, sunflower and soybean.

The areas were located in the resort region. From 100 *H. trionum* plants was harvested mature capsules, one piece per plant, which is then brought to the laboratory.

Of 100 capsules were measured: the number of bracts, the height and width of the calyx, capsule weight, capsule length and width, the length of the hairs.

It was determined the number of grains per capsule, the weight thereof, the length and width of the seeds, TSW.

These characters which are expressed variability, was using the histograms method (or frequency polygon, FP%). In this method they were used either as such absolute values or as the class intervals. Study has highlighted several aspect and namely:

i) modal amounts (largest frequency),

ii) limits of the ranges of variability of the characters studied,

iii) the specifics of each character of the ecotype of weed (Craven et al, 2011) in analyzed area.

Among all 12 characters were analyzed correlations and regressions fixed in equation. These correlations could express some trends in the studied ecotype.

The expression values was used Excel. Another method was the statistical calculation of all values obtained.

It used analysis of variance (ANOVA), for the ranges of variation.

Statistical parameters were calculated using the formula:

$$\bar{a} = \frac{\Sigma x}{n},$$

where ā = mean of determinations,

x = determinated values,

S^2 (variance) $= \frac{1}{n-1}\left[\Sigma x^2 - \frac{(\Sigma x)^2}{n}\right],$

S (standard error) = $\sqrt{S^2}$,

S % (variation coefficient) = $\frac{S}{\bar{a}}100$.

Finally it was developed a summary of the data on the study of variability of fruit *H.trionum* characters obtained by determinations.

RESULTS AND DISCUSSIONS

H. trionum **variability of fruit characters.** The plant forms o lot of fruits with a specific configuration (*Malvaceae* fam.).

The first segment of the fruit is the bracts circle at the base. Still, the number of 8-10 pieces are elongated, thin, hairy, greenish.

From measurements showed that their number was slightly larg - Figure 3.

The variability of this character was between 7 and 12 tracks.

Modal value was 11 pieces (39%), followed by capitula with 10 pieces (33%). Bracts with few pieces – 7-8, were 1% and 2% respectively.

Capsula with 12 bracts constituted 19%.

The aspect of bracts is characteristic at the fruit base- Figure 4.

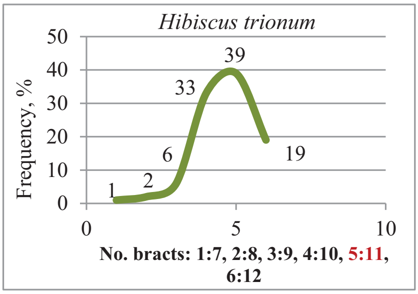

Figure 3. Frequency of papery sepals no. From extern calyx

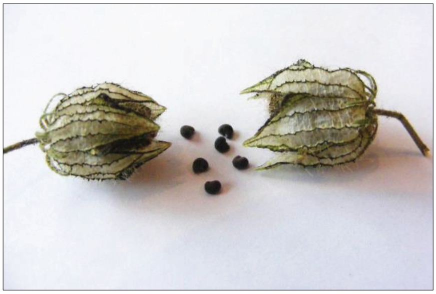

Figure 4. Capsule with specific calyx

Calyx of *H. trionum* fruit has heights between 12 and 19 mm. Greater frequency was 17 mm (29%). This was followed by the 16 mm (24%) and 15 mm (23%). Capsula with short calix- 12 mm, constututed only 2% (Figure 5). Calyx width variability was between 7 and 15 mm. The modal value was 12 mm (35%), followed by the 13 mm (27%). Capsula with small values of calyx- 7-9 mm, constituted 1-2% of total (Figure 6).

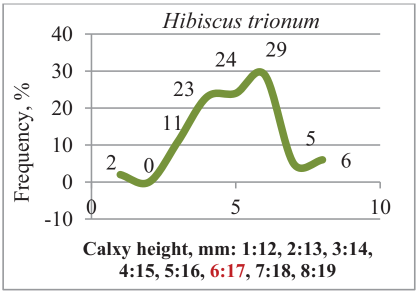

Figure 5. Frequency of calyx height

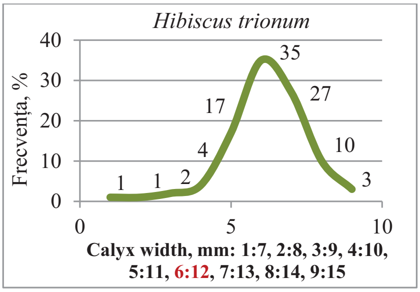

Figure 6. Frequency of calyx width

The weight of an capsula dressed in calyx with bracts at the base, fluctuated between 70 and 250 mg. Greater frequency of those had 170-200 mg (40%) (Figure 7). Near them were 130-160 mg of capsula (38%). Weights were lowest for capsula with 50-80 mg (2%) and those with over 240 mg (2%). The capsula complex of weed consists in ring od basic bracts, the calyx, and capsules that are a multitude of spreading hairs (Figure 8).

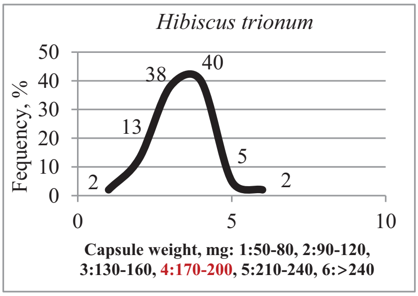

Figure 7. Frequency of capsule weight

Figure 8. Capsulary complex of *H. trionum* weed

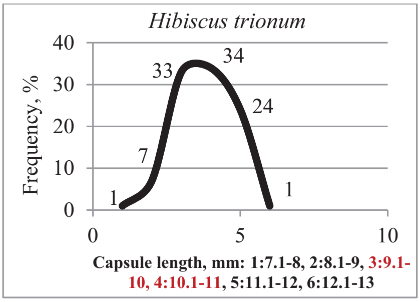

Figure 9. Frequency of capsule length

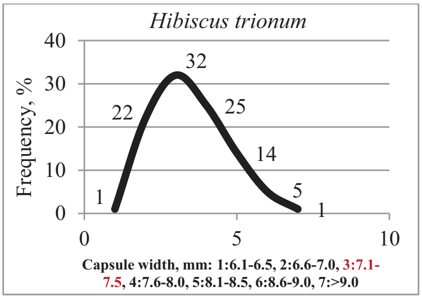

Figure 10. Frequency of capsule width

Capsula shape is cylindrical, rounded at the top, consisting of the 5 valves combined one with each other. The length of the capsule showed values ranging from 7.1 to 13 mm (Figure 9). The highest frequencies they have the capsula between 10-1-11 mm (34%) and from 9.1-10 mm (33%). The long capsula have been followed by those with 11.1-12 mm (24%). The shortest and the longest capsula have each 1% variability.

The capsula measured in the middle part, had a thickness ranging from 6.1 to 9.0 mm (Figure 10). They dominated capsula with 7.1-7.5 mm wide (32%). They followed those with 7.6-8.0 mm (25%) and 6.6-7.0 mm (22%). The narrowest capsula and the widest ones have 1% by the total.

Hairs of weed capsula demonstrated various lengths. Their size ranged between 1.7 and 3.5 mm (Figure 11). The highest frequency had a brush with 2.3-2.5 mm (27%), followed by the 2.0-2.2 mm and 2.6-2.8 mm, each with 22%. Hairs distribution is relatively uniform on the surface of the capsula and in a big number (Figure 12).

In a capsule of *H.trionum* on forms a large number of seeds. At maturity the 5 rags unfold, and they are released in the agricultural environment. The analysis showed that the total number of seeds per capsule was between 10 and 41 pieces (Figure 13). The seed lot of capsule was between 21-25 (28%) and 26-30 (28%), followed equally by the 16-20 (14%) and 31-35 (14%). Capsula with fewest and the most seeds (10 and 41 pieces) have only 2% each. These grains contained by the capsules weighted between 20 and 140 mg- Figure 14. The highest frequency of seeds had a total weight of 80-100 mg (45%). There is a direct link between the two deteminations (no. of seeds and its weight).

The plant produces specific seeds, kidney or heart-shaped - Figure 18. The dimensions of the *H. trionum* seeds have lengths generally about 2.0 mm, or between 2 and 3 mm. From determinations revealed that they had lengths between 1.7 and 2.1 mm (Figure 15). The highest frequency had seeds of 2.0 mm length (44%), followed by the 1.9 mm (30%). Other lengths together accounted for only 26%.

Width in the middle portion of seed somewhat lower values, which are between 1.2 and 1.9 mm (Figure 16). Modal value was 1.6 mm (32%). The lowest values were 1%, and the highest, 3%.

The absolute weight of seeds expressed by the thousand seed weight (TSW) showed values between 1.1 and 6.0 g (Figure 17). With these values is considered that the seeds of this plant are rarely small and light. The modal value was 3.1-4.0 g (46%), followed by those with 2.1-3.0 g (24%) and those with 4.5-5 g (19%). Smaller and higher values were together 11%.

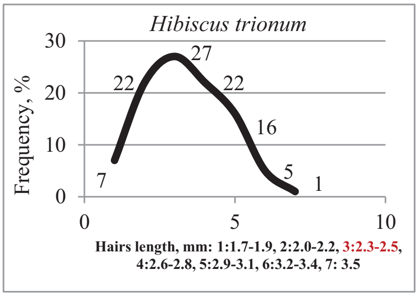

Figure 11. Frequency of hairs length

Figure 12. Mature capsules with specific hairs

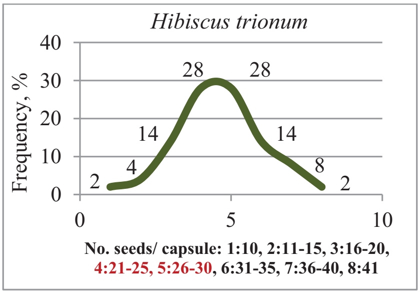

Figure 13. Frequency of seeds no. from one capsule.

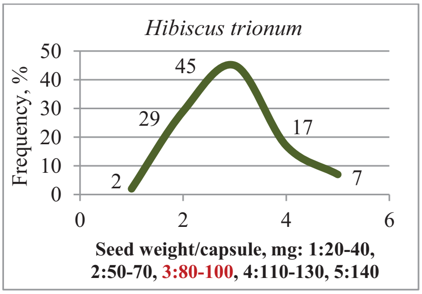

Figure 14. Frequency of seeds weight/capsule

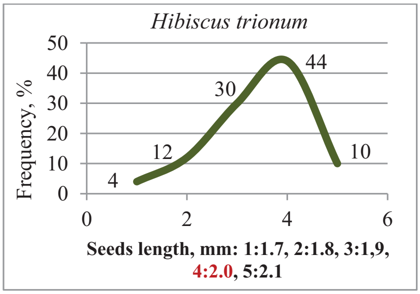

Figure 15. Frequency of seeds length

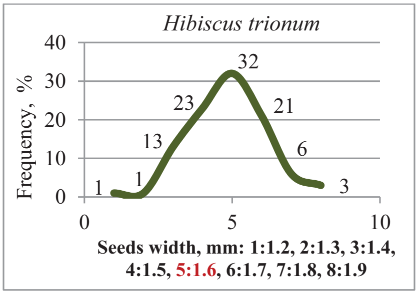

Figure 16. Frequency of seeds width

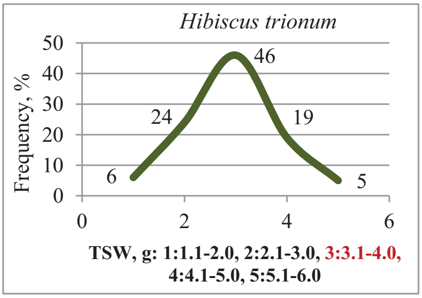

Figure 17. Frequency of thousand seeds weight, TSW

Figure 18. *H. trionum* seeds aspect

Correlations between different characters analyzed. The fruits have shown quite different causal link between the observed characters (Table 1). Among these stand out the negative correlation between the number of seed from a capsule and capsule dimensions ($r = -0.266^{00}$ length, $r = -0.373^{000}$ width) and with TSW ($r = -0.362^{000}$), which shows that when the plant produces bigger and heavier seeds, their number is smaller.

The layout is positive to the higher spread and adaptability into the crops. Among the positive linkages, the width of the capsule and total weight of capsule (r = 0.285**).

Table 1. Correlations between different fruits characters of *H.trionum* weed

Character	No. bracts	Calyx height	Calyx width	Capsule weight	Capsule length	Capsule width	Hair length	No.seeds/ capsule	Seeds weight	Seed length	Seed width	TSW
No. bracts	1	**-0.041**	**0.133***	**-0.125**	**0.209***	**0.189**	**-0.104**	**0.071**	**0.056**	**0.020**	**-0.055**	**0.028**
Calyx height		1	**0.425*****	**0.241***	**0.240***	**0.178**	**0.162**	**-0.020**	**0.156**	**0.126**	**0.145**	**0.252****
Calyx width			1	**0.285****	**0.107**	**0.304****	**0.105**	**0.035**	**0.197***	**0.276****	**0.245***	**0.224***
Caps. weight				1	**0.281***	**0.483*****	**0.186**	**0.535*****	**0.674*****	**0.185**	**-0.082**	**0.228***
Caps. length					1	**0.286****	**0.141**	**0.248***	**0.064**	**0.095**	**-0.095**	**-0.074**
Caps. width						1	**-0.010**	**0.315****	**0.405*****	**0.143**	**0.066**	**0.142**
Hair length							1	**0.094**	**0.042**	**-0.041**	**-0.026**	**0.030**
No.seeds/ caps								1	**0.513*****	**-0.266^{00}**	**-0.373^{000}**	**-0.362^{000}**
Seed weight									1	**0.010**	**-0.064**	**0.566*****
Seed length										1	**0.471*****	**0.253****
Seed width											1	**0.235***
TSW												1
LSD 5 % = 0.19 LSD 1 % = 0.25 LSD 0.1 % = 0.32												

Statistical analysis of the weed fruits variability.

The values obtained were characteristic. Thus the number of bracts at the bottom of the capsule was 10.6 pieces, tha calyx has a height of 16 mm and a width of 12 mm. The capsule weighed 160.8 mg. It have length of 10 mm, a width of 7.6 mm and 2.5 mm hairs long. A capsule produced an average of 26 seeds, which climbed 91 mg. The seeds have a length of 1.9 mm, width of 1.6 mm and 3.5 g thousand seeds weight (Table 2).

Table 2. Statistical indices of *H. trionum* fruits

Indices*	Calyx			Capsule				Seeds				
	Bracts no.	Length mm	Width mm	Weight g	Length mm	Width mm	Hair length	Capsule no.	Weight mg	Length mm	Width mm	TSW g
ā	**10.64**	**16.00**	**12.16**	**160.8**	**10.36**	**7.561**	**2.495**	**26.13**	**90.9**	**1.942**	**1.586**	**3.515**
s^2	0.980	2.422	1.853	0.001	0.831	0.450	0.155	45.02	0.001	0.016	0.017	1.099
s	0.990	1.556	1.361	0.034	0.911	0.671	0.394	6.710	0.024	0.128	0.130	1.048
Cv%	**9.30**	**9.73**	**11.19**	**21.39**	**8.79**	**8.87**	**15.77**	**25.68**	**2.64**	**6.58**	**8.19**	**29.82**

*ā-media, s^2-variance, s-standard error, Cv-variation coefficient

CONCLUSIONS

A widespread species that cause significant damage in field crops is *Hibiscus trionum* L. weed. Existing type in these areas in the south is well adapted to the specific biology.

To a control through its management's good to know as many morphological characters.

Currently it has been found that species expressing a wider variability could contribute to finding the most appropriate methods of control. Morphological variability, especially reproductive, being less known, may express cross-type existing in these conditions (Table 3).

Thus, the fruit was based on several large bracts and bigger calyx. The capsule had somewhat smaller dimensions, with 2.5 mm hairs. The seed of capsule were several and weighted about ½ of the capsule. The seed dimensions were smaller also. The mass of a thousand seeds (TSW) was relatively low.

Table 3. Values of fruit characters variability, *H. trionum* weed

Character		Literature	Research
Calyx	Bracts no.	8 - 11	7 - 12
	Length, mm	-	12 - 19
	Width, mm	-	7 - 15
Capsule	Weight, mg	-	70- 250
	Length, mm	15 - 20	7.8 – 12.9
	Width, mm	-	6.4 – 9.2
	Hair length, mm	-	1.7 – 3.5
Seeds	No./ capsule	-	10 - 41
	Weight, mg	-	20- 140
	Length, mm	2.0 – 3.0	1.7 – 2.1
	Width, mm	-	1.2 – 1.9
	TSW, g	-	1.28-5.88

REFERENCES

Chandler J.M., Dale J.E., 1974. Comparative growth of four malvaceous species. Proceedings of the 27th Annual Meeting of the Southern Weed Science Society: 116-117.

Chirila C., Pintilie C., 1986. Buruienile din culturile agricole și combaterea lor. (XXIV). *Hibiscus trionum* L. Productia Vegetala, Cereale și Plante Tehnice, 38(1):25-27.

Craven L.A., de Lange P.J., Lally T.R., Murray B.G., Johnson S.B., 2011. The indigenous Australasian bladder ketmia species (*Hibiscus trionum* complex, *Malvaceae*). New Zealand Journal of Botany 49: 27-40.

Murray B.G., Craven L.A., de Lange P.J., 2008. New observations on chromosome number variation in *Hibiscus trionum* s.l. (*Malvaceae*) and their implications for systematics and conservation. New Zealand Journal of Botany, 46: 315- 319.

Teo-Sherrell C.P.A., Mortensen D.A., Keaton M.E., 1996. Fates of weed seeds in soil: a seeded core method of study. Journal of Applied Ecology, 33(5):1107-1113.

Westra P., Pearson C.H., Ristau R., Schweissing F., 1996. Venice mallow (*Hibiscus trionum*) seed production and persistence in soil in Colorado. Weed Technology, 10(1): 22-28.

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MATHEMATICAL MODELING OF THIN LAYER DRYING KINETICS OF WHITE MULBERRY (*Morus alba* L.) IN SOLAR TUNNEL DRIER

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Abstract

Drying of thin layer white mulberry fruits was studied using a solar tunnel dryer under the ecological conditions of Isparta, Turkey. An experimental solar dryer with a flat plate solar collector has been constructed at the Department of Agricultural Machinery and Technologies Engineering at Suleyman Demirel University. In this work, the effects of solar tunnel drying on drying time, drying ratio of white mulberry were investigated. During the drying process, solar irradiation, drying air temperature, relative humidity, and air velocity were measured constantly in different parts of the dryer. The change of white mulberry fruits mass was measured daily. In this study, the fresh white mulberry fruit samples were selected, sorted, washed in water. The drying characteristic curves were evaluated against ten mathematical models and the Midlli-Kucuk was found to be the best descriptive model for solar tunnel drying of thin layer white mulberry fruit samples.

Key words*: Drying characteristics, white mulberry fruits, tunnel dryer, mathematical modeling.*

INTRODUCTION

The production of white mulberry in 2005 was 78,000 tons in Turkey. Mulberry trees are extensively grown for their leaves as foods for silkworms. There are three varieties of mulberry: white mulberry (*Morus alba* L.), black mulberry (*Morus nigra* L.), and red mulberry (*Morus rubra* L.).

White mulberry originated in Western Asia, red mulberry in North and South America, and black mulberry is from Southern Russia.

White mulberry fruit has a high level of moisture content at harvest. Because of the short harvesting season and their sensitivity to storage, fresh mulberry fruits should be preserved in some form. Unwashed berries can be kept only several days in a refrigerator in a container.

A commonly used preservation method for mulberry is drying. Their fruits can be eaten raw or dried or used in mulberry pekmez, juices, paste, marmalade and wine production (Maskan and Gögüs,1998).

Drying using the sun under the open sky for preserving food and agricultural crops has been practiced since ancient times. However, this process has many disadvantages, spoilt products due to rain, wind, moisture and dust; loss of produce due to birds and animals; deterioration in the harvested crops due to decomposition, insect attacks and fungi etc.

Further, the process is labor intensive, time consuming and requires a large area for spreading the produce out to dry. Artificial mechanical drying, a relatively recent development, is energy intensive and expensive, and ultimately increases the product cost.

Solar-drying technology proposes an alternative which can process the vegetables and fruits in clean, hygienic and sanitary conditions to national and international standards with zero energy costs.

It saves energy, time, occupies less area, improves product quality, makes the process more efficient and protects the environment (Sharma et al., 2009).

Solar tunnel drier can be operated by a fan driven by photovoltaic module and this system removes moisture inside dryer.

Additionally, it was reported that fan power requirement from photovoltaic module is low. Solar tunnel drier was utilized for drying of many agricultural products such as fruits, vegetables, cereals, grain, legumes, oil seeds, spices and even fish and meat (Bala et al., 2003).

The main objective of this study to use the solar tunnel dryer for thin layer drying of white mulberry fruits.
This study specifically focused on evaluation of the effects of white mulberry fruits on the drying process using a solar tunnel dryer in Isparta conditions and to determine the best describing mathematical model to experimental data.

MATERIALS AND METHODS

Homogeneously sized mulberry samples were used in this study as experimental material. Fresh mulberry samples (*Morus alba* L) were purchased from the supermarket to use in the experiment.
A solar tunnel dryer constructed at Department of Agricultural Machinery and Technologies Engineering at Suleyman Demirel University was used in this study (Figure 1).

Figure 1. The experimental solar tunnel dryer

It comprised of a flat plate solar collector, a drying tunnel, a solar cell module, and a small axial fan. All units are mounted on metal frame. The bottom of solar collector has hexagonal channels and are directly connected to drying tunnel. The bottom of solar tunnel dryer is painted black to absorb radiation.
The collector is coated with a transparent polycarbonate material. The dryer is equipped with a 150 W solar cell module. A fan delivers air to the drying tunnel. Solar energy absorption area of the collector is 2 m length and 1.9 m width. The drying tunnel area is twice the area of collector. The dryer is oriented in east-west direction and its drying tunnel is not shaded by trees or buildings between 9:00 am and 5:00 pm.
Mulberry samples weighted on a balance reading to 0.01 g (Sartorius GP3202, Germany). Approximately 1000 g of mulberry samples were placed into trays and processed for drying experiments. Drying experiment started after completion of the loading at 9:00 am and was paused at 5:00 pm.
Weight loss of the mulberry samples in the solar tunnel drier was measured during the drying period at one hour interval with a digital balance. In the afternoon after 5:00 pm, the samples of mulberry in the solar tunnel drier were kept in the drier in the environmental conditions. Then, mulberry samples were exposed to the same weather conditions. The drying process was terminated until no mass change was detected.
Experiments were carried out on July 22-24, 2016. Solar irradiance was measured hourly (09:00 am - 17:00 pm) on a horizontal surface by pyranometer. Relative humidity and temperature of drying air were measured using K type thermocouples and DT-3 hygrometer at the drying tunnel of dryer. Air velocity at the outlet of drying tunnel was measured by a hotwire anemometer.
Mulberry samples were subjected to the moisture analysis at the oven at the temperature of 105 °C for 24 hours.
The moisture ratio (MR) was calculated based on moisture content as a function of time (t) (M(t)), initial moisture content of samples (M_0), and equilibrium moisture content of samples (M_e).

$$MR = \frac{M(t) - M_e}{M_0 - M_e} \quad (1)$$

All moisture contents were reported as wet basis (%, w.b). Simplification of MR in Eq. (1) as M/Mo was suggested by Diamente and Munro, 1993, Elicin and Sacılık, 2005, due to the continuous fluctuation of relative humidity of drying air under solar tunnel dryer conditions. Therefore, the drying rate as g_{water}/h (DR) of the white mulberry samples was determined by Eq. (2)

$$DR = \frac{M_{t+dt} - M_t}{dt} \quad (2)$$

Where M_{t+dt} is the moisture content at t+dt (g water/g dry matter). A non-linear regression analysis (Sigma Plot 12.00) was applied to

experimentally obtained MR as a function of time using drying models given in Table 1.
The constants (a, n, b, c, m, k, and g) of models tested in Table 1 were determined based on the non-linear regression analysis.

The performance of models was evaluated by coefficient of determination (R^2), the standard error of estimate (SEE), and residual sum of square (RSS).

Table 1. Mathematical models tested for the moisture ratio values of the white mulberry samples

No	Model name	Model Equation	References
1	Diffusion approach	MR=a exp(-k t)+(1-a) exp(-k b t)	Artnaseaw et al. 2010
2	Henderson and pabis	MR=a exp(-k t)	Doymaz, 2014
3	Logarithmic	MR=a exp(-k t)+c	Akpinar 2008
4	Midilli et al.	MR=a exp($-kt^m$)+b t	Midilli et al. 2002
5	Newton	MR=exp(-kt)	Toğrul and Pehlivan 2002
6	Page	MR=exp($-kt^n$)	Akpinar 2008
7	Two term	MR=a exp($-k_0t$)+b exp($-k_1t$)	Yaldiz et al.2001
8	Two term exponential	MR=a exp(-kt)+(1-a)*exp(-m*k*x)	Sharaf-Elden et al. 1980
9	Verma et al.	MR=a exp(-kt)+(1-a) exp(-gt)	Verma et al. 1985
10	Wang and Singh	MR=1+at+bt^2	Babalis et al. 2006

RESULTS AND DISCUSSIONS

Solar drying of white mulberry samples was conducted on July in 2016. Throughout the drying experiment, the weather was sunny and no rain was recorded. The drying experiment lasted for 3 days.
The influence of thin layer white mulberry samples on moisture ratio and drying rate were also investigated.

The drying time necessary for reduction of initial moisture content from (80 % w.b.) to the desired final moisture content up to (12,4% w.b.) for solar tunnel drying was found to be 32 hours.
As shown in Figure 1, moisture ratio decreased continuously with decreasing moisture content. The absence of lines in drying cycle in each day in Figure 2 indicates the night periods (Saçılık and Eliçin, 2005).

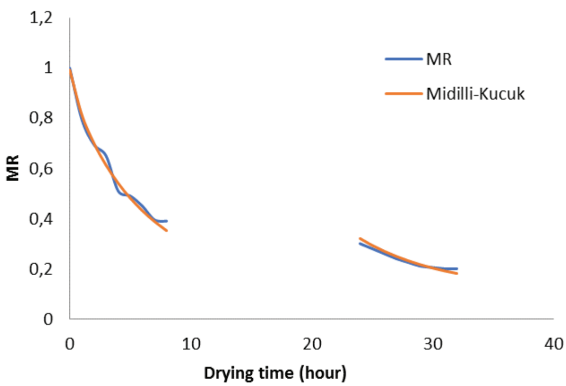

Figure 2. Variation of moisture ratio with drying time for solar tunnel drying of white mulberry

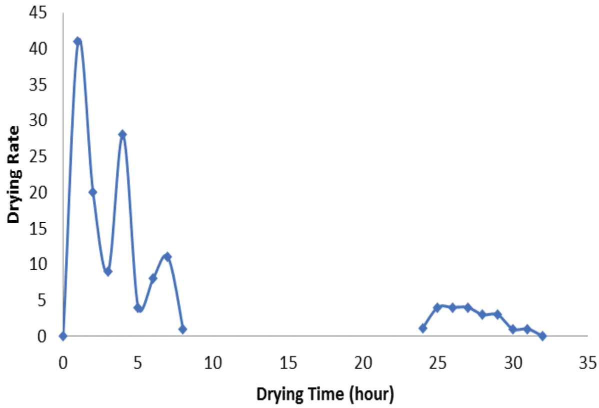

Figure 3. Variation of drying rate as a function of drying time for solar tunnel drying of white mulberry

The change of drying rate as a function of time is depicted in Figure 3 in solar tunnel drier. The results showed that the drying rate was 41.2 g/h within one hour and at the final stage of drying rate decreased to 1.5 g/h for white mulberry samples. The drying rate sharply increased within one hour and then decreased. This behavior was periodic and gradually diminishing in magnitude on each day of drying.

Table 2 shows the outcomes of nonlinear regression analysis applied to the ten drying models to the experimental data for white mulberry samples with R^2, SEE, and RSS. The best model describing drying of white mulberry samples in given conditions was determined based on R^2 with the lower value of SEE and RSS, which are evaluation criteria used to compare the statistical validity of the fit. The results showed that the R^2, SEE, and RSS values of nonlinear regression analysis ranged from 0.9515 to 0.9937, from 0.0206 to 0.0548, and from 0.0060 to 0.0451, respectively (Table 2). Furthermore, Midilli et al. model yielded the highest R^2 (0.9937) for white mulberry samples, with the lowest SEE and RSS values (Table 2).

Table 2. Results of nonlinear regression analysis of fitting the ten drying models to the experimental data for solar tunnel drying of mulberry samples

	Model No									
	1	2	3	4	5	6	7	8	9	10
R^2	0.9519	0.9722	0.9912	0.9937	0.9519	0.9928	0.9918	0.9915	0.9915	0.9625
SEE (±)	0.0548	0.0404	0.0235	0.0206	0.0515	0.0206	0.0235	0.0231	0.0231	0.0469
RSS (±)	0.0451	0.0261	0.0083	0.0060	0.0451	0.0068	0.0077	0.0080	0.0080	0.0352

CONCLUSIONS

In this work, experiment of solar tunnel drying of white mulberry samples are presented. Based on the experimental results reported, following conclusions can be made:

Drying time decreased considerably with increased temperature.

Different mathematical models, namely, Diffusion Approach, Henderson and Pabis, Logarithmic, Midilli-Kucuk, Newton, Page, Two Term, Two Term Exponential, Verma Wang and Singh used to describe the drying kinetics of white mulberry samples. The Midilli-Kucuk model gave excellent fit for all data points with higher R^2 values and lower SEE and RSS values.

REFERENCES

Akpinar A.K., 2008. Mathematical modeling and experimental investigation on sun and solar drying of white mulberry. J. of Mechanical Science and Techn. 22 pp: 1544-1553.

Artnaseaw A., Theerakulpısut S., Benjapıyapon C., 2010. Development of a vacuum heat pump dryer for drying chili. Biosyst. Eng. 105. pp: 130-138.

Babalis S.J., Papanicolaou E., Kyriakis N., Belessiotis V. G., 2006. Evaluation of thin layer drying models for describing drying kinetics of figs (Ficus carica). Journal of Food Engineering 75(2): 205-214.

Bala B.K., Mondol M.R.A., Biswas B.K., Das Chowdury B.L., Janjai S., 2003. Solar Drying of Pineapple Using Solar Tunnel Drier. Renewable Energy. 28. pp:183-190.

Diamente L.M., Munro P.A., 1993. Mathematical modeling of the thin layer solar drying of sweet potato slices. Solar Energy. 51. pp: 271-276.

Doymaz I., 2014. Suitability of thin-layer drying models for ınfrared drying of peach slices. Journal of food processing and preservation. 38 (6). pp: 2232-2239.

Elicin A.K., Sacılık K., 2005. An Experimental Study for Solar Tunnel Drying of Apple. Journal of Agricultural Sciences. 11 (2). pp:207-211.

Maskan M., Gogus F., 1998. Sorption isotherms and drying characteristics of mulberry (Morus alba), J. Food Eng., 37 437-449.

Midilli A., Kucuk H., Yapar Z., 2002. A new model for single layer drying. Dry Technol l20 (7):1503-1513.

Sharma A., Chen C.R., Lan N.V., 2009. Solar-energy drying systems: A review, Renewable and Sustainable Energy Reviews, 13. Pp:1185-1210.

Sharaf-Elden Y.I., Blaisdell J.L., Hamdy M.Y., 1980. A model for ear corn drying. Transactions of the ASAE. 5. 1261-1265

Toğrul I.T., Pehlivan D., 2002. Mathematical modeling of solar drying of apricots in thin layers. J. of Food Engineering. 55 pp:209-216.

Verma L.R., Bucklin R.A., Endan J.B., Wratten F.T., 1985. Effects of drying air parameters on rice drying models. Transactions of the ASAE. 28. 296-301.

Yaldiz O., Ertekin C., Uzun H.I., 2001. Mathematical modelling of thin layer solar drying of Sultana grapes. Energy. 26. 457-465.

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FORAGE MAIZE YIELD IN FUNCTION OF RAINFALL IN CLIMATIC CONDITIONS OF VOJVODINA (REPUBLIC OF SERBIA)

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Abstract

Knowledge on the variability of average rainfall characteristics during growing season is essential for efficient management of plant production. Maize is a very convenient crop for forage production. In Serbia, maize is grown under dry land farming, so that yield is highly dependent on amount and distribution of rainfall during the growing season. The aim of this investigation was to estimate the effects of rainfall (amount of rainfall during the growing season and average monthly rainfall) on the maize forage yield in the Autonomous Province of Vojvodina (Republic of Serbia) for the period 2000-2015. Investigated of rainfall characteristics from 2000 to 2015 were lower than optimal amount of rainfall, which indicates that the distribution of rainfall was not satisfactory for maximum plants production. The coefficient of variation indicates moderately fluctuations of monthly rainfall. Regression equations indicate that forage yield increased with increasing amounts of rainfall characteristics. The lower increase forage yield was in April (0.9%) and the highest increase in August (35.1%). Forage maize yield had strong positive relationship with amount of rainfall during the growing season and average monthly rainfall for May and August. On other hand, values of correlation coefficients for other studied rainfall characteristics indicated that there is positive relationship with forage maize yield but not significant. The implication of this finding is that the amount of rainfall determined the forage yield. The important determinant is the distribution of rainfall within the year.

Key words: *correlation, regression, forage maize yield, rainfall characteristics, Vojvodina.*

INTRODUCTION

Climate change is expected to have impact on rainfall quantity and distribution. Lalić et al. (2011) predicted reduction of rainfall in Vojvodina for future times. It is therefore important to examine the impact of climate change on crop production. Many studies have focused on the impact of climate change on maize grain yield, while less on forage yield. The high production of green mass per unit area, energy content of dry matter and quality of biomass make it very convenient crop for forage production (Mandić et al., 2013). Today, selecting hybrids with high grain and silage yields allows flexibility in the fall when harvest decisions are made. In Serbia, stay green hybrids which are suitable for the production of grain and silage are increasingly used in production practice. This flexibility is very important because it is difficult to predict the condition of the crop at harvest. However, it is common that in unfavourable conditions, farmers are reoriented on silage production instead of the planed grain production. Many researches showed that forage maize yield depends on the amount of rainfall during vegetation stages. Tóthné Zsubori et al. (2010) and Mandić et al. (2015) reported that forage yield and dry matter yield are affected by year and maize hybrids. These traits have higher values in years with favourable climatic conditions. Amount of rainfall from June to August is crucial factor for maize biomass production and grain yield (Randjelovic et al., 2011). Studying the effect of rainfall on maize yield over longer period (1949-2013), Milošević et al. (2015) have found that maize grain yield is strongly correlated with rainfall during growth period, especially summer months rainfall (July and August). The rainfall during growth period explained 14% of inter-annual variability of yield. Videnović et al. (2013) report that trend of maize grain yield and amount of rainfall have similar variations in Zemun Polje during the period 1965-2012. The maize yield variation ranged from +40% to –43%, variation in sum of rainfall from +64% to –49%. Contrary, Huang et al. (2015) report that growing season rainfall in the eastern

United States for the period 1963-2011 did not influence on maize grain yield.

This research is focused on the analysis of the characteristics of growing season rainfall during sixteen years (2000-2015) in the Autonomous Province of Vojvodina (Republic of Serbia) and impact on forage maize yield.

MATERIALS AND METHODS

Rainfall characteristics data from seven meteorological stations in Vojvodina were used from the Meteorological yearbooks of the Republic Hydrometeorological Service of Serbia for period 2000-2015. Rainfall data from meteorological stations Vršac, Zrenjanin, Kikinda, Palić, Rimski Šančevi (Novi Sad), Sombor and Sremska Mitrovica were used. Maize harvest is performed when the dry matter is 34-36%, usually during the second half of August and beginning of September. Data for forage yield of maize were used from the Statistical Office of the Republic of Serbia from 2000 to 2015.

Data were analysed using statistical software 'Excel' and STATISTICA (version 10; StatSoft, Tulsa, Oklahoma, USA). The Shapiro-Wilk test was used for assessment of normality. The data were statistically processed by the linear regression method and correlation analysis. Calculation of the level of significance was based on regression analysis. The significance level was set at $P \leq 0.05$, $P \leq 0.01$ and $P \leq 0.001$. The Pearson's correlation coefficient was used to determine the strength of the association between climatic characteristics variability and forage yield.

RESULTS AND DISCUSSIONS

Rainfall characteristics and forage yield for the period 2000-2015 in Vojvodina region are shown in Table 1. Average amount of rainfall during the growing season was 305 mm, and ranged from 116.4 mm (2010) to 527.6 mm (2010) (Figure 1). Average monthly rainfall for April was 44.7 mm, and ranged from 2.2 mm to 102.8 mm. Average monthly rainfall for May was 70.3 mm and ranged from 27.4 mm to 149.5 mm. Average monthly rainfall for June was 76.6 mm and ranged from 22.3 mm to 200.5 mm. Average monthly rainfall for July was 59.7 mm and ranged from 13.4 mm to 137.1 mm. Average monthly rainfall for August was 53.7 mm, and ranged from 3.3 mm to 140.7 mm.

Table 1. Descriptive statistics for rainfall characteristics (mm) and forage maize yield (t ha^{-1}) in Vojvodina from 2000 to 2015

Item	Mean	Minimum	Maximum	CV %	% of RGS
RGS	305.0	116.4	527.6	39.5	100
April	44.7	2.2	102.8	69.9	14.7
May	70.3	27.4	149.5	52.2	23.0
June	76.6	22.3	200.5	64.9	25.1
July	59.7	13.4	137.1	56.5	19.6
August	53.7	3.3	140.7	72.5	17.6
FMY	22.7	11.8	31.8	24.5	-

Legend: RGS - amount of rainfall during the growing season, FMY - forage maize yield, CV - coefficient of variation, ** - significant at 1% level of probability, * - significant at 5% level of probability.

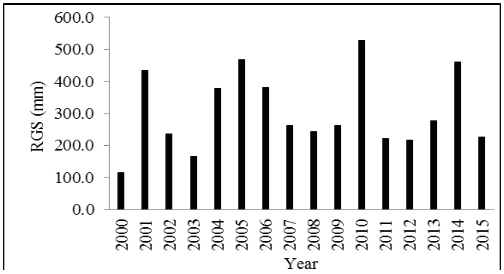

Figure 1. Amount of rainfall during the growing season (RGS) in Vojvodina from 2000 to 2015

In Serbia, maize needs 490 mm of rainfall during growing season for grain production, by months - in April 50 mm, May 75 mm, June 90 mm, July 100 mm, August 95 mm and September 80 mm. Maize for forage mass production needs 410 mm of water per season, because it is harvested during the second half of August and beginning of September. Amount of monthly rainfalls from 2000 to 2015 were lower than optimal amount of rainfall for maize. Generally, distribution of rainfall was not satisfactory for maximum plant production. Also, results showed that monthly rainfall for August had the highest coefficient of variation (72.5%), followed by monthly rainfall for April (69.9%), monthly rainfall for June (64.9%), monthly rainfall for July (56.5%), monthly rainfall for May (52.2%), and amount of rainfall during the growing season (39.5%). The coefficient of variation of rainfall characteristics is an index of climatic risk, indicating a likelihood of fluctuations crop yield from year to year. The coefficient of variation of rainfall characteristics is above 39.5 % indicating that it is moderately variable. Generally, results showed that Vojvodina district received similar amount of rainfall during the growing season from 2000-2016 (305 mm), such as Milošević et al. (2015) obtained for period 1943-2013 (303.5 mm). This region received the highest amount of rainfall during growing season in June (25.1%) when plants of maize were at the stage of intensive stem growth. The lower amount of rainfall in June reduced stem cell expansion and reduced plant height. The plant height has the highest direct effects on fresh maize forage yield (Carpici and Celik, 2010). On the other hand, region received the lowest amount of rainfall during growing season in April (14.7%). In Serbia, the optimal time for sowing of maize was in April. Mandić (2011) established that the rolling should always be applied after seed is sown, because then the extreme drought in the beginning of the growing period does not affect the germination. Average forage maize yield over longer period was 22.7 t ha^{-1} and varied from 11.8 t ha^{-1} (2000) to 31.8 t ha^{-1} (2010) (Figure 2).

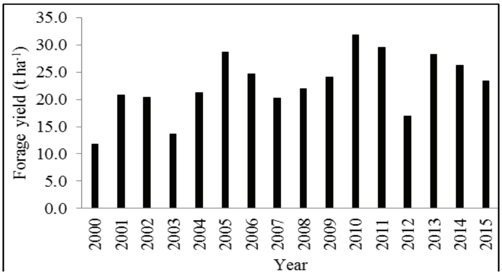

Figure 2. Forage maize yield in Vojvodina from 2000 to 2015

The coefficient of variation was 24.5%. This may be important factor limiting for milk and meat production on farms because there is no continuous high production of silage mass per unit area for feeding livestock. However, the coefficient of variability of forage maize yield could be result of the joint effect of the rainfall characteristics variability and non-climatic factors. Silage is a convenient and economical concept for feeding animals. On the other hand, Milošević et al. (2015) have found that annual variability of grain maize yield in Vojvodina from 1949 to 2013 was 33%.

Regression equations indicate that forage yield increased with increasing amounts of rainfall (Table 2). For every increase of 1 mm of rainfall during growing period, April, May, June, July and August, maize yield increased by 30.3, 17.4, 85.3, 44.6, 60.4 and 84.7 kg ha^{-1}, respectively. The highest increase of forage yield was in May and August. The regression coefficient of determination for amount of rainfall during the growing season was 43% which indicated that about 43% of variation in maize yield could be explained by rainfall variability. The remaining 57% were largely due to other variables outside the regression model that also affect maize yield (maize genetics, technical factors and other climatic factors).

Table 2. Regression result on the effect of rainfall characteristics on forage maize yield and correlation coefficients

Item	Regression equation	R^2	r
RGS	y = 0.0303x + 13.468	0.4297	0.66**
April	y = 0.0174x + 21.932	0.0095	0.10
May	y = 0.0853x + 16.707	0.3171	0.56*
June	y = 0.0446x + 19.290	0.1587	0.40
July	y = 0.0604x + 19.102	0.1338	0.37
August	y = 0.0847x + 18.159	0.3514	0.60*

Legend: RGS - amount of rainfall during the growing season, FMY - forage maize yield, CV - coefficient of variation, ** - significant at 1% level of probability, * - significant at 5% level of probability.

The regression coefficient of determination for monthly rainfall for April, May, June, July and August were 0.9%, 31.7%, 15.9%, 13.4% and 35.1%, respectively. In Serbia, in May, maize is in the vegetation stage (from 3rd to 9th leaf). During May, number of potential leaves and ears is determined (V5 vegetative stage), such as rows per ear (V6 vegetative stage). In August, maize is at grain filing stage. The water deficit in May reduces number of leaves per plant which is positively correlated with forage yield (Srivas and Singh, 2004; Icoz and Kara, 2009), and decreased leaf ratio (Carpici and Celik, 2010). Deficit of water in August reduces the grain weight per ear, 1,000 grain weight and ear percentage. Values of correlation analysis showed that forage maize yield had strong positive relationship with amount of rainfall during the growing season (r=0.66), monthly rainfall for May (r=0.56) and

August (r = 0.60). This implies that variations of rainfall amount in growing season, relate mostly to the annual variations in forage maize yield. On other hand, values of correlation coefficients for other studied monthly rainfall amounts indicated that there was a positive relationship with forage maize yield but not significant. The implication of this finding is that the amount of rainfall determined the forage yield. The important determinant is the distribution of rainfall within the year. Milošević et al. (2015) have concluded that, in Vojvodina, rainfall in July and August show a significant positive correlation with maize grain yield, but in other months, rainfall shows no significant correlation with yield. Rashid and Ghulam (2011) and Adamgbe and Ujoh (2013) have found highly significant correlation between amount of rainfall during the growing season and maize yield in Pakistan and Nigeria, respectively.

CONCLUSIONS

In Vojvodina, during sixteen-year period (2000-2015), the amount of rainfall during the growing season was 305 mm with coefficient of variation (39.5%), and this was lower than optimal amount of rainfall for forage production (410 mm). The coefficient of variation indicates moderate fluctuations of monthly rainfall. The study showed that rainfall variations had impact on forage maize yield, especially monthly rainfall in May and August. The regression coefficient of determination showed that about 43% of variation in maize yield could be explained by rainfall variability, while remaining 57% by maize genetics, technical factors and other climatic factors. The implication of this finding is that the amount of rainfall determined the forage yield. The important determinant is the distribution of rainfall within the year.

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REFERENCES

Adamgbe E.M., Ujoh F., 2013. Effect of variability in rainfall characteristics on maize yield in Gboko, Nigeria. Journal of Environmental Protection, 4:881-887.

Carpici E.B., Celik N., 2010. Determining possible relationships between yield and yield-related components in forage maize (*Zea mays* L.) using correlation and path analysis. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 38(3):280-285.

Huang C., Duiker S.W., Deng L., Fang C., Zeng W., 2015. Article influence of precipitation on maize yield in the Eastern United States. Sustainability, 7:5996-6010.

Icoz M., Kara S.M., 2009. Effect of plant density on yield and yield component relationships in silage corn. VIII Field Crops Congress in Turkey, p. 869-872.

Lalić B., Mihailović D. T., Podraščanin Z., 2011. Future State of Climate in Vojvodina and Expected Effects on Crop Production. Ratarstvo i povrtarstvo/Field and Vegetable Crops Research 48:403-418.

Mandić V., 2011. Genotype response of stay green maize hybrids on increased crop density. PhD dissertation, Faculty of Agriculture, University of Belgrade, Republic of Serbia, p. 1-162.

Mandić V., Krnjaja V., Bijelić Z., Tomić Z., Simić A., Stanojković A., Petričević M., Caro-Petrović V., 2015. The effect of crop density on yield of forage maize. Biotechnology in Animal Husbandry, 31(4): 567-575.

Mandić V., Simić A., Tomić Z., Krnjaja V., Bijelić Z., Marinkov G., Stojanović LJ., 2013. Effect of drought and foliar fertilization on maize production. Proceedings of the 10th International Symposium Modern Trends in Livestock Production, p. 416-429.

Milošević D.D., Savić S.M., Stojanović V., Popov-Raljić J., 2015. Effects of precipitation and temperatures on crop yield variability in Vojvodina (Serbia). Italian Journal of agrometeorology, 3:35-46.

Randjelovic V., Prodanovic S., Tomic Z., Bijelic Z., Simic A., 2011. Genotype and year effect on grain yield and nutritive values of maize (*Zea mays* L.). Journal of Animal and Veterinary Advances, 10(7):835-840.

Rashid K., Ghulam R., 2011. Rainfall variability and maize production over the Potohar Plateau of Pakistan. Pakistan Journal of Meteorology, 8(15): 63-74.

Srivas S.K., Singh U.P., 2004. Genetic variability, character association and path analysis of yield and its component traits in forage maize (*Zea mays* L.). Range Management and Agroforestry, 25(2):149-153.

Tóthné Zsubori Z., Pok I., Hegyi Z., Marton C.L., 2010. Genotype and year effects on morphological and agronomical traits of silage maize (*Zea mays* L.) hybrids. Acta Agronomica Hungarica, 58:81-89.

Videnović Ž.., Dumanović Z., Simić M., Srdić J., Babić M., Dragičević V., 2013. Genetic potential and maize production in Serbia. Genetika, 45(3):667-677.

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THE BROADENING OF DISTRIBUTION OF THE INVASIVE SPECIES *Diabrotica virgifera virgifera* Leconte IN THE AREA OF MUNTENIA REGION UNDER SPECIFIC CLIMATIC AND TROPHIC CONDITIONS

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Abstract

The spread of invasive species to a new area is influenced and conditioned by a number of drivers that can increase or control (meaning slow down) the speed of invasion. The largest shares in the factors which determine this area of spread are the geographical factors and the trophic and climatic conditions. For that reason, it is intended that immediately after the invasion, when pathways and vectors are determining which facilitated the invasion (early detection), to proceed with a monitoring program in order to develop and establish a management of control of the new pest. The present paper discusses on the possibility of developing the procedures for the surveillance work of maize crops in Southern and South-Eastern Romania to identify, monitor and evaluate the pest potential of Diabrotica virgifera virgifera. The research area included localities from counties in the Southern and South-Eastern Romania, where the monitoring was conducted with specific pheromone traps.

Key words: *invasive species, monitoring, risk assessment*.

INTRODUCTION

In the maize crop from Southern Romania there is about 25 species of insect pests that cause damage considered economically significant. Since 1996 a new invasive species has been registered in the west side of the country (first mention in Nădlac, 1996) and since 1999 this has started to produce significant damage to crops in this area, counties Arad, Timiș and Bihor. It is about on the invasive insect species *Diabrotica virgifera virgifera* LeConte *(Coleoptera: Chrysomelidae)*, the western corn rootworm (WCR). It belongs to a relatively numerous group of species and is considered the main corn pest in USA. Soon after invasion in Europe, one European program for prevention and monitoring had started (Berger, 1996; Vidal et al., 2005). Within the frame of the first meeting (Graz, Austria, 1995) there were established, for the first time, the methods for early detection and monitoring of the species in the invaded countries.

Pheromone traps with specific sex pheromone (Tóth et al., 1996) and the bait based on cucurbitacin were used. Alongside these techniques, it was recommended using yellow glue traps, type Multigard®, supplied by Scentry in Montana, USA. In the 2000-2016 period, the species continues to spread in Europe and western Asia at a rate of 20 km/year, strictly in close dependence on the presence of host plants, especially in the field crops. The current status of WCR in European countries is presented in Table 1.

Discovered and first formal description by LeConte in 1868 from beetles collected near Fort Wallace, Kansas, USA, the species became reported as maize pest in 1909, (Gillette, 1912) approximately 50 years after. From 1909 to 1948, the insect spread eastward at an average rate of about 19 km per year (Metcalf, 1986).

Large-scale applications of soil insecticides were first made in 1949 and more than 700,000 ha were being treated with insecticides by 1954 (Ball and Weekman, 1962).

However, resistance to the soil insecticides was noted as early as 1959, but the insecticide-resistant strain spread eastward at a rate even faster than 112 km/year (Ball and Weekman, 1962; Metcalf, 1983).

In Romania the actual distribution was established by the Phytosanitary Quarantine laboratory team as it is shown in Figure 1 (Manole, 1999).

Table 1. Actual status of *D. virgifera virgifera* in Europe

Country	Year	Locality	Status	Measures
Serbia	1992	Surcin	present	Control
Montenegro	1993	Bijelo Polje	present	Control
Hungary	1995	Csongrád	present	Control
Croatia	1995	Bosnjaci	present	Monitoring
Romania	1996	Nădlac	present	Control
Bosnia-Herzegovina	1997	Tuzla-Posavina	present	Monitoring
Bulgaria	1998	Bregovo	present	Monitoring
Italy	1998	Marco Polo di Tessera (Venice)	eradicated	Monitoring
Slovakia	2000	Lucenec	present	Monitoring
Switzerland	2000	Lugano/Agno	eradicated	Monitoring
Ukraine	2001	Zakarpatya	present	Monitoring
Austria	2002	Deutsch Jahrndorf	present	Control
France	2002	Roissy/Le Bourget/Orly	eradicated	Monitoring
Czech Republic	2002	Cejc	present	Monitoring
UK	2003	London	eradicated	Monitoring
Netherland	2003	Amsterdam	eradicated	Monitoring
Belgium	2003	Brussels	eradicated	Monitoring
Slovenia	2003	Pomurje	present	Monitoring
Poland	2005	Dukla	present	Monitoring
Germany	2007	Baden-Württemberg	eradicated	Monitoring
Belarus	2009	Brest	eradicated	Monitoring
Greece	2009	Salonic	present	Monitoring
Albania	2010	Gjegjan	present	Monitoring
Russia	2011	Matveev Kurgan	present	Monitoring

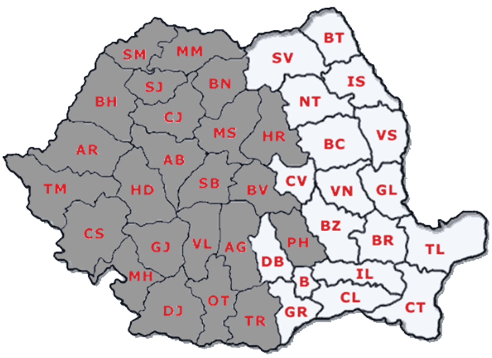

Figure 1. The spreading of *D. virgifera virgifera* in Romania in 1999

The scope of this paper is related to the possibility of developing a procedure for the surveillance of some crops in Southern and South-Eastern Romania and to identify, monitor and establish the pest potential of *D. virgifera virgifera*.

MATERIALS AND METHODS

The monitoring of adult populations of WCR practiced by European countries has allowed a rapid detection and establishing of the spread of this invasive pest since the insect has been first observed in Serbia. As it was shown in Table 1, the monitoring activity is still important in countries with or without isolated infestations, as well as in countries where WCR population is still spreading, and this is the situation in Romania. Our research seeks to establish the habitat, and to early detect the presence of species of WCR in counties from southern Romania, where in the well-known Romanian Plains (Bărăgan, Big Island of Brăila and the Danube plain) the corn is the most cultivated agricultural plant. The survey corn area included localities from the counties Dâmbovita, Teleorman, Giurgiu, Călărași and Constanța (Ciocăneşti, Drăgăneşti-Vlașca, Naipu, Fundulea, Amzacea), where a number of 1-4 pheromone traps were placed, according to the monitored area. The traps with sex pheromone (3- (4-methoxyphenyl)-2propenal) were bought from the company Csal♀m♂N®, a trademark of the Institute of Plant Protection MTA ATK, Budapest, Hungary, which are used species within the communication system chemical to lure males (Figure 2). Throughout the investigation period, the mean temperature and precipitations (liter/m^2) were registered with a digital field device.

Figure 2. KLPfero + pheromone trap in corn crop

RESULTS AND DISCUSSIONS

Distribution and rate of spreading of *D. virgifera virgifera* was correlated with some environmental factors, and in every analysis of the rate and speed of invasion, those must be taken into consideration. First of all, it is necessary to establish the trophic guild for this species belonging to the largest tribe of Luperini (Wilcox, 1965; Wilcox, 1972).

After many years of the investigation in the natural habitat from North America, it seems that the WCR species, beside of their chemical attraction on maize volatile emissions, (E)-β-farnesene, (E)-β-caryophyllene), they were influenced by the relative humidity (RH%) existing in the field. Taking into account this aspect, there could be an explanation for the low densities of adults of the pest in the south counties of Romania (Ialomița, Brăila, Galați, Constanța, Călărași), despite of the large surfaces of maize. As it is shown in Figure 3, in the observed areas, the climatic conditions especially in the summer months, July and August, of the year 2016, were characterized by much reduced rainfalls and very high values of temperatures. The dry conditions are not favorable for feeding and development larvae or adult.

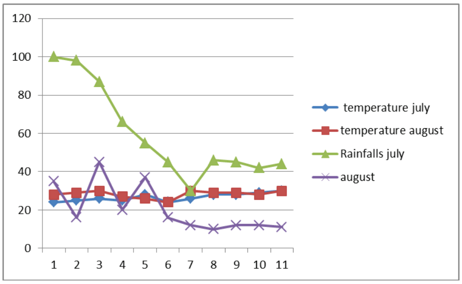

Figure 3. Average temperature ($^{\circ}$C) and rainfalls (mm) in the field of samples collection

The WCR, *D. virgifera virgifera* as a member of the *virgifera* subdivision of the largest genus Diabrotica (Smith, 1966), is a specialist on the Poaceae plants and ancestrally probably it reached maturity only on grasses, such as *Zea* spp., *Setaria* spp., and couch grasses in several genera (Clark and Hibbard, 2004; Oyediran et al., 2004; Moeser, 2003; Manole, 1999). Another important aspect related to WCR spreading and distribution must be the cultivated surface of maize. In Romania this crop is the first culture as importance. In 2015, Romania has the most area of maize (2.52 mil ha) in Europe (INS, 2016). In October 2003, the European Union introduced emergency measures to prevent the spread of WCR (Commission Decision 2003/766/EC) and also the Central and Eastern European countries of Bosnia-Herzegovina, Bulgaria, Croatia, Hungary, Romania, Serbia and Slovak Republic have initiated a new regional activity for integrated pest management for WCR as an FAO Trust Fund Project (GTFS/RER/017/ITA) with government of Italy like donor (Berger, 1996). Our investigation started from that point out, because one of the intriguing facts related to the tropho-dynamic module of the species, the abundance of food resources in the south of Romania does not seem to be the main factor for the spread and distribution of species.

Previous research (Manole, 1999) found WCR only in the county Sibiu but not in the counties from southern Romania. The monitoring program concerning the invasion of WCR in Romania started in 1996, soon after the first pest detection in Nădlac, using the same techniques as described in 1995 (Kiss, 2003). Although not the major area of emphasis, the continuation of in-country monitoring was included in this national research project. The monitoring of adult populations has allowed a rapid detection and establishes the spread of this invasive pest inside the country territory. Monitoring is still important for isolated infestations as well as where WCR populations are still spreading. Thus, in these areas, the monitoring has served as a means for detection, and in some instances, containment and control; in the case of new appearances outside the regular spread line, for eradication purposes. The monitoring data could provide information necessary for making quarantine and other regulatory decisions. In terms of thermal and hydrological data in 2016 (especially during the summer months, July and August), they indicated a dry climate, with temperatures reached 35-38°C, frequently in the shade. For this reason and because of the delay in placement of traps at the beginning of the flight of WCR adult (early June, overlapping flowering period and silk from corn), in the area of Fundulea and Amzacea, WCR adults were not trapped although the symptoms of attack were present (Table 2).

Table 2. The presence of WCR adults in the monitored areas during July-August in 2016

Locality	Number of adults	
	♀	♂
Cornățelu	3	46
Naipu	-	20
Drăgănești-Vlașca	-	5
Fundulea	-	-
Amzacea	-	-

As it is shown in Table 2, the presence of WCR adults were established in three out of five collecting points, despite the fact that symptoms of larvae attacks appeared in all locations (Figure 4).

Figure 4. Characteristic "gooseneck" symptom of WCR attack

The pheromonal traps used, Csal♀m♂N®, KLPfero + containing cucurbitacin bait, were able to capture both sexes. Our trapping data showed that the flight activity of males was much intense than of the females, which prefered to feed on the ear corn silk (Table 2). The presence of the adult males in the traps could be, also the effect of ending of the mating period and preparing to hibernate. In the Figure 5, the number of trapped insects appears to confirm a higher density of the pest in the maize crop from Dâmbovița County, probably due to the better climatic situation in the field, especially RH%. Another factor that could be taken into consideration must be the behavior of the adult related to so called 'alternative host'.

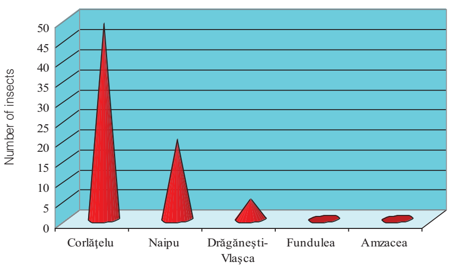

Figure 5. The abundance of WCR adult in monitored areas

Females of *D. virgifera virgifera* do not lay their eggs on a host plant such as maize, for instance, the eggs are laid in the soil in the late autumn, and the larvae emerge the following spring. Host location is then carried out underground by the neonate larvae. The time between egg hatch and larval establishment is one of the more vulnerable times in the life cycle of these insects (Toepfer and Kuhlmann, 2005). If host establishment is delayed for as little as 24 h, survival to the adult stage is significantly reduced (Branson, 1989). Therefore, timing of egg hatch and root availability is so critical. Root toughness may also be a limiting factor. In the light of previous investigations (Abe, 2000; Andersen, 1987; Branson and Krysan, 1981) their data suggest that WCR larvae not only prefer newly developed roots, as was already known but of 41 grasses and 27 broadleaf species were evaluated in early studies giving insight into 'grasses only' as larval hosts (Branson and Ortman, 1967). To evaluate the food conversion efficiency as WCR food resources for alternative host plants must take into consideration the chemical-olfactive behavior of WCR to other important plant volatiles such as cucurbitacin which, for majority of other species this compound was repellent. The corn crop in the field in Dâmbovița County was located near some important surfaces rich in spontaneous vegetation and that could provide an explanation on the higher population density than in Ialomița and Călărași counties for example.

CONCLUSIONS

The trapping data in this study had confirmed the presence of the species *D. virgifera virgifera* in maize crops from Teleorman, Giurgiu and Dâmbovița Counties situated in the South side of Romania.

It was noted the first registration of the pest presence in the County Dâmbovița as result of extending of the corn crop in this zone. Although the area of maize crop has increased in the counties in Southern Romania, no investigation on *D. virgifera virgifera* has been carried out so far, by the plant quarantine service to establish the presence and density of the pest.

In large areas of corn growing, (i.e. The Big Island of Brăila) that are the greatest areas of monoculture corn and the places where the chemical treatments to seeds and in vegetation are strongly carried out, besides signaling the presence and monitoring, is necessary to determine the resistance of the species to plant protection products used.

Given the spread of *D. virgifera virgifera* in Romania, related to the specific hosts such as maize, soya or pumpkin crops, it will be necessary to continue monitoring activity in 2017.

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REFERENCES

Abe M., Matsuda K., Tamaki Y., 2000. Differences in feeding response among three cucurbitaceous feeding leaf beetles to cucurbitacins, Applied Entomology and Zoology, 35:137-142.

Andersen J.F., 1987. Composition of the floral odor of *Cucurbita maxima* Duches (*Cucurbitaceae*), Journal of Agricultural and Food Chemistry, 35:60-62.

Ball H.J., Weekman G.T., 1962. Insecticide resistance in the adult western corn rootworm in Nebraska, Journal of Economic Entomology, 55:439-441.

Berger H.K., 1996. Multi-country coordination efforts to deal with the western corn rootworm (*Diabrotica virgifera virgifera*), IWGO News Letter, 16:26-29.

Branson T.F., Ortman E.E., 1967. Host range of larvae of the western corn rootworm: further studies, Journal of Economic Entomology, 60:201-203.

Branson T.F., Krysan J.L., 1981. Feeding and oviposition behavior and life cycle strategies of Diabrotica: an evolutionary view with implications for pest management, Environmental Entomology, 10:826-831.

Branson T.F., 1989. Survival of starved neonate larvae of *Diabrotica virgifera virgifera* LeConte (*Coleoptera*: *Chrysomelidae*), Journal of the Kansas Entomological Society, 62:521-523.

Clark T.L., Hibbard B.E., 2004. A comparison of non-maize hosts to support western corn rootworm (*Coleoptera*: *Chrysomelidae*) larval biology, Environmental Entomology, 33:681-689.

Gillette C.P., 1912. *Diabrotica virgifera virgifera* LeConte as a corn rootworm, Journal of Economic Entomology, 5:364-366.

INS - Anuarul Statistic al României 2016.

Kiss J., 2003. Final report on western corn rootworm (WCR), *Diabrotica virgifera virgifera* LeConte, network activity, UN FAO Report no.PR 21261.

Manole T., 1999. Raport cu privire la prezența și răspândirea speciei *Diabrotica virgifera virgifera* LeConte (*Coleoptera*: *Chrysomelidae*), (viermele vestic al rădăcinilor de porumb) în Transilvania, Direcția Agricolă Fitosanitară MADR, 55 pag.

Metcalf R.J., 1983. Implications and prognosis of resistance to insecticides. In: Georghiou, G., P., & Saito, T., (eds) – Pest resistance to pesticides, John Wiley & Sons, NY, pp. 703-733.

Metcalf R.J., 1986. Foreword, In: Krysan, J.L., & Miller, T.A., (eds) – Methods for the study of pest Diabrotica, Springer-Verlag, NY, pp. VII-XV.

Moeser J., 2003. Nutritional ecology of the invasive maize pest *Diabrotica virgifera virgifera* LeConte in Europe, PhD dissertation.

Oyediran I.O., Hibbard B.E., Clark T.L., 2004. Prairie grasses as alternate hosts of western corn rootworm (*Coleoptera*: *Chrysomelidae*), Environmental Entomology, 33:740-747.

Smith R.F., 1966. The distribution of Diabroticites in Western North America, Bulletin of the Entomological Society of America, 12:108-110.

Toepfer S., Kuhlmann U., 2005. Natural mortality factors acting on western corn rootworm populations: a comparison between the United States and Central Europe, In: Western Corn Rootworm-Ecology and management, Vidal, S., Kuhlmann, U., Edwards, C.,R., (eds), chapter 5, pp. 95-119.

Tóth M., Toth V., Ujvary I., Sivcev I., Manojlovic B., Ilovai Z., 1996. Sex pheromone trapping of *Diabrotica virgifera virgifera* LeConte in Central Europe, Növényvédelem, 32(9):447-452.

Vidal S., Kuhlmann U., Edwards C.R., 2005. Western Corn Rootworm – Ecology and Management, CABI Publish., 310 pp. Wilcox J. A., 1965. A synopsis of the North America Galerucinae (*Coleoptera*: *Chrysomelidae*), Bulletin no. 400, NY State Museum and Science Service, Albany, New Jersey, 226 pp.

Wilcox J.A., 1972a. Coleopterorum catalogus supplementa (*Chrysomelidae*: *Galerucinae*: *Luperini*: *Aulacophorina*: *Diabroticina*), pars 78, fasc. 2, 2nd edn. Dr W. Junk, Dordrecht, The Netherlands.

Wilcox J.,A., 1972b, Coleopterorum catalogus supplementa *Chrysomelidae*: *Galerucinae*: *Luperini*: *Luperina*), pars 78, fasc. 3, 2nd edn. Dr W. Junk, Dordrecht, The Netherlands.

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AN INVESTIGATION INTO THE FEASIBILITY OF HYBRID AND ALL-ELECTRIC AGRICULTURAL MACHINES

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Abstract

Whilst manufacturers in the passenger car, commercial and public service vehicle industries have introduced hybrid and all-electric vehicles, to commercial success, there is an apparent lack of hybrid and all-electric technology in the agricultural machinery sector.
This project used a three-stage approach to investigate whether current hybrid and all-electric drivetrains could feasibly replace the diesel engine in an agricultural tractor. Firstly, a current systems review, gathered information from a range of industries where alternative powertrains have been successful, to gain an understanding of the properties and capabilities of available systems. The second element; a series of real-world practical tests, collected data about the requirements of agricultural tractors in use, this would be used to determine whether the alternative technology currently available could cope with the demands placed on a machine. Finally, a questionnaire, collected data from those working in the agricultural sector; this would be used to gauge attitudes and opinions towards alternative power systems.
There were two sets of practical tests. The first used a McCormick MC120, in a round bale loading exercise, on a farm in Cheshire, in November of 2015. The second set of tests used a New Holland TS90, operating a feeder wagon, on a medium sized dairy farm, in Derbyshire. These tests ran from November 2015 to early February 2016. Calculations proved the cost of charging an all-electric system capable of producing the required output of the practical tests would be more than the cost of diesel for the same output.

Key words*: all electric technology, agricultural machinery, alternative power systems, power, torque, hybrid.*

INTRODUCTION

The industrial food supply system is the worlds' largest consumer of fossil fuels and one of the greatest producers of greenhouse gases. Cheap and readily available energy is essential, in the construction and maintenance of the infrastructure needed to facilitate the agricultural industry (Church, 2005).
Spackman (2012) warns that fuel security is an ever-increasing issue for everyone.
Increasing costs and environmental awareness has made the use of alternative power methods, such as hybrid and all-electric vehicles, widely accepted in many industries (Phelan, 2015); however, agriculture does not appear to be adopting the technology.
This research project investigated whether hybrid and all-electric technology can feasibly replace the diesel engine, in an agricultural machine, and critically analyse why the technology appears to have been adopted more readily in other industries.
The investigation began with a simple thought. Many cars and buses on UK roads are being powered with hybrid or all-electric drivetrains, so why are there no hybrid or electric tractors?
Alternative drive technologies are becoming increasingly important. Strict emissions regulations and the finite nature of fossil fuels make using alternative drive concepts inevitable (Bosch, 2009).
Mild Hybrid – A combustion engine is supported by a low powered electric motor. The vehicle cannot run purely on electrical power.
Full Hybrid – The vehicle is mainly powered by a combustion engine. It can be driven short distances using electrical power.
Plug-in Hybrid – The vehicle is powered by a combustion engine but can be driven longer distances using electrical power. The battery can also be charged directly from an electrical socket.
Electric Vehicle – The vehicle is powered solely by an electric motor. The battery is recharged from an electrical socket or charging station.

Electric Vehicle with Range Extender – The vehicle is powered solely by an electric motor. A small combustion engine can charge the battery as needed, but the engine cannot power the vehicle alone.

Electric Vehicle Technology

Youngs (2012) explains that AEVs work on similar principles to any rechargeable battery device such as a toothbrush or battery drill. An electric car has a bank of high-voltage rechargeable batteries and at least one electric motor. A controller feeds electricity to the electric motor(s) based on accelerator pedal position. Once drained, the battery pack is recharged. Table 1 lists the specifications of a selection of AEVs.

Table 1. Electric Vehicle Specifications

Make and Model	Electric Motor Kw/Nm)	Battery Pack Output Kw/hr)	Charging Time (hrs)	Battery Pack (Kg)
Volkswagen e-Golf	85/270	24.2 @ 323V	8 @ 240V/13A AC 0.5 @ DC Fast Charge	318
Ford, Focus Electric	107/ 250	23	3-4 @ 32A 6-7 @ 16A 10-11 @ 10A	318
Nissan, Leaf	80/280	24 or 30	4 or 5.5 @ 240V/12A	306
Chevrolet, Bolt	150/ 360	60	2 @ 240V/16A AC 0.5 @ DC Fast Charge	435
Mitsubishi, i-MiEV	49/196	16 @ 330V	6 @ 240V/15A, 14 @ 120V/12A, 22 @ 120V/8A,	150

Table 2. Electric Vehicle Specifications cont

Make and Model	Weight (Kg)	Weight of Battery Pack (Kg)	Price
Volkswagen e-Golf	1585	318	£31650
Ford, Focus Electric	1674	318	£31145
Nissan, Leaf	1945	306	£16,290 –£24,990
Chevrolet, Bolt	1625	435	N/A
Mitsubishi, i-MiEV	1170	150	N/A

Recharging

It is difficult to determine exactly how long it takes to charge an AEV. It depends on the condition of the batteries, the state of charge and the voltage and amperage of the electricity supplied to the vehicle (Plug In America, 2015) 3.3 - Hybrid Vehicle Technology.

Cobb (2014) explains there are three main types of hybrid electric vehicle (HEV); full, mild and plug-in hybrids; which were explained at the beginning of this section. Lake (2015), explains that most hybrid vehicles work on one of two systems; series or parallel.

Series Hybrid Technology

A series system solely relies on the electric motor to propel the vehicle. The electric motor is powered by a battery pack, or an engine driven generator. A control module determines how much power is required and takes energy either from the battery pack or generator accordingly (Lake, 2015).

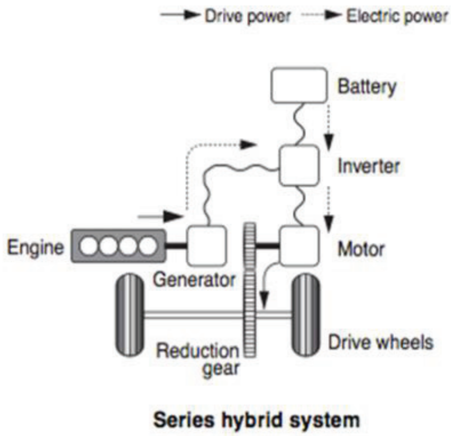

Figure 1. Diagram showing the layout and power flow through a series hybrid system
Source: Katsoupis, 2013

Parallel Hybrid Technology

In a parallel system, both the electric motor and the combustion engine work in tandem to propel the vehicle; the engine and the electric motor are both connected to the transmission. A controller determines when the electric motor is used and when to switch to the engine. In circumstances where short power boosts are required, when accelerating quickly for example, both the combustion engine and the electric motor work together to power the transmission (Lake, 2015).

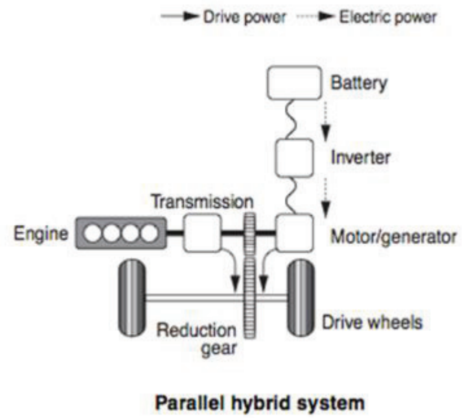

Figure 2. Diagram showing the layout and power flow through a parallel hybrid system (Source: Katsoupis, 2013)

Regenerative Braking

The future feasibility of electrical powertrains is greatly dependant on efficient batteries, intelligent energy management and the recovery of braking energy. Regenerative braking systems are a key element of alternatively powered vehicles (Bosch, 2009).

Solberg (2007) explains that when decelerating, a vehicles kinetic energy is transformed into heat by friction between the brake pads and discs. This heat is dissipated to the atmosphere and the kinetic energy is essentially lost. Recuperation or regenerative braking systems, recover kinetic energy from a vehicle decelerating, by turning the electric motor, which drives the vehicle, into a generator, recharging the batteries.

MATERIALS AND METHODS

The success of hybrid and all electric vehicles in industries has been demonstrated, however, the question was posed as to why this technology has not been implemented in agricultural machines.

The investigation aims are split into three areas:

Current Systems Review – researching the capabilities, benefits and drawbacks of current hybrid and all-electric vehicles.

A Feasibility Study - discovering whether; with current equipment capabilities, it is possible for a hybrid or all electric vehicle to carry out routine tasks, in place of a diesel-powered alternative

A Perception Study – collecting information from, mainly farmers and agricultural workers, to review whether people would buy an electric or hybrid tractor, if it were possible to produce one that could carry out the same tasks as their current machine.

Two farms near Manchester were contacted and participated in the study; they agreed to be of any assistance they could, where and when available. Both farmers agreed they and their staff would complete questionnaires for use in the perception study.

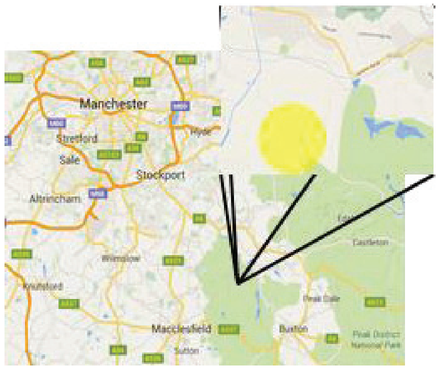

Figure 3. Location of farms used in the research project

Farm 1 has a dairy herd of between 120-130 head, milking twice daily, with just over 142 hectares of grazing and silage land. The owner offered the services of his tractor and feeder wagon, for the feasibility study.

Farm 2 is a 50 hectares' farm situated next door. The farm produces between 1000-1100 round bales of haylage and silage, a year, used for feeding horses and deer at the local farms and Country Park. The owner operates the farm single handed and uses one tractor for everything, his machine was also offered for the feasibility study.

The areas for investigated included:

Passenger Vehicle Technology – Including passenger cars, SUVs and high performance cars.

Commercial Vehicles and Buses – Many bus companies are now using hybrid buses; have they been a success? Investigate their power capabilities.

Articles and Journals – Current and past studies and reports written about the topic.

Manufacturer Future Plans – Research manufacturers' future machinery plans; are there any planning on producing electric tractors?

Testing

Fuel Consumption Test

Record how much fuel a diesel tractor uses completing a measurable, routine task; for these experiments, a tractor operating a feeder wagon and a tractor loading/unloading haylage bales. Fuel consumption recorded 10 times to provide a data set to calculate averages from.

Power Requirement Calculation

Use dynamometer to calculate how much power a machine is using to complete a task, by measuring its fuel usage; known as fuel to power ratio this is given as Horsepower per Litre, this is converted to Kilowatts per Litre, as this is the unit of measurement for electrical power output.

Current System Analysis

Using the output calculation and the previous current vehicle investigation it will be possible to conclude whether, with current technology, it is possible to create an electric or hybrid vehicle to replace the diesel engine.

Perception study

Using mainly questionnaires and interviews; data centred on individuals' perceptions of electric vehicles, questions included:
What does the interviewee do for work, farmer, farmhand, contractor etc?
What main uses do they have for agricultural machines?
What current vehicles do they own?
Does the interviewee own/ever considered owning an electric or hybrid vehicle?
Is there particular reasons they would not purchase an electric or hybrid vehicle
By compiling the data, it is possible to find trends in the answers, for example those who own electric vehicles may be more likely to purchase an electric tractor, whereas those who are contractors may be concerned about the cost implications.

RESULTS AND DISCUSSION

The first practical tests recorded the amount of fuel used and time taken to complete common farmyard tasks, these results were used to calculate average fuel use per minute figures.

Figure 4. Measuring fuel used

Table 3. Displaying the time taken and fuel used to complete the ten bale handling tests

Test No.	Time Taken (min/sec)	Fuel Used (ml)	
1	6:28	560	
2	6:27	600	
3	6:06	580	
4	6:14	650	
5	6:07	600	
6	6:36	480	
7	5:37	475	
8	6:57	470	
9	5:56	560	
10	6:02	500	
Total	72.52	5475	
Average (mean)	7.25	547.5	75.6 ml/min

The second set of tests used a dynamometer to determine the power and torque requirements of the practical tests, based on the amount of fuel used.

Figure 5. Tractor under test using a Fromet dynamometer

Eight tests were run with each machine used in the practical tests
Each test lasted fifteen minutes and demanded an increasing amount of power and torque from the machines.
The results collected from the dynamometer tests were plotted onto scatter charts. Using the

average fuel consumption per minute figures previously calculated, the power and the torque demand of the practical tests is determined.

Table 4. Showing the fuel used and the power produced through each of the fifteen-minute dynamometer tests, at set output increments

Time (min)	Power %	Power (hp)/Kw)	Fuel (ml)	Torque (lb/ft)/(Nm)
15:00	10	11/8	1900	62/84
15:00	25	29/22	2900	145/196.6
15:00	50	57/43	4200	292/395.9
15:00	75	86/65	5300	446/604.7

Table 5. Showing the fuel used and the torque produced through each of the fifteen-minute dynamometer tests, at set output increments

Time (min)	Torque %	Torque (lb/ft)/(Nm)	Fuel Used (ml)
15:00	10	83/113	2470
15:00	25	209/284	3720
15:00	50	417/567	4880
15:00	75	626/851	5200

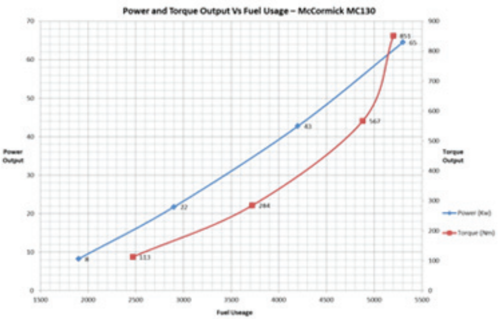

Figure 6. Showing power and torque output v^s fuel use for McCormick MC130 tractor

The McCormick tractor produced a stable power curve with strong correlation between power production and fuel consumption. Using the data in Table 6, it is possible to estimate the power output of the tractor at the desired fuel usage rate of 1314 ml in fifteen minutes.

It is apparent, from the data that the more power produced, the more efficient the engine becomes; meaning using the mean average of all results for calculations would not provide accurate figures. Instead the 10% output value will be used, as it is closest to the expected figure. At a rate of 237.5 ml/Kw, the tractor would expectantly produce 5.5Kw of power, when using 1314 ml per fifteen minutes.

Table 6. Calculating power output per unit of fuel for the McCormick tractor, used for the bale handling tests

Power %	Power (Kw)	Fuel Used (ml)	Power Produced per Unit of Fuel (ml/Kw)
10	8	1900	237.5
25	22	2900	131.8
50	43	4200	97.7
75	65	5300	81.5
AVERAGE			137.1

The same calculations are used to estimate the torque requirements of the practical tests. These figures are more difficult to calculate accurately as the tractors torque curve did not have as close a correlation as the power curve.

Table 7, lists torque output per unit of fuel; similarly, to power, torque production becomes more efficient as it increases. Therefore, the calculations will use the 10% values. At the rate of 21 ml/Nm, the tractor produces 63 Nm of torque, using 1314 ml of fuel in fifteen minutes.

Table 7. Calculating torque output per unit of fuel for the McCormick tractor, used for the bale handling tests

Torque %	Torque (Nm)	Fuel Used (ml)	Torque Produced per Unit of Fuel (ml/Nm)
10	113	2470	21.9
25	284	3720	13.1
50	567	4880	8.6
75	851	5200	6.1
AVERAGE			12.4

Feeder Wagon Test

Table 8. Displaying the time taken and fuel used to complete the ten feeder wagon tests

Test No.	Time Taken (mins)	Fuel Used (ml)	
1	94.52	8550	
2	91.00	7890	
3	65.47	6000	
4	93.46	8750	
5	83.49	8300	
6	73.40	6840	
7	70.10	6830	
8	67.00	6450	
9	61.40	6160	
10	60.00	5810	
Total	759.84	71580	
Average	75.84	7158.0	94.74 ml/min

Table 9. Showing the fuel used and the power produced through each of the fifteen-minute dynamometer tests, at set output increments

Time (min)	Power %	Power (hp)/(Kw)	Torque (Nm)	Fuel Used (ml)
15:00	10	9/7	87	1225
15:00	25	22/17	220	1870
15:00	50	44/33	465	2450
15:00	75	66/50	683	3680

Table 10. Showing the fuel used and the torque produced through each of the fifteen-minute dynamometer tests, at set output increments

Time (min)	Torque %	Torque (lb/ft)(/Nm)	Power (hp)	Fuel Used (ml)
15:00	10	53/72	6	1275
15:00	25	132/180	15	1500
15:00	50	265/360	26	1875
15:00	75	397/540	41	2550

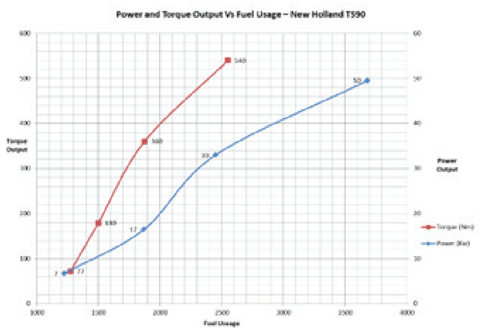

Figure 7. Showing the torque and power production figures (Y axis) against fuel usage (X axis)

The feeder wagon tests provided more useful data, than the bale handling exercise.
On average the test used 94.1ml/min of fuel.
To replicate the power and torque requirements of the practical tests the tractor must use 1412ml of fuel during the fifteen-minute dynamometer test.
Figure 7 displays the power and torque output where this figure is reached.

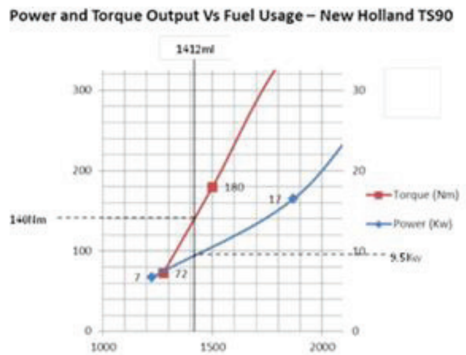

Figure 8. An extract from Figure 7, showing the fuel consumption at 10% and 25% power and torque outputs, 1412ml is marked with the black line, on the X axis, the power and torque figures are marked with the dashed lines on the Y axis.

Questionnaires

The original proposal called for 100 questionnaires to be completed, the sample size reduced to 30 throughout the study, as the questionnaires retrieved more information than originally expected.
The largest issues participants identified, were charging time (21, 27%), cost of purchase (18, 23%), capabilities (16, 20%).

Analysis of Questionnaires

The lead in questions collected information about the participants' job role and machinery usage. These questions were designed to discover whether there were correlations between participants' machinery usage and purpose, and their openness towards new technologies. When the responses were compiled, there appeared to be no correlation.

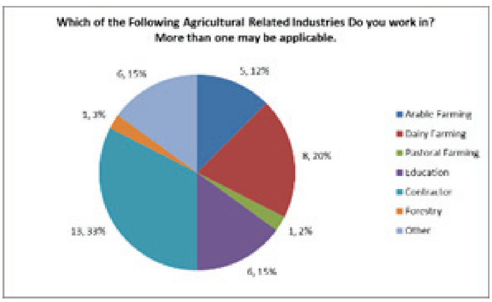

Figure 9. Showing spread of participants' industrial background

Questions gathered information from a wide range of agricultural workers, of the thirty questioned; only 6.7% owned a hybrid or electric vehicle. The report began by investigating how alternatively powered vehicles are becoming popular in the passenger vehicle market; the responses from this question demonstrate an apparent lack of these vehicles being used by the agricultural workforce.

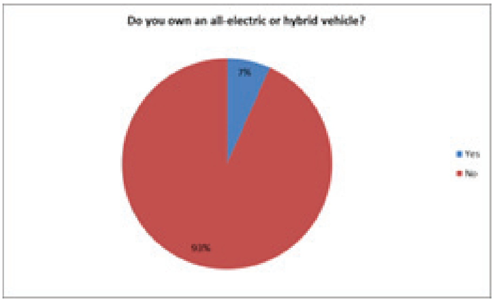

Figure 10. Showing percentage ownership of electric powered vehicles

20% of participants answered that they had considered purchasing an alternatively powered vehicle, two of which already owned vehicles, leaving the others, who considered purchasing a HEV or AEV but never did.

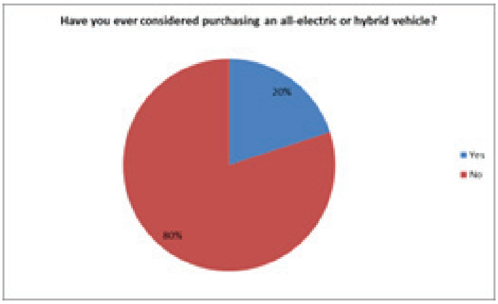

Figure 11. Indication of considering the purchase of an electric powered vehicle

Those participants who had considered purchasing an alternatively powered machine, but hadn't bought one, had researched the topic, including the views and opinions of current and previous owners.

Participants were asked which technology they believed would be more suitable in an agricultural environment. Hybrid systems were considered as more suitable for agricultural uses. The lack of a need to charge a hybrid vehicle and the benefits of having a diesel engine, for backup in case of electrical failure and the lighter weight of a hybrid system over a heavy bank of batteries and a large electric motor.

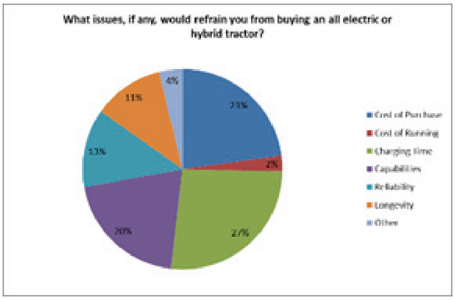

Figure 12. Showing reasons for not purchasing an electric powered vehicle

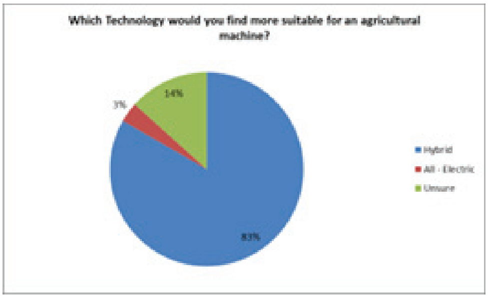

Figure 13. Indicates which of the electric vehicle technologies would be considered more suitable for agriculture

The responses from 67% participants showed that they would consider replacing a current vehicle with an alternatively powered tractor.

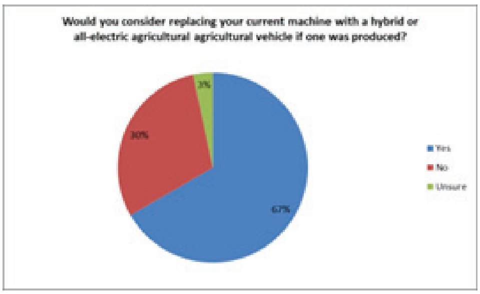

Figure 14. Indicates the concept of replacing a current agricultural machine with an electric powered alternative

66% of participants answered that they would consider purchasing a hybrid or all-electric tractor, if one were produced.

Capability and feasibility are two separate concepts.

Whilst the results from the investigation demonstrate, there are a range of all-electric systems capable of the outputs required from a tractor.
The feasibility of an all-electric or hybrid system replacing a diesel engine goes beyond their capable outputs. Cost of purchase, cost of running, predicted lifespan and weight were areas analysed by the investigation.
Using the data collected from the practical tests and the specifications compiled throughout the current systems review the investigation analysed how alternative drivetrains would cope with the demands placed on a tractor through regular use.
The concerns raised in the questionnaire responses, became focus points for the discussion.
Cost of purchase, running costs, capabilities and lifespan were the main areas for discussion.

Machinery Requirements

The test result and analysis section calculated how much power and torque a machine must produce in order to complete the routine tasks, used for the investigation. To complete the bale handling exercise, the tractor used 5.5 Kw of power and 63 Nm of torque over an average time of 6:15 (min:sec). The tractor completing the feeder wagon exercise needed to produce 9.5Kw of power and 140 Nm of torque for an average time of 1:12:06 (hr:min:sec).

Electrical Vehicle Capabilities

The Electric vehicle section at the beginning of the report analysed popular all-electric vehicles; their capabilities listed in Table 1. All five of the electrical systems fitted to the example vehicles were capable of producing the power and torque requirements of both practical tests. To be deemed feasible, the electrical system would need to be able to complete the tasks repeatedly. The largest battery, by power output, in Table 1, is used in the Chevrolet Bolt, with a maximum power output of 60 Kw/hr. This battery coupled with its motor, could continually produce the power required by the bale handling exercise for 10:56 (hr:min), and the feeder wagon exercise for 6:20 (hr:min). The smallest battery, by output, fitted to the Mitsubishi i-MiEV, could sustain the required output of the bale handling test for 2:54 (hr:min) and the feeder wagon test for 1:42 (hr:min). Both times are longer than the maximum time taken to complete either exercise.

Weight and Fuel

All-electric vehicles have no engine or fuel tank. The McCormick MC120 carries 196 litres (L) of diesel, weighing approximately 170Kg (Argo Tractors, 2009). The tractors engine, weighs 306Kg, plus approximately 20 L of coolant and oil (Perkins Engines Company Limited, 2014).
The combined weight of the tractors fuel and engine equals approximately 496 Kg; 62 Kg heavier than the most powerful and heaviest electrical system of the range in Table 1, (pp.12); Taking into account that the bale handling exercise consumed 87.6 ml/min of fuel, the fuel on board, could complete the task continually for 37:20 (hr:min), using the calculations from the previous section this is over three and a half times longer than the predicted length of time an electric system could manage.
The 4-cylinder turbo charged engine in the New Holland TS90 weighs 408 Kg (New Holland Agriculture, 2016). The fuel tank has a capacity of 159 L; approximately 140 Kg of diesel (Tractor-Database, 2012); giving a combined weight of 548 Kg. This is 113 Kg heavier than the Chevrolet Bolts' electrical system, previously used for comparison. As discussed the electric motor and batteries are capable of producing the tasks requirements for 6:20 (hr:min). At an average fuel usage rate of 94.1ml/min the tractor carries enough fuel to continually run for approximately 28:10 (hr:min); over four times the length of the electrical system.

Cost

Tables 1 and 3 provide comparative prices for the Volkswagen Golf and Ford Focus. The e-Golf is over £ 11000 more expensive than the petrol example; the difference between the Focus electric and diesel model is over £12000; approximately 30% more costly.

Cost of Recharging

The charging time of an AEV depends heavily on the type of charger used. The Chevrolet Bolt has been used for comparison in the previous sections, however, the exact specification of its on-board charging system was unobtainable. Therefore, the Volkswagen system will be used for this comparison.

The Volkswagen system charges at a rate of 7.2 Kw/hr and a full charge takes 8 hrs. The Energy Saving Trust, (2016); states the average UK electricity price for March 2016, is 13.86 pence per Kw/hr (ppKw/hr). With a 7.2 kw/hr draw for 8 hrs at 13.86 ppKw/hr; a full charge would cost approximately £7.98.

Using previous calculations, it can be determined that the e-Golf's 24.2 Kw/hr battery pack could produce the feeder wagon exercises required power for 2:30 (hr:min); on a full charge. To complete that task for the same amount of time at the fuel usage rate of 94.1 ml/min; the diesel-powered tractor would use 16.94 L of fuel.

The Agriculture and Horticulture Development Board, (2016); states the average UK red diesel price for March 2016 is 38.62 pence per litre (ppl), equalling a total cost of £6.54, for 2:30 (hr:min) of required output.

Lifetime

Cobb, (2014); discusses lifetime expectations of electric vehicle batteries. The author explains that the majority of AEV and HEV manufacturers provide battery pack warranties with their vehicles. The warranty periods are described as a good estimate for what users can expect from a battery pack over a given time.

The Nissan Leaf, listed in Table 1, is sold in the UK with a battery warranty, guaranteeing a minimum of 75% battery output for 8 years for 30 Kw/hr packs and 5 years for 24 Kw/hr packs (Nissan Great Britain, 2015).

The battery from the Chevrolet Bolt, the most powerful of the range, is covered by an 8-year warranty. The manufacturer states that, depending on use, the batteries capacity would reduce by 10-30% over the warranty period (Chevrolet, 2015).

The New Holland TS90 tractor, used for the feeder wagon tests, is 13 years old and has completed over 6000 hrs of service. When new, the manufacturer claimed the engine could produce 90 hp, the dynamometer results, show the tractor is now capable of 87.4 hp, a loss of 2.6 hp or less than 3%, over its lifetime.

The larger, McCormick MC120 tractor left the factory with a rated output of 115 hp; during the dynamometer tests, (see appendix 8); the tractor produced 114.3 hp, a loss of 0.7 hp or 0.6%, over four years and over 1500 hrs of service.

Hybrid Vehicle Suitability

The report has discussed, in detail the feasibility of electric drivetrains in agricultural tractors. The following sub-section will analyse the various hybrid drivetrains explained in the current systems review.

Reputable sources of information concerning hybrid vehicle systems and their capabilities were difficult to find throughout the investigation. Many books and articles had been written about the working principles of the systems, however, there appeared to be a distinct lack of comparable data between hybrid vehicles and their fossil fuelled alternatives. When discussing comparative pricing and weight in the following text, only one vehicle manufacturer provided enough data to form an argument. Many of the theories and technologies discussed by manufacturers were deemed unsuitable for an agricultural product, as this section explains.

Agricultural tractors are designed to meet a unique set of requirements; including pulling heavy loads at low speeds for long periods, in low traction conditions. So far, development of hybrid and all-electric systems has been directed at the needs of passenger cars, which have their own requirements, not always similar to those of agricultural machines, (Hewson, 2009).

Regenerative Braking

Regenerative braking and kinetic energy recovery systems are fundamental elements of any hybrid system. These systems recover energy through vehicle deceleration. This technology is utilised frequently in a car or truck, constantly speeding up and slowing down throughout a journey. In situations, such as fieldwork, where tractors are travelling at constant speeds, with a stable load, for long periods; a system that relies on deceleration is less suitable.

Commercial Vehicle Systems

Commercial vehicles use parallel hybrid systems. The Renault HYBRIS truck relies on electrical power to propel the vehicle from stationary to 20 Km/hr, at which point the diesel engine in the vehicle takes over and accelerates the vehicle to top speed.

The McCormick MC120 measured the distance travelled throughout the bale handling tests, accurately, and calculated an average distance of 389 metres; the tests took an average time of 6:15 (min:sec), giving an average speed of 3.7 Km/hr

The New Holland tractor, used for the feeder wagon tests, did not have the capacity to measure distance travelled accurately; therefore, a Trimble wheel was used to measure the total distance covered by the exercise; approximately 700 metres; travelling took an average time of 8:33 (min:sec), giving an average speed of 4.9 km/hr.

If a speed sensing system, such as the one in a Renault truck were to be utilised, for the tractors, completing the practical tests, the combustion engine would not engage, as the speed would remain too low. This point links back to a statement made by Hewson (2009), who commented that tractors are required to pull heavy loads at low speeds; a system which uses only electrical power at low speeds would limit the scope of use of a machine.

Cost and Weight

The Volkswagen Golf is a passenger car, available in both a hybrid and combustion engine version. Similar to the comparison between the all-electric and petrol Golf, made in the previous section, the Golf GTE hybrid is over £13500 more expensive and 350 Kg heavier than the petrol model.

Eriksson (2013); commented, in an article reporting on hybrid commercial vehicles; that the current cost of hybrid technology is forcing the overall cost of a vehicle so high that it is difficult for operators to achieve any economic gains from them. AEVs were also proven less economically viable where purchase costs and a calculated approximate charging costs, were both higher than diesel alternatives.

The information publicly available for the three commercial vehicle examples did not include comparative weight or cost data. The gross vehicle weights were quoted, however, the tare weights; those which measure a vehicle's weight with no load, were not specified; therefore, the study could not compare the payload differences between a hybrid and diesel example.

The topic of weight relates back to an argument made by Randall (2012); who commented how it is unlikely that pure-electric trucks will become available in the near future due to significant sacrifices to vehicle payload, with the use of a battery pack and motor.

Series Systems

Series hybrid systems use a combustion engine as an electricity generator. All motive power and propulsion is by electric motors, the power supply is either by a small battery pack, or directly from the generator.

An article published in Profi (2015); reported that transmission manufacturer, ZF had produced a prototype electronic wheel drive. The system is designed for retrofitting to trailed equipment and not as a replacement for the mechanical drive and diesel power used in tractors.

The possibility that tractors will become more like mobile diesel electricity generators, used to power electrical machinery and implements, links to an article written by Patrico (2013); where the author discussed the idea of replacing mechanical hydraulic pumps, hoses and shafts with more efficient electric motors. The main drawback of the system is described as a chicken and egg scenario, where tractor manufacturers will not develop a hybrid machine until there are electric implements to power; however, implement manufacturers will not produce electric machinery until there are diesel-electric tractors to pull them.

CONCLUSIONS

Using the information compiled throughout the study, the following points were concluded:

All of the all-electric systems reviewed were capable of producing the power required by the exercises.

The tractor diesel systems and engines were both heavier than any of the all-electric systems.

The example all-electric and hybrid vehicles were both over £13,000 more expensive than a comparable combustion engine car.

The cost of charging an all-electric system capable of the required output, of the feeder wagon tests - £7.98. The cost of diesel for the same output, from the test tractor- £6.5.
In addition, the data collected demonstrated how two farmers were regularly using a fraction of their machines potential. Posing the question; Do farmers need to purchase the large, powerful machines seen in modern farmyards, or are they purchasing machines, which are wasting more energy than they are utilising?

Areas for further study

This investigation drew together a small amount of information from many different sources. The practical testing element, although successful in terms of data collection, only collected data from a small number of machines and activities. In future, it would be beneficial for another study to gather more information from a larger amount of farming practices, to better understand what is required from modern agricultural machines. Whilst the two tasks selected were common and routine, they were not representative of the range of tasks tractors are designed for. Future studies may look at the power and torque requirements of heavier tasks, such as cultivation, harvesting or application processes.
Controllability of the tasks made gathering accurate data difficult with this study. This became apparent when collecting data from the feeder wagon exercise; as explained in the discussion section; it was impossible to accurately determine the power requirements of the task at specific points, such as loading and travelling. A future study may benefit from taking more time collecting results in stages throughout the exercises.
Although the original proposal never attempted to investigate the topic of machinery use and size, the data collected showed how two farmers were regularly using machines, which were only utilising a fraction of their potential. It is questionable as to whether large powerful machines are really necessary for tasks which, in these cases could be easily completed with less powerful tractors.

ACKNOWLEDGEMENTS

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REFERENCES

Agriculture and Horticulture Development Board, 2016. Monthly Fuel Price Tracker.
Church N., 2005. Why Our Food is So Dependent on Oil. Resilience, 1 April.
Cobb J., 2014. How Long Will An Electric Car's Battery Last? Hybrid Cars - Auto Alternatives, 30 April.
Eriksson C., 2013. Volvos' Electric Hybrid as Reliable as a Diesel Truck. Automo.
Hewson J., 2009. There are Major Barriers to the Mass Production of Electric Tractors. The Guardian, 25 November.
Katsoupis J., 2013. How Your Toyota Hybrid Works. [Online] Available at: www.wellesleytoyota.com/ bid/328878/How-Your-Toyota-Hybrid-Engine-Works
Lake R., 2015. The Difference Between Parallel Hybrid Cars & Series Hybrid Cars. [Online] Available at: http://www.livestrong.com/article/174905-the-difference-between-parallel-hybrid-cars-series-hybrid-cars/
Patrico J., 2013. Hybrids Are Here ... Almost. Progressive Farmer, November.
Perkins Engines Company Limited, 2014. 1100 Series - 1104D-44TA. London: Perkins Engines Company Limited.
Phelan M., 2015. Survey says: Acceptance of Alt-fuel Cars on the Rise. [Online] available at: http://www.freep.com/story/money/cars/mark-phelan/2015/06/20/electric-vehicle-buyers-survey-hybrid/71082232/
Profi, 2015. ZF Electric Drive. Profi, November, p. 50.
Randall P., 2012. Don't Expect to See Any Pure Electric Trucks Any Time Soon. [Online] Available at: http://thechargingpoint.azurewebsites.net/news/UK-haulage-goes-hybrid-with-Renault.html
Spackman P., 2012. Crops for fuel are big business at Cereals 2012. Farmers Weekly, 18 June.
Spackman P., 2012. Crops for fuel are big business at Cereals 2012. Farmers Weekly, 18 June.
Robert Bosch, 2009. Chassis Systems Control. Heilbron: Robert Bosch Gmbh.
Tractor-Database, 2012. New Hollnad TS90. [Online]
Available at: http://www.tractor-db.com/en/tractor/ 1333/new-holland-ts90
Youngs J., 2012. How Do Electric Cars Work? [Online] Available at: http://www.jdpower.com/cars/ articles/safety-and-mpg/how-do-electric-cars-work

ABBREVIATIONS AND TERMINOLOGY

All-electric Vehicle – AEV; a vehicle propelled by an electric motor and batteries.
Hybrid Electric Vehicle – HEV; a vehicle propelled by an electric motor, working in tandem with a petrol or diesel engine.
Horsepower – hp; a unit of power, equal to 0.74 Kilowatts.
Kilowatts – Kw; a unit of power, equal to 1.34 Horsepower.
Kilowatts per hour – Kw/hr
Decibel – db; a unit of sound level.
Second- sec; a measure of time
Minute – min; a measure of time
Hour – hr; a measure of time.
Volts – V; a measure of electrical voltage.
Amps – A; a measure of electrical amperage.
Alternating Current – AC
Direct Current – DC
Millilitres per Minute – ml/min; a measure of consumption per minute.
Gross Vehicle Weight – GVW; the maximum permissible weight a vehicle can weigh.
Data Protection Act 1998 – DPA
Market Research Society – MRS
Information Commissioners Office – ICO

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THERMAL AND WATER RISK AGRO-METEOROLOGICAL PARAMETERS AND THEIR IMPACT ON WINTER WHEAT CROPS (*Triticum aestivum* L.) IN MUNTENIA REGION

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Abstract

Thermal and water risk agro-meteorological parameters can have a direct and sometimes irreversible impact on crops, causing a significant reduction in agriculture production when it manifests severely, especially in certain critical ranges corresponding to the maximum winter wheat temperature and water discharge of the in Muntenia region.
Extreme meteorological phenomena, which can cause significant crop damages by their action, intensity and increased annual frequency, should be very well known and analyzed in order to take the adequate prevention and mitigation actions.
The lack of the rainfall over a long period causes visible negative effects on various components of the environment, but most important on the agricultural elements.
Due to the high thermal potential and to the optimal rainfall in southern Romania, Muntenia region presents the most favorable conditions for winter wheat crop.

***Key words**: agro-meteorological indices, thermal and water risk, winter wheat.*

INTRODUCTION

The analysis of the thermal and water risk indices consist in agro-meteorological conditions characterization under crop's specific reference limits, closely related to the plants physiological demands, so that their positive or negative changes compared to the optimal thresholds are reflected in plant vegetation evolution and implicit in the harvest (Berbecel et al., 1980).
The potential of thermal resources of a region express natural conditions in terms of temperature values necessary for growth and development of plant species (Mateescu et al., 1999). The temperature scale values, there are certain limits to reference specific biological genotype (variety / hybrid), the top and bottom, in which the intensity of the physiological processes is apparent correlation with the values of this parameter. Variations in the positive / negative of the maximum optimal reflected thereby to the state of the growing crop and implicitly in crops, depending on the intensity and duration of thermal stress, genetic characteristics of genotypes grown expressed by the physiological requirements and resistance to extreme temperatures, the growth stage and development, technology, culture etc.
Temperature factor is one of the most important meteorological factors in the life of the plant. Biophysical and biochemical processes of the plant, as well as the water absorption of the gases and mineral salts, their movements within the plant, respiration, photosynthesis, etc. and the processes of growth and development depend on this factor. The rate of progress of the various stages of plant growth is influenced by the temperature, thereby determining the advance or delay of the phenological phases.
Rainfall is the main source of water for agricultural plant growth and the most significant elements of this parameter meteorological variability quantitative distribution and spatial-temporal distribution (Mateescu et al., 2003). The annual amount of

rainfall is indicative of specific varying amounts of each area of interest, and means the absence or abundance normality. The average yearly rainfall is a rainfall indicator climate reference for a agricultural zone, which may relate to extreme years, consider cases of agroclimatic risk. This value expresses the potential resources needed of rainfall determine the suitability of an agricultural area to a species or variety or hybrid.
The agricultural area of Muntenia region (Figure 1) shows the most favorable agrometeorological conditions, due to the high thermal potential compared to rainfall, the limiting factor with a negative impact on crop yields obtained from winter wheat and corn crops, is given by water from precipitation.

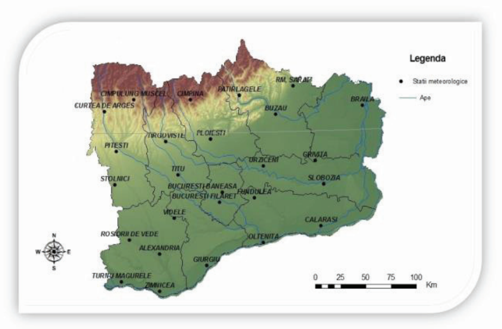

Figure 1. Muntenia Region

The climate of the Muntenia region is characterized by a temperate-continental regime, with submediteranee influences and aridity (sharper east of Arges and Bărăgan) between interfering movements east to the west (Posea, 2005). In the winter season, this area is exposed to blizzards and summer, to intense invasion or continental air masses. The air temperature remains negative, and during the day in 30-35 days from 110 days of frost. During the first half of warm season (March to August), the maximum temperatures above 25°C in 110-120 days, and 30°C in 40-60 days, absolute maximum values may exceed even 40°C. In this region signaled a high frequency's days, and the tropical nights, which highlights the character continental climate.
In terms of rainfall, the annual value in Muntenia is below 500 mm in the western region and below 400 mm in the east. In the summer season, are characteristic of prolonged periods of drought, up to 80-100 days with fine weather, strong insolation and wind (Bogdan et al., 1999).

MATERIALS AND METHODS

Specific agro-meteorological parameters, characterizing thermal and water risks impact on winter wheat crops in Muntenia region were analyzed.
The methodology was based on Muntenia's thermal and hydro resources analysis, with reference to the study of hydro-thermal specific indices, in direct correlation with the winter wheat plants water demands (Berbecel et al., 1970).
In order to evaluate the potential of the Muntenia available agro-climatic resources we have considered the data recorded at agro-meteorological weather stations that are representative for the agricultural region in the study area.
These meteorological data are continuous and cover the time period 1961-2015, analysis being carried out in terms of multi-annual averages relative to the 1981-2010 climate reference (***). The following parameters were studied:
Winter harshness, expressed by the phenomena intensity, namely cold intensity (sums of mean air temperatures below 0°C) recorded in the November to March period and frost intensity (sums of minimum air temperatures ≤15°C) in December-February interval.
Average production data of the early autumn and late spring frosts, respectively the dates when the air temperature fall below 0°C in autumn and winter seasons.
Spring index, expressed by sums of positive average temperatures and calculated for the 1st of February to the 10th April interval.
The intensity (sums of maximum temperatures ≥32°C) and duration (average number of days with maximum temperatures ≥32°C) of the heat phenomenon from June to August.
Precipitation amounts over specific intervals from the agriculture point of view, in direct correlation with the water winter wheat demands (September-October, November-March, April-October, May-June and September-August).

RESULTS AND DISCUSSIONS

Depending on the species (thermophilic, mesophilic) and phenological stages (germination, sprouting, plant emergence, budded, etc.), agricultural crops requirements on temperature are variable. To browse each phenological stage, the crop plants must achieve thermal thresholds (sums of temperatures) required for each specific genotype. Winter wheat crop has a special feature which is that it passes through the agriculture cold season (December-February), when the thermal variations specific to our country climate take place.

Heat index is of particular importance in the succession of growth and development phases of winter wheat crop. The agriculture plants vegetative processes rhythms differentiate depending on the demands of the cultivated species, the physiological processes intensity being in direct correlation with the heat factor evolution between genotype-specific thresholds.

In Figure 2 illustrates the evolution of the multi-annual temperature averages (1961-2015) recorded at representative weather stations from Muntenia agricultural region. It points out that at the majority of weather stations there is a linear upward trend, with positive deviations between 0.5 and 1.3°C and only isolated, at Campulung station, with negative deviation to the reference period 1981-2010.

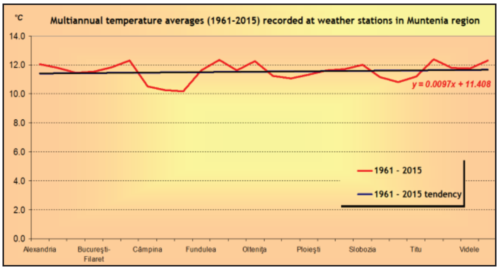

Figure 2. Multiannual temperature averages (1961-2015) recorded at weather stations in Muntenia region

Analysis of agro-meteorological indices specific to the crop year cold season (from November to March) outlines the degree of favorability with regard to the crops growing conditions, in terms of thermal resources (Mateescu et al., 1999).

Agro-meteorological parameter "winter harshness" characterizes the cold period by the average daily amount of negative air temperatures (Σtmed.≤0°C/cold units) recorded in the November to March period and by the amount of minimum air temperatures below -10 ... -15°C / frost units in December-February period in order to assess the winter crops conditions for autumn wheat. Thus, the analysis of "cold units" (Tmed≤0°C) accumulated in the period 1961 to 2015 (Figure 3a) compared to the range of 1981 to 2010 (Figure 3b) show the character of a normal winter phenomenon with an moderate intensity (201-240 "cold units") in most parts of the region. Local north, west and south of the territory, cold intensity was low (<200 "cold units").

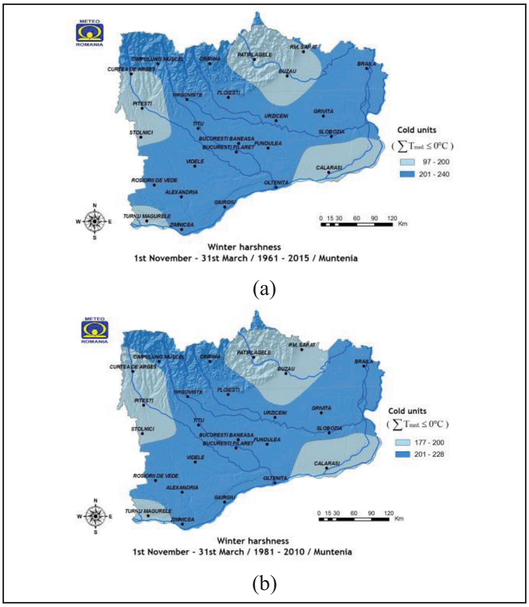

Figure 3. Cold units recorded during November-March period from 1961 to 2015 (a) compared to the period 1981-2010 (b) in Muntenia Region

Figure 4 presents the "frost units" spatial distribution, respectively the sum of the minimum negative air temperatures below the agricultural crops critical limits of resistance (Tmin.≤-15°C), in Muntenia region. In 1961-2015 interval, below 10 frost units were recorded, which characterizes a mild winter in most agricultural areas. In central, northern and southwestern region, frost has locally recorded a moderate intensity (11 to 30 frost units / normal winter).

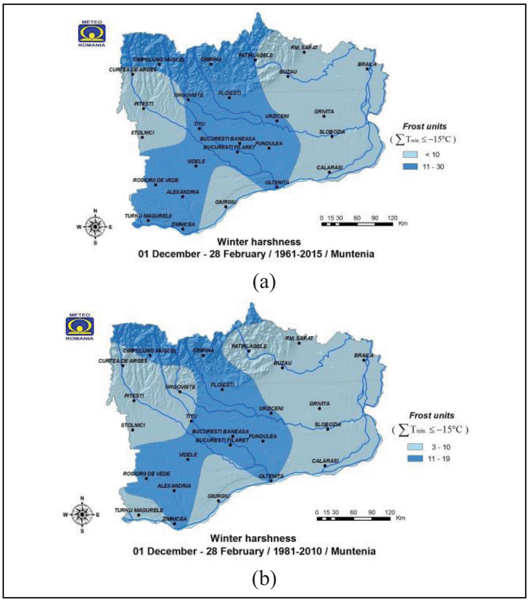

Figure 4. Frost units recorded in the December-February 1961-2015 period (a) compared to the interval 1981-2010 (b) in Muntenia Region

The frost phenomenon represents the lowering of the minimum air temperature below 0°C during the crops active growing. Late frosts cause great damage in agricultural production, especially when they occur 2-3 weeks earlier and later respectively, compared to the annual average data, landform specific. In agriculture is important to know the frost occurrence date for each crop year in order to reduce the damages through specific actions (Mateescu et al., 2016). Resulting in cell protoplasm dehydration and water freezing in tissues, low temperatures negative impact manifests itself in different ways. Winter frosts (minimum temperatures lower than -25°C) can lead to a decrease in the number of winter wheat plants or even to their complete destruction by node twinning damaging.

Repeated frosts and thaws, which typically occur during the late winter, contribute to plants uprooting. By freezing, soil water expands and raises the surface layer of soil with plants, causing breakage and node twinning plants nakedness, plants being exposed to subsequent temperature decreases in and thus to easily perish. Frosts determines not only the braking and early termination of the plant vegetation cycle development, but even their partial or total death.

Field crops are less affected by the late spring frosts, respectively by the air temperatures below 0°C in the spring season, taking into consideration the lower plant sensitivity in this season. Typically, critical moments in plants life (flowering, fructification) are occurring outside frost periods. In Muntenia Region, the muti-annual average spring-frost date for 2001-2015 interval covers the entire month of April (Figure 5).

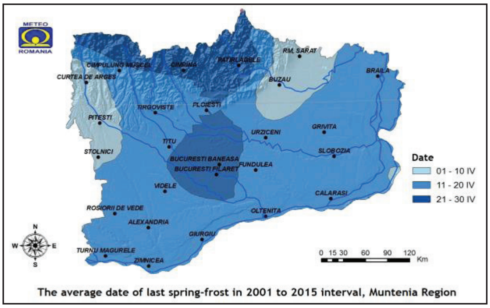

Figure 5. The average date of last spring-frost in 2001 to 2015 interval, Muntenia Region

Early autumn frosts cause damages, especially to vegetable crops (tomatoes, eggplant, peppers), the harvest of grapes and field crops which ends its vegetation period later (corn, potato, sugar beet), especially in the last 10 days of October and the first 10 days of November, for Muntenia region (Figure 6).

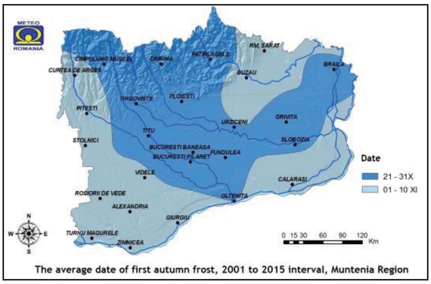

Figure 6. The average date of first autumn frost, 2001 to 2015 interval, Muntenia Region

From the 1st February to the 10th April thermal strong oscillations occur from year to year, with implications on the vegetation resumption and on the agricultural operations management. Usually, heating in February is favorable for winter wheat crops, leading to an advance in vegetation and intensively dry matter accumulation in the grain (Axinte et al., 2006).

The spring index expressed in units of heat (ΣTmed≥0°C) and calculated from the 1st of February to the 10th of April, characterizes the potential heat in the transition period, from winter to spring season. On the entire agricultural territory of Muntenia region, in the period 1961-2015, the spring index totaled 110-301 heat units, which means a late and very late spring season (Figure 7).

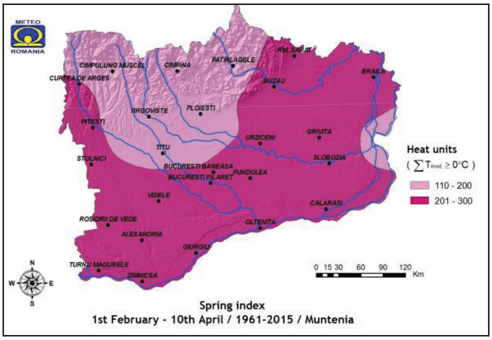

Figure 7. Spring index in Muntenia Region, 1961-2015 period

During the warm season of the year, especially in the critical period with peak water and temperature demands, a risk agro-meteorological parameter particularly important, with implications on the winter wheat production significant reduction is the heat phenomenon that can be characterized both in intensity (Σtmax.≥32°C / units of the "heat") and duration (number of days with ΣTmax≥32°C). For the autumn crops, particularly in May and June, the insemination and pollination plants processes are affected by the drying plant phenomenon and the accumulation of dry matter in the grain bad is faulty, a consequence being the fact that the wheat grains are drying (Axinte et al., 2006).

The maximum air temperature values, exceeding 32°C, recorded on successive days / consecutive days (over 5 days), can lead to an earlier outbreak in the phenological phases and thus to maturation and ripening processes forcing by shortening the grain dry matter accumulation, and so producing a 10-15 days gap compared to normal dates and to actual production dates of these phases.

Figure 8 illustrates the scorching heat intensity Muntenia spatial distribution in the 1961-2015 period compared to the reference period of 1981-2010. Over the analysed period, the scorching heat phenomenon presented a high intensity (31-50 units of "heat") and accentuated (51-70 units of "heat") on extensive agricultural areas in the region. In northern and northwestern territory, moderate level of phenomenon intensity was reported (Figure 8a). In the reference period 1981-2010, the phenomenon of "heat" showed a moderate intensity (18 to 30 units of "heat") in northwestern and locally in northern part of the region. A phenomenon high intensity (31-50 units of "heat") was reported in the central and eastern region. Emphasized values the "scorching heat" (51-81 units of "heat") were recorded in the southwest and isolated southern agricultural territory (Figure 8b).

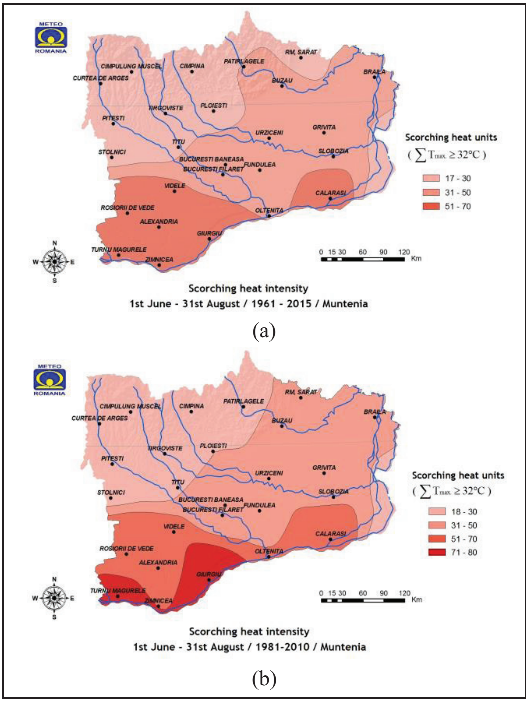

Figure 8. The scorching heat intensity in 1961 to 2015 period (a) compared to the period 1981-2010 (b), in Muntenia

In Muntenia Region, the highest values of the scorching phenomenon intensity, in the period under review, were recorded during extremely dry years 2000, 2007, 2012, 2013 and 2015, frequent at Giurgiu weather station: 203.6 units of “heat” / 2000, 222.5 units of "heat" / 2007, 296.2 units of "heat" / 2012, 275.4 units of "heat" / 2013, 135.1 units of "heat" / 2015, 132.4 units of "heat" / 2003 (Table 1), and also at Turnu Măgurele (147.8 units of "heat" / 1993, 116.1 units of "heat" / 1998, 110.4 units of ”heat” / 1962) and Roşiorii de Vede (129.8 units of "heat" / 1987) meteorological stations.

Table 1. Maximum values of "heat" units recorded at Muntenia weather stations in extremely dry years, June-August period

Year	The weather station	*Maximum values of “heat” units*
2000	***Giurgiu***	**203.6**
2001	Călăraşi	*104.7*
2002	Giurgiu	80.9
2003	Giurgiu	**132.4**
2004	Turnu Măgurele	51.5
2005	Turnu Măgurele	25.9
2006	Turnu Măgurele	65.2
2007	***Giurgiu***	**222.5**
2008	Giurgiu	*120.1*
2009	Giurgiu	84.2
2010	Giurgiu	*100.7*
2011	Turnu Măgurele	55.3
2012	***Giurgiu***	**296.2**
2013	***Giurgiu***	**275.4**
2014	Turnu Măgurele	53.9
2015	Giurgiu	**135.1**

Figure 9 illustrates the graphical representation of the average number of days with "heat" in Muntenia. There is the increase in the average number of days of "heat" (28 days), in particular from 2001 to 2015.

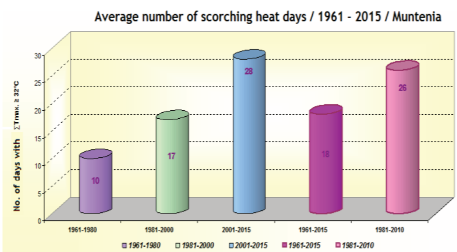

Figure 9. Scorching heat phenomenon duration during 1961-2015 period

Analyzing the rainfall amounts in Muntenia region during the autumn sowing, respectively from September to October, 1961-2015 (Figure 10a) and in the reference period 1981-2010 (Figure 10b), we can see that rainfall was optimal (81-112 mm) in most of the agricultural land.

Moderate amounts of rainfall (73-80 mm) were recorded in the eastern and southwestern region locally (Figure 10).

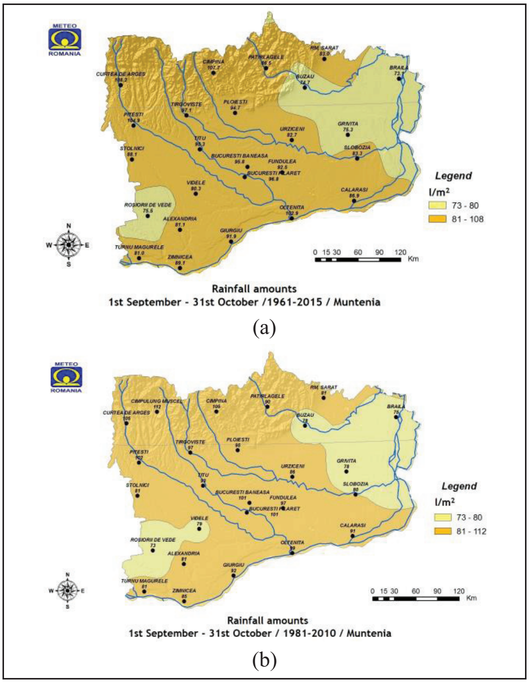

Figure 10. Rainfall amounts, September and October, 1961-2015 period (a) compared to the reference period (b), in Muntenia

During the soil water accumulation (November to March), cumulative rainfall from 1961 to 2015, were deficient (below 200 mm) compared to the optimal water requirements for the autumn wheat crop, in most parts of the region.

In the north-west and South-Muntenia local, precipitation characterizes an optimal rainfall (201-227 mm) (Figure 11).

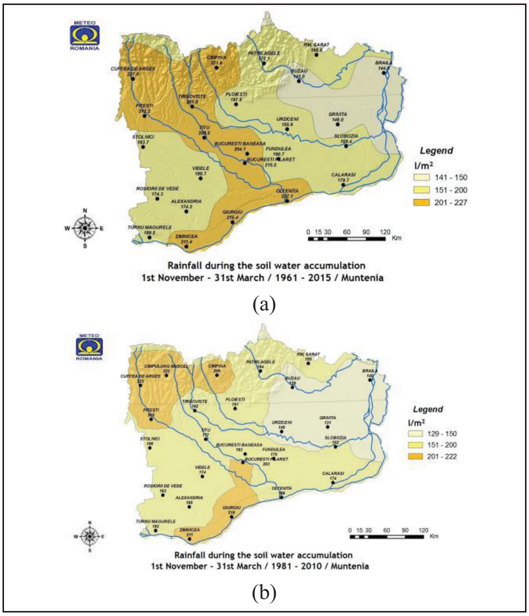

Figure 11. Rainfall during the soil water accumulation from 1961 to 2015 (a), compared with the reference range (b), in Muntenia

Rainfall during autumn wheat maximum water consumption , when plants go through earing, flowering and grain filling formation phases, from May to June, respectively 1961-2015, was deficient (113-200 mm) in most agricultural areas of Muntenia region. In northern part of the region the amounts of water (151-202 mm) were optimal (Figure 12).

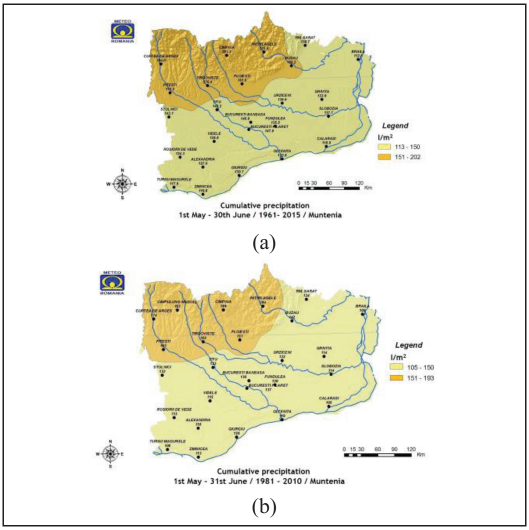

Figure 12. Cumulative precipitation in May and June, 1961-2015 (a) compared to the reference period (b), in Muntenia

In the analyzed period, rainfall amounts during the agricultural year, September to August, give the moderate drought character (451-600 mm) of rainfall in most agricultural areas of Muntenia. Optimal (601-779 mm) values of precipitation were recorded mainly in the northern part (Figure 13).

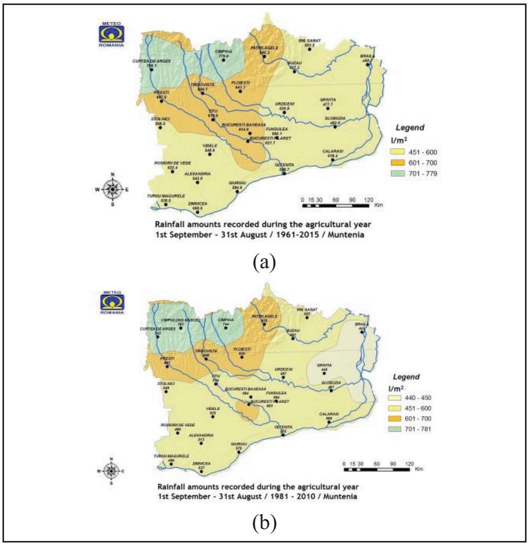

Figure 13. Rainfall amounts recorded during the agricultural year, in Muntenia, 1961-2015 (a) compared to 1981-2010 reference period (b)

In Table 2 are presented the rainfall deficit expressed as a percentage, during the extreme drought crop years 2001-2002, 2002-2003, 2006-2007, 2011-2012 and 2014-2015 (Mateescu et al., 2003) compared to the reference period 1981 -2010. The precipitation deficits vary from 83% in 2006-2007 to 116% in the agricultural year 2014/2015, with amplitude of 33%.

Table 2. Precipitation deficits of (%) during dry crop years 2001-2002, 2002-2003, 2006-2007, 2011-2012 and 2014-2015 in Region Muntenia

Agricultural year	Precipitation deficits (%)
2001-2002	89
2002-2003	92
2006-2007	83
2011-2012	92
2014-2015	116

CONCLUSIONS

At most weather stations representative for the Muntenia Region agricultural territory, the evolution of the air temperatures multi-annual value averages, in the period 1961-2015, presented a linear upward trend.

In terms of the amount of cold (from November to March) and frost units (from December to February) cumulated in the analyzed period cold season the character of normal (cold units) and mild winter (frost units) in most of the region is highlighted.

In the Muntenia region, the last spring frost multi-annual average (2001-2015) date is reached throughout April, and early autumn frosts occur especially in the last 10 days of October and the first 10 days of November.

On the whole Muntenia region agricultural area, the spring index describes a late and very late spring in the 1961-2015 period.

In the analyzed period, the “heat" phenomenon presented a high and accentuated intensity on the extensive agricultural areas in the region. The "scorching heat" intensity highest values were recorded during the extreme drought years 2000, 2007, 2012, 2013 and 2015, frequently at weather stations Giurgiu, Turnu Măgurele and Roşiorii de Vede. Especially in the period 2001-2015 are found increased average number of days with "heat".

In the period 1961-2015, based on the water optimal requirements in Muntenia autumn wheat crop, rainfall analyzed in terms of specific ranges of agricultural perspective, characterizes optimal rainfall (September-October) conditions and moderate drought (November to March, May-June and September-august).

REFERENCES

Axinte M., Roman Gh.V., Borcean I., Muntean L., 2006. Crop edition-IV. Ion Ionescu de la Brad Publishing House, Iaşi.

Berbecel O. et al., 1970. Agrometeorology, Ceres Publishing House, Bucharest.

Berbecel O., Ciovică N., Eftimescu M., Mihoc C., 1980. Valorisation of climate considerations in agriculture, Terra Magazine, nr. 1.

Bogdan O., Niculescu E., 1999. Climate Risks in Romania. Romanian Academy, Istitutul Geographically, Bucharest.

Mateescu E., Alexandru D., Oprea O.A., Manea A., 2016. Guidelines agro-meteorological. National Meteorological Administration Bucharest.

Mateescu E., Marica A., Oprisescu R., Oprea O., Palade A., 2003. Agrometeorological characteristics specific to agriculture in 1999-2003, NMA Annual Scientific Session, Collection of Works, 10 to 12 June 2003, Bucharest, ISBN 973-0 -03,099-5.

Mateescu E., Povară R., Oprisescu R., 1999. Study stress agro-meteorological parameters and their impact on winter wheat during earing - flowering - grain filling, Scientific Papers USAMV Bucharest, Series A, XLII, no. 1, 1999, ISSN 1221-5339, Bucharest, pp 133-149.

Posea G., Bogdan O., Zavoianu I., Buza M., Bălteanu D., Niculescu Gh., 2005. Geography, vol. V: Romanian Plain, the Danube, Dobrogea Plateau, Romanian Black Sea coast and Continental Shelf. Romanian Academy Publishing House, Bucharest.

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INSECTICIDE ACTIVITY OF PLANT EXTRACTS AGAINST PESTS OF OILSEED RAPE

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Abstract

Oilseed rape attacked by many pests, some of them, such pollen beetle (Meligethes aeneus F.) and blossom beetle (Tropinota hirta Poda) appear in phenophase green-yellow button-flowering generative organs damage and cause serious damage, resulting in yields significantly reduced.
In recent years, in order to protect the environment, beneficial insects and pollinators limiting the use of chemical means to control enemies. This necessitates the need to seek new alternatives, as a number of substances of plant origin exhibiting an insecticidal effect.
Therefore, under laboratory conditions tested plant extracts: walnut (Juglans regia L.), wild walnut (Ailantthus altissima Swing.), tobacco (Nicotiana tabacum L.), against adult pollen beetle (M. aeneus) and blosson beetle (T. hirta).
The results of conduct studies show that high effectiveness against adults poleen beetle (Meligethes aeneus F.) occurs with the use of plant extracts in a solution with a concentration above 1% more on the third day, bat by blossom beetle (Tropinota hirta Poda), an effect of treatment with the extract was observed only 7^{th} day irrespective of the concentration.

Key words: *oilseed rape, pests, biological control, insecticide, plant extracts.*

INTRODUCTION

Limiting the application of chemical means to control pests of crops, in order to protect the environment, maintain biodiversity, preserving regulatory role of beneficial insects and pollinators, and economic aspects of plant protection, make it necessary to seek new alternatives for control pests.
In the literature there are reports of a number of natural plant products that exhibit insecticidal action and can be successfully used in the control of pests. Moreover, they are safe for humans, domestic animals do not have a negative impact on beneficial species and pollinators for crops.
During flowering key pests on oil seed rape are: pollen beetle (*Meligethes aeneus* F.), blossom beetle (*Tropinota (Epicometis) hirta* Poda) and *Oxythyrea funesta* Poda.
According to several authors Hansen (1996), Coll et al., (1998), Mason and Huber (2002), Heimbach et al. (2007), Kazachkova (2007), Ahmanl et al. (2009), Erban et al. (2017) pollen beetle (*M. aeneus*) directly threatens yields in some years could compromise the crop damages adults and larvae (Blight and Smart, 199). They feed on flower buds, and therefore the yield of seed are significantly reduced (Ruther and Thiemann, 1997). The losses in some years reach 30-80%, while in the case of mass-multiplication 100% (Wegorek and Zamoyska, 2008).
According to Farkas and Kondor (2014) blossom beetle (*Tropinota hirta* Poda) also damage reproductive parts of rape and favorable climatic conditions can spread massively in rapeseed sowing. The main cause damage to adults who eat mostly color and mass appearance causing serious damage.
In recent years pollen beetle (*M. aeneus*) and blossom beetle (*T. hirta*), shows resistance applied in practice insektitsidae as a result of which seek alternative plants extracts – protective means of control that are safe for bees, as it is known that the oil seed rape is one of the best honey plants and are often frequented by bees during flowering.
In their studies Bommarco et al. (2012) found that the bees play an important role in the pollination of oil seed rape as a result of which is obtained in a higher yield as compared with the pollination by wind.

According Pavela (2011) on the one hand the insecticide effect of plant extracts is possible to reduce the density of the enemy, the other to cause antifidant action.

A number of authors Pavela (2005, 2006, 2009), Pavela et al. (2009 a,b), Zabka et al. (2009), Nerio et al. (2010) in their research found that essential oils derived from plant species exhibit insecticidal, fungicidal and bacterial action. As in most cases the essential oils exhibit activity against pests (Isman, 2000; Nerio et al., 2010).

Pavela (2011) tested the insecticidal activity of essential oils from 9 plant species: *Carum carvi* L., *Cinnamomum osmophloeum* Kaneh., *Citrus aurantium* L., *Foeniculum vulgare* Mill., *Lavandula angustifolia* L., *Mentha arvensis* L., *Nepeta cataria* L., *Ocimum basilicum* L., *Thymus vulgaris* L. against adults pollen beetle. The results of the monitoring show that the tested essential oils exhibit high efficacy and cause of death of adult insects. Plant extracts of caraway (*Carum sarvi* L.) and thyme (*Thymus vulgaris* L.) exhibit the highest efficiency from 65,6 to 63,8%.

Based on their observations Hummelbrunner and Isman (2001), Pavela (2008) found that essential oils of vegetable origin can cause not only mortality, they also affect fertility and lifespan of their enemies.

In this regard, the present to establish insecticidal activity of some plant extracts against economically important pests poleen beetle (*Meligethes aeneus* F.) and blossom beetle (*Tropinota hirta* Poda).

MATERIALS AND METHODS

Studies have been conducted in the laboratory at the Agricultural University - Plovdiv. V test took plants extracts of the following types: walnut (*Juglans regia* L.), wild walnut (*Ailantthus altissima* Swing.), Tobacco (*Nicotiana tabacum* L.). To this end, overnight soaked 100 mg of plant mass from in 100 ml of water, then were prepared working solutions at concentrations 0, 0,1, 1 and 100%. Experiment was conducted in 3 repetitions and variations.

In plastic containers are placed in 10 adult insects of polen beetle (*M .aeneus*) and blossom beetle (*T. hirta*) and colors of rape inflorescence immersed in the respective working solution.

The readings took place on the 3rd, 5th and 7th day.

RESULTS AND DISCUSSIONS

The results obtained of testing the insecticidal activity of plant extracts from wild walnut (*Ailantthus altissima* Swing.), tobacco (*Nicotiana tabacum* L.), are presented in Table 1 in pollen beetle (*Meligethes aeneus* F.) and Table 2 in bottom beetle (*Tropinota hirta* Poda).

From the data in Table 1 shows that the tested plant extracts definitely affect the viability of pollen beetle (*M. aeneus*). At all concentrations tested after the third day was not found alive adults pollen beetle (*M. aeneus*). This can explain it with the presence of toxic substances specific to those plant species.

Therefore it was conducted comparing the mean values at the various concentrations. The results of the statistical processing are presented in Table 2 and Figure 1. Of these, it is seen that the control concentration of 0% differs significantly from the results for the other concentrations (0.1, 1 and 100%). This gives us reason to believe that the accompanying solution concentration independent exhibits insecticidal activity against adults of pollen beetle (*M. aeneus*). Between the results at various concentrations there is little statistical difference at 0.1% and 100%.

In Figure 1 are shown that at a concentration above 1% the results are almost identical. Therefore for control against adults pollen beetle (*M. aeneus*) plant extracts to be applied concentration 1%.

Table 1. Reporting efficiency plant extracts of days and concentrations

Concentration (%) Day	3rd	5th	7th
0	10	7.33	5
0.1	3.33	0	0
1.0	2.67	0	0
100	1.33	0	0

Table 2. Variable T-test for Dependent Samples Marked differences are significant at p <0.05000

	Mean	Std.Dv.	t	p
cv100	**1.33333**	**0.577350**		
cv1	2.66667	1.154701	-1.5119	0.269703
cv0,1	3.33333	0.577350	-1.9761	0.013506
cv0	10.00000	0,000000	-26.0000	0.001476
cv1	**2.66667**	**1.154701**		
cv0,1	3.33333	0.577350	-0.7559	0.528595
cv0	10.00000	0.000000	-11.0000	0.008163
cv0,1	**3.33333**	**0.577350**		
cv0	10.00000	0.000000	-20.0000	0.002491

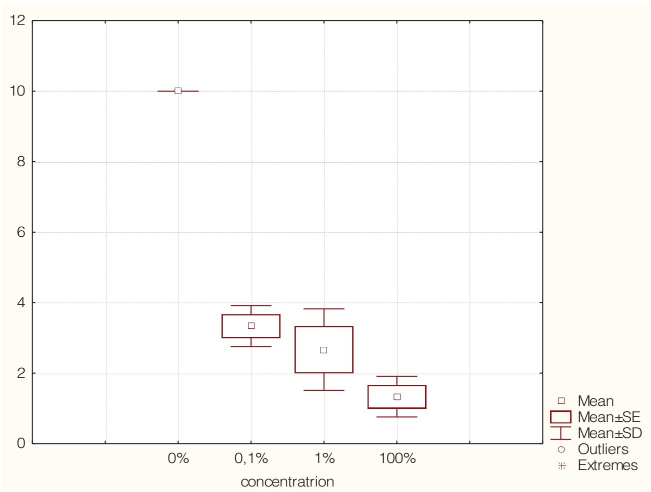

Figure 1. Comparing the averages of the results

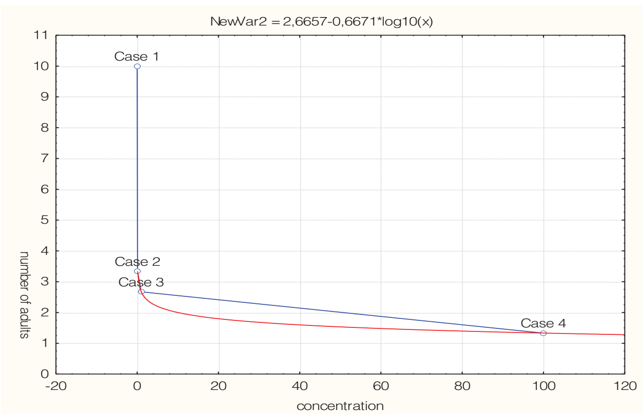

Figure 2. Comparing the averages of the results

Table 3 presents data on the effect of plant extracts against adults bottom beetle (*T. hirta*). There are significant differences in efficacy at various concentrations. There is a defined initiation toxic action, which gradually increases and the seventh day reaches a maximum value, as the efficiency of the test concentrations of 0.1, 1 and 100% on the 7th day was higher compared with that of 3th. This significantly distinguishes it from control.

Table 3. Reporting efficiency plant extracts of days and concentrations

Concentration (%) Day	3rd	5th	7th
0	10	8	4.67
0.1	4.33	3	0.33
1.0	4.33	2.33	0.33
100	2.33	1.33	0.33

From the results of Table 3 and the following figures clearly observed trend of reducing the number of living adults of bloom beetle (*T. hirta*) with an increase in concentration and the number of days after treatment. From Figure 3 logarithmic and Figure 4 (in the control, and a concentration of 0.1%) the relationship between the number of days and live adult passes at a linear – Figure 5 and Figure 6 (at concentrations of 1 and 100%)

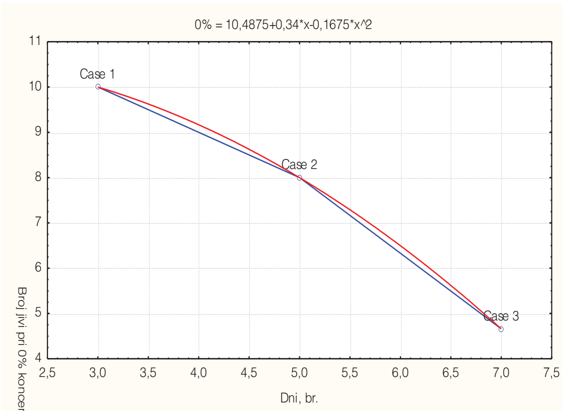

Figure 3. Mortality

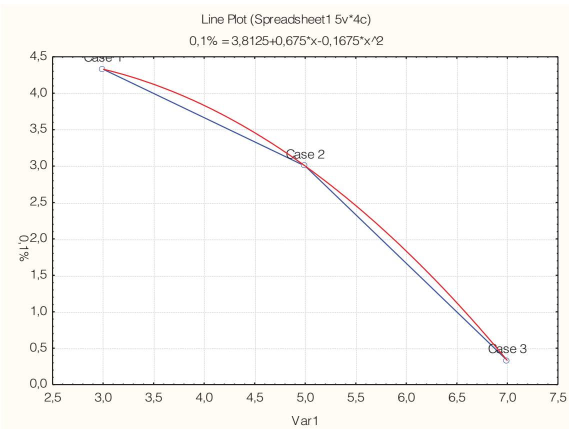

Figure 4. Mortality in concentration 0.1%

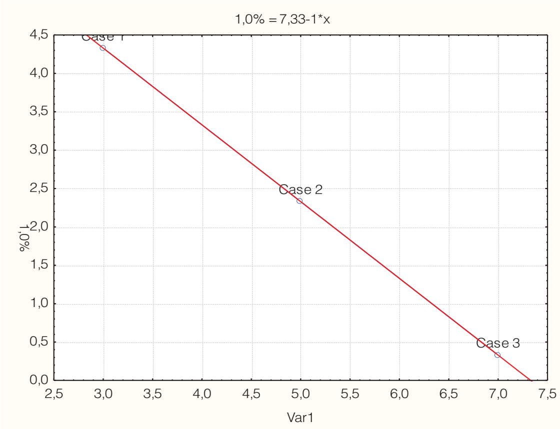

Figure 5. Mortality in concentration 1%

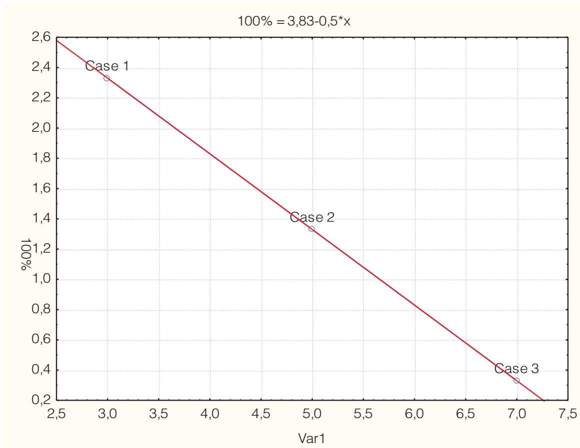

Figure 6. Mortality in concentration 100%

From the figures it can be seen that the number of living adults on the 7th day closer to 0 and at three concentrations of the extract. As an option to speed up the process of destroying them is adding another extract / other plants or repetition of the treatment during the observed period - for example, on the 4th day. However, it is an object of another study.

CONCLUSIONS

As a result of research can draw the following conclusions:

- High efficiency against adults of pollen beetle (*M. aeneus*) occurs upon administration of the pellet in the proposed solution with a concentration of more than 1% even on the third day;
- Due to the greater body weight of bloom beetle (*T. hirta*) and in consequence thereof slower insecticidal action effect of the treatment with the extract was observed only on the 7th day irrespective of the concentration.
- The results are a prerequisite for the application of plant extracts in systems for combating pests of oil seed rape which successfully solves the problem of environmental protection, beneficial insects and bees.

REFERENCES

Ahmanl I., Lehrman A., Ekbom B., 2009. Impact of herbivory and pollination on performance and competitive ability of oilseed rape transformed for pollen beetle resistance. Interactions (2009) 3:105–113.

Blight M.M., Smart L.E.,1999. Influence of visual cues and isothiocyanate lures on capture of the pollen beetle, *Meligethes aeneus* in field traps. Journal of Chemical Ecology, Vol.25:1501-1516.

Bommarco R., Marini L., Vaissiere B., 2012. Insect pollination enhances seed yield, quality, and market value in oilseed rape. Oecologia 169:1025-1032.

Coll C., Booth E.J., Sutherland K.G., 1998. Pest and diseases control requirements for spring oilseed rape in northern climates. Brighton Crop Protection Conference, Pests & Diseases, Volume 3, Proceeding of an International Conference, Brighton, UK, 16-19 November, p.1059-1064.

Erban T., Harant K., Chalupnikova J., Kocourek F., Stara J., 2017. Beyond the survival and death of the deltamethrin-threatened pollen beetle *Meligethes aeneus*: An in-depth proteomic study employing a transcriptome database, Journal of Proteomics, p. 281–289.

Farkas I., Kondor Zs., 2014. The shaggy Rosenkaefer *Epicometis* (*Tropinota*) *hirta* in winter raps - increasing damage. 55. Austrian Plant Protection Days, 26.11. and 27.11.2014, p.45-46.

Hansen L.M., 1996. Blossom beetles in oilseed rape – monitoring and threshold,Danske Plantevernskonference. Sygdomme og skadedyr., p.139-143.

Heimbach U., Muler A., Thieme T., 2007. First Steps to analyse pyrethroid resistance of different oilseed rape pests in Germany. Nachrichtenblatt des Deutschen Pflanzenschutzdienstes, Vol. 58:1-5.

Hummelbrunner L.A., Isman M.B., 2001. Acute, sublethal, antifeedant, and synergistic effects of monoterpenoid essential oil compounds on tobacco cutworm, *Spodoptera litura* (*Lep., Noctuidae*). J.Agric. Food Chem. 49 (2):715–720.

Isman M.B., 2000. Plant essential oils for pest and disease management. Crop Prot.19, 603–608.

Kazachkova N.I., 2007. Genotype analysis and studies of parathyroid resistance of the Oilseed rape (Brassica napus) Insect pest Pollen beetle (*Meligethes aeneus*). Thesis of Swedish university of Agriculture Sciences, p.1-20.

Mason P., Huber J.T., 2002. Biological control programmes in Canada, 1981-2000. CABI Publishing: Wallingford.

Nerio L.S., Olivero-Verbel J., Stashenko E., 2010. Repellent activity of essential oils:a review. Bioresour. Technol. 101, 372–378.

Pavela R., 2005. Insecticidal activity of some essential oils against larvae of Spodoptera littoralis. Fitoterapia 76, p.691–696.

Pavela R., 2006. Insecticidal activity of essential oils against Cabbage aphid (*Brevicoryne brassicae*). JEOBP 9 (2):99–106.

Pavela R., 2008. Acute and synergistic effects of some monoterpenoid essential oil compounds on the house fly (*Musca domestica* L.). JEOBP 11, 451–459.

Pavela R., 2009. Larvicidal property of essential oils against Culex quinquefasciatus Say (*Diptera: Culicidae*). Ind. Crop Prod. 30 (2):311–315.

Pavela R., Sajfrtova M., Sovova H., Karban J., Barnet M., 2009a. The effects of extracts obtained by supercritical fluid extraction and traditional extraction techniques on larvae *Leptinotarsa decemlineata* Say. J. Essent. Oil Res. 21, 367–373.

Pavela R., Vrchotova N., Triska J., 2009b. Mosquitocidal activities of thyme oils (*Thymus vulgaris* L.) against Culex quinquefasciatus (*Diptera:Culicidae*). Parasitol. Res. 105 (5):1365–1370.

Pavela R., 2011. Insecticidal and repellent activity of selected essential oils against of the pollen beetle, *Meligethes aeneus* (Fabricius) adults. Industrial Crops and Products, Vol.34, Issue 1, p. 888–892.

Ruther J., Thiemann K.,1997. Response of the pollen beetle *Meligethes aeneus* to volatiles emitted by intact plants and conspecifics. Entmologia Experimentalis et Applicata, Vol.84, p.183-188.

Węgorek P., Zamoyska J., 2008. Current status of resistance in pollen beetle (*Meligethes aeneus* F.) to selected active substances of insecticides in Poland. Bull. OEPP/EPPO Bull. 38,p.91–94.

Zabka M., Pavela R., Slezakova L., 2009. Antifungal effect of *Pimenta dioica* essential oil against dangerous pathogenic and toxinogenic fungi. Ind. Crop Prod. 30 (2):250–253.

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MORPHOLOGICAL CHARACTERIZATION OF *Alisma plantago-aquatica* L. (*Alismataceae*): A CASE STUDY AND LITERATURE REVIEW

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Abstract

This study focuses on some structural features noticed in Alisma plantago-aquatica. With plant material collected from Bugeac Lake (Dobrudja), the morphological analysis of water-plantain's vegetative organs is reported herein. In our survey, cross-sections were performed throughout the stem and stalk. Also, we examined the literature knowledge on A. plantago-aquatica, in terms of importance and adaptative changes of this perennial plant to wetland ecosystems highlighted by characteristics of leaves and root system.

***Key words**: Alisma plantago-aquatica, wetland, vegetative organs, cross section.*

INTRODUCTION

The species of *Alisma* aquatic genus are mainly found in the northern hemisphere, growing in the muddy edges of marshes and lakes (Robinson, 2004). Common water-plantain, *Alisma plantago-aquatica* L. (Alismatales. Alismataceae) is a shoreline plant, characterized by lance-shaped leaves, with many tiny pale lilac flowers blooming from June to August, each with three petals and three sepals, disposed on a pyramid-shape inflorescence, taller than the rest of the plant (http://www.nzpcn.org.nz/; https://agr.mt.gov/). Also known as devil's spoons, mad dog weed or thumbwort, this wetland perennial plant is a widespread species occurring from Northern Europe to Africa and Southeast Asia and is reported native in Romania (http://www.kew.org/science-conservation/; Lansdown, 2014).

As far as we know, *A. plantago-aquatica* was analyzed before in terms of phytochemical compounds (Chau et al., 2007), water and osmotic potentials (Klymchuk et al., 2008), phenotypic plasticity (Kordyum et al., 2012), embryogenesis (Świerczyńska and Bohdanowicz, 2014), heavy metal adsorption (Ushakumary and Madhu, 2014), genome size (Hidalgo et al., 2015) and biomorphological adaptations (Savinykh et al., 2015). Regarded as a desirable species in wetlands, water-plantain may be used to stabilize the metals in the substrate and can be eaten by animals (Fritioff, 2005; http://www.pir.sa.gov.au/).

The human interest in studying this plant species is based on its use in ornamental gardens and for medicinal purposes (Lansdown, 2014).

The aim of this paper is to list and describe the main features and morpho-anatomical structures, responsible for living of water-plantain in wetland environments.

As Kırım et al. (2014) suggested, all the inhabitants of the wetland have to be protected, since they are important for biological diversity.

MATERIALS AND METHODS

Area description

In a previous study, we described the Bugeac Lake area from southwest of Dobrudja (44°05'30.6"N, 27°25'45.2"E), where another freshwater plant - *Nymphoides peltata* - was collected and cross-sectioned in order to follow the morpho-anatomy adaptations to environment (Săndulescu et al., 2016).

Bugeac Lake, a natural wetland ecosystem hosting several species, including water-plantain is represented in Figure 1.

Biological material

According to IUCN Red List of Threatened Species, *A. plantago-aquatica* is an herbaceous amphibious helophyte (Lansdown, 2014).

For the vegetation of Bugeac Lake, water-plantain was reported as helohydatophyte species, belonging to Schoenoplectetum tabernaemontani association (Dinu and Radu, 2004).

Figure 1. Wetland ecosystem hosting *Nymphoides peltata*, *Butomus umbellatus* and *A. plantago-aquatica* (Bugeac Lake, August 2014)

For this report, we used ethanol preserved material belonging to *Alisma plantago-aquatica*. The plants were collected by hand-pulling, in August 2014 (Figure 2).

Several transversal sections were performed through the stem and stalks of inflorescence (peduncle) of water-plantain, using razor blades.

The morphological features were described with an ML-4M IOR microscope.

Figure 2. *A. plantago-aquatica* growing on the shores of Bugeac Lake (see the arrow)

RESULTS AND DISCUSSIONS

The morphological features of water-plantain from Bugeac Lake

In cross section, the stem of water-plantain (Figure 3a) collected from the lakeshore of Bugeac Lake presented: epidermis, assimilating parenchyma, sclerenchyma (mechanical tissue), conducting fascicules and, in central, the medullary lacuna (Figure 3b).

Figure 3 a. *A. plantago-aquatica*: cross section of the stem (magnification x6)

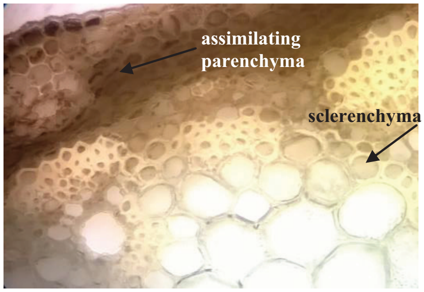

Figure 3 b. Cross section of the stem in *A. plantago-aquatica*, showing parenchyma and mechanical tissues (magnification x20)

The mixed conducting fascicules are collaterally closed-type, arranged in two-three concentric circles.

The small, external (Figure 4a) and the large, internal ones (Figure 4b) are surrounded by sclerenchyma.

Figure 4. Conducting fasicules in *A . plantago-aquatica*: a. external; b. internal (magnification x 20)

In cross section, the cut edges stalk of the inflorescence (peduncle) has epidermis with one-layer of large cells, covered by well-developed cuticle (Figure 5).

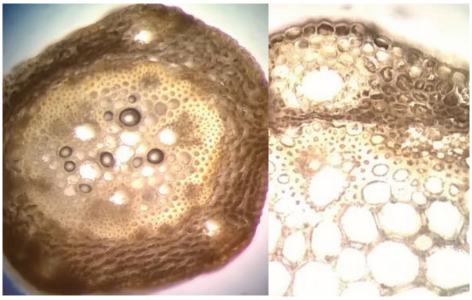

Figure 5. *A. plantago-aquatica*: cross sections (x6; x 20) of the stalk

The conducting tissues of the stalk is represented by both phloem and xylem bundles, collaterally-closed type, irregularly disposed in two rows, surrounded by mechanical tissue of sclerenchyma (Figure 6).

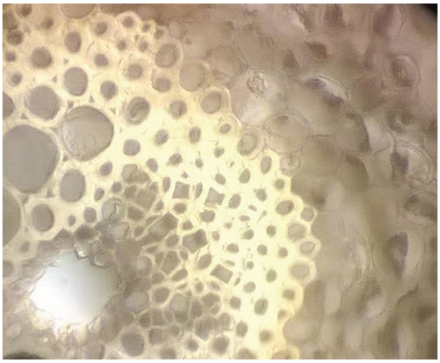

Figure 6. Conducting fascicules in the stalk of *A. plantago-aquatica* (x20)

The supporting tissues represented by sclerenchyma characterized by thickened cell cellulose walls, lead to strength and stiffness involved in aquatic plant resistance (Lamberti-Raverot and Puijalon, 2012).

The morphological features of water-plantain: a literature review

As far as we know, the available data concerning morpho-anatomy of the *Alisma* genus members are still scarce. A Romanian researcher investigated the anatomy of adventitious root, rhizome and leaf in *Alisma cordifolia* L. (Bercu, 2009).

The relatively few studies on *A. plantago-aquatica* reveal some features of leaves and root.

Thus, in water-plantain, aerenchyma – represented by large intercellular spaces designed for oxygen uptake – appears to be present in stem, leaves and root (Kordyum et al., 2012). As Jung et al. (2008) stated, a well-developed aerenchyma is an important feature of wetland plants.

The adventive roots of *A. plantago-aquatica* are characterized by the presence of aerenchyma surrounded with epidermis and one cortex layer. Kordyum et al. (2012) who studied the root anatomy of mature *A. plantago-aquatica*, have noted that the presence or absence of aerenchima depends on changes in water supply: in plant species growing on riverside, the root system has small intercellular spaces, similar to terrestrial plants of the same species.

Furthermore, according to Seago et al. (2005), there are wetland plant roots which do not have any aerenchyma tissue.

The light micrograph of a section through a leaf stalk (petiole) of *A. plantago-aquatica*, showed: an epidermis covered by a thin cuticle, outer cortex represented by three layers of parenchyma cells, middle cortex with lacunar spaces, inner cortex and large vascular bundles consisting in endodermis, a ring of phloem, a ring of xylem and the pith at the centre (http://www.sciencephoto.com/).

CONCLUSIONS

The case study and also the literature survey revealed some structural characteristics and adaptations of water-plantain for living under wetland conditions.

In terms of *A. plantago-aquatica*, we focused to the knowledge of morphological structure of this plant species, by describing the cross section of the stem and stalk. The previous reports investigated mainly the root ant the leaf of this species.

Unlike other reports, in the stem of *A. plantago-aquatica* collected from the shore of Bugeac Lake in summer of 2014 the aerenchyma was not present, instead a central medullary lacuna was present.

As in literature a full study regarding the histoanatomy of *A. plantago-aquatica* almost lack, we anticipate that more research papers are required in order to understand its life and adaptative changes in different environments subject to fluctuating water levels.

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REFERENCES

Bercu R., 2009. Histonanatomy of *Echinodorus cordifolius* (L.) Griseb. (Alismataceae). Studia Universitatis "Vasile Goldiş", Seria Ştiinţele Vieţii 19, 2: 283-286.

Chau V.M., Phan V.K., Pham H.Y., Tran T.H., Braca A., 2007. Protostane-type triterpenes from the rhizomes of *Alisma plantago-aquatica*. Tap Chi Hoa Hoc. 45(1):120-125.

Fritoff A., 2005. Metal accumulation by plants. Evaluation of the use of plants in storm water treatment. PhD thesis, pp.56, https://www.diva-portal.org/smash/.

Hidalgo O., Garcia S., Garnatje T., Mumbrú M., Patterson A., Vigo J., Vallès J., 2015. Genome size in aquatic and wetland plants: fitting with the large genome constraint hypothesis with a few relevant exceptions. Plant Systematics and Evolution 301(7): 1927-1936.

Jung J., Lee S.C., Choi H-K., 2008. Anatomical patterns of aerenchyma in aquatic and wetland plants. Journal of Plant Biology 51 (6): 428-439.

Kırım B., Coban D., Güler M., 2014. Floating aquatic plants and their impact on wetlands in Turkey. Available on: http://www.limnology.ro/water2014/proceedings/13_Birsen.pdf

Klymchuk D., Vorobyova T., Sivash O., Jadko S., 2008. Effects of water deficit on the water relations of *Alisma plantago-aquatica* L. under natural environment. Gen. Appl. Plant Physiology, 34(3-4): 227-238.

Kordyum Y.L., Kozeko L.Y., Ovcharenko Y.V., 2012. Phenotypic plasticity of aerial-aquatic plants *Alisma plantago-aquatica* L. and *Sium latifolium* L.: structural and molecular aspects. Botanica 3 (52): 11-16.

Lamberti-Raverot B., Puijalon S., 2012. Nutrient enrichment affects the mechanical resistance of aquatic plants. J Exp Bot. 63(17): 6115–6123.

Robinson P., 2004. Rock and water plants. Practical gardening handbook. Anness Publishing, London, 132 pp.

Savinykh N.P., Shabalkina S.V., Lelekova E. V., 2015. Biomorphological adaptations of helophytes. Contemporary Problems of Ecology 8 (5): 550–559.

Săndulescu E.B., Vasile Scăeţeanu G., Şchiopu T., Oltenacu N., Stavrescu-Bedivan M.M., 2016. Morpho-anatomy and adaptation to some Romanian aquatic environments of *Nymphoides peltata* (Gmel.) O. Kuntze (Asterales: Menyanthaceae). Scientific Papers. Series A. Agronomy, LIX: 537-542.

Seago Jr. J., Marsh L., Stevens K., Soukup A., Votrubova O., Enstone D., 2005. A re-examination of the root cortex in wetland flowering plants with respect to aerenchyma. Annals of Botany 96: 565–579.

Świerczyńska J., Bohdanowicz J., 2014. *Alisma plantago-aquatica* L.: the cytoskeleton of the suspensor development. Acta Soc Bot Pol 83(2): 159-166.

Ushakumary E.R., Madhu G., 2014. Studies on Zinc (II) Adsorption Using *Alisma plantago-aquatica*. Journal of Clean Energy Technologies, 2 (2): 112-117.

***http://www.nzpcn.org.nz/flora_details.aspx?ID=2433

***https://agr.mt.gov/Portals/168/Documents/Archive/Weeds/Aquatics_Guide-Shoreline_Plants.pdf

***http://www.kew.org/science-conservation/plants-fungi/alisma-plantago-aquatica-common-water-plantain

***http://www.sciencephoto.com/media/663212/view

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RESEARCH OF INFLUENCE OF WASTES FROM THE WINE INDUSTRY ON FERTILITY OF CAMBIC CHERNOZEM AND PLANT PRODUCTIVITY OF GRAPE-VINE

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Abstract

This article presents the results of field-testing of two wastes: wine lees and vinasse, from grape processing. The results demonstrated that administration of two doses of wine lees (13 and 16 t/ha), the vinasse (300-600 m^3/ha) favoured the significant increase of organic matter, phosphorus and exchangeable potassium in the arable layer of soil. Application of wine lees at a dose of 13 to 26 t/ha annually ensured a significant increase grape 1.4-2.3 t/ha, or 15-25% more than the unfertilized control, which made 9.3 t/ha. Significant impact on the productivity of plants of wine lees and vinasse was at a dose of 300 to 600 m^3/ha. Average growth was 0.9-1.0 t/ha or 10-11% more than the control.

***Key words**: wine lees, vinasse, plant productivity, soil fertility.*

INTRODUCTION

Currently the wineries from the Republic of Moldova accumulate as waste about 25-30 thousand tons of wine lees and 50 thousand cubic meters of vinasse.

The total amount of waste from the wine industry is impressive and is constantly growing. The wastes contain primary elements very necessary for plant nutrition and soil fertility, which require recovered permanently.

One hundred cubic meter of lees contains approximately 210 kg of nitrogen, 100 kg of phosphorus and 750 kg of potassium. Less concentrated in nutrients, but no less valuable is vinasse.

The waste in question is not used in any way and there are no regulations in our country for its liquidation. It originates in agriculture, so all the containing elements were taken from the soil. So it will be fair as they return to soil through fertilization. Accumulation and spilling without any legal norms of winery wastes causes a serious pollutant impact on the environment, but primarily on soil and surface water. International research in terms of characteristics and use in agriculture of wastes from the production of alcoholic beverages are very few (Gemtos et al., 1999; Luz et al., 2009; Tejada et al., 2009).

MATERIALS AND METHODS

The research was conducted during 2011-2016 years on different wastes from wine making industry. Object of the study were the lees and vinasse. The research and observations of appreciation of fertilizer potential of them were made at tehnological - experimental station "Codru", Chisinau minicipality. Experience is located on silty clay leached chernozem: humus contenr 4.31%; P_2O_5 - 34.2 ppm; K_2O - 430 ppm; pH - 6.8. Wastes were applied to a plantation of Sauvignon grapevines in bearing. Experience scheme is shown in table 1. The surface evidence of the plot - 55 m^2. The number of repetitions - 3. For soil analysis were used the following methods: organic matter - Tiurin method, $N\text{-}NO_3$ - after Grandval-Leaju, mobile phosphorus and potasium - Machighin method; The statistical processing of the results obtained in the investigation was carried out by Dospehov method.

RESULTS AND DISCUSSIONS

Organic matter content. Average data for 6 years demonstrated that doses of wine yeast 13 and 26 t/ha, (equivalent to 100 and 200 kg N/ha per year) led to a significant increase of organic matter content in 0-30 cm layer of soil

(Table 1). The application of vinasse doses of 300 (K_{450}) and 600 m^3/ha (K_{900}) leads to significant increases in organic matter content values in average over 6 years by 0.18 and 0.27% or 4788 and 7182 kg/ha.

Table 1. The influence of wine wastes on organic matter content in the 0-30 cm layer of cambic chernozem, % of soil mass. Technological-experimental Station "Codru"

Variant	Years						Average for 6 years	Increase compared to the control	
	2011	2012	2013	2014	2015	2016		%	kg/ha
Witness	4.28	4.25	3.90	3.76	3.79	3.97	3.99	-	-
Wine yeast, 13 t/ha per year	4.39	4.38	4.08	4.28	3.98	4.23	4.22	0.23	6118
Wine yeast, 26 t/ha per year	4.46	4.55	4.27	4.46	4.13	4.29	4.36	0.37	9842
Vinasse 300 m^3/ha per year	4.44	4.63	4.11	3.91	3.94	4.00	4.17	0.18	4788
Vinasse 600 m^3/ha per year	4.48	4.73	4.23	4.12	4.00	3.99	4.26	0.27	7182
DL 0.5%	0.10	0.11	0.10	0.13	0.14	0.10	0.17	-	-
P, %	4.9	6.3	8.2	7.8	7.8	8.4	5.1	-	-

Mineral nitrogen. Influence of wastes from the production of alcoholic beverages on the content of mineral nitrogen in the arable layer of cambic chernozem is presented in Table 2.

Table 2. Waste wine influence on mineral nitrogen in 0-30 cm layer of cambic chernozem, mg N/kg sol

Variant	Years						Average for 6 years	Increase compared to the control	
	2011	2012	2013	2014	2015	2016		mg/kg	kg/ha
Witness	8.1	8.4	4.3	2.1	1.3	0.60	4.13	-	-
Wine yeast, 13 t/ha per year	11.,7	12.9	5.0	9.2	2.4	1.30	7.08	3.0	6.8
Wine yeast, 26 t/ha per year	14.1	13.7	5.5	11.4	3.1	1.19	8.17	4.0	9.0
Vinasse 300 m^3/ha per year	11.6	10.9	2.4	2.2	4.2	0.75	5.34	1.2	2.7
Vinasse 600 m^3/ha per year	10.0	11.5	2.1	3.9	4.7	0.64	5.47	1.3	2.9
DL 0.5%	1.6	1.4	1.1	1.9	1.0	1.1	1.2	-	-
Sx, %	8.3	9.1	3.9	4.2	9.4	10.3	5.1	-	-

It emphasizes that fertilization with wine yeast at doses containing 100 and 200 kg N/ha resulted in significant increase of mineral nitrogen content.

The mean value of the six years of mineral nitrogen content compared to the control increased by 3.0-4.0 mg/kg. Fertilization with vinasse doses of 300 and 600 m^3/ha decreased significantly soil mineral nitrogen only in the first and second year of action.

Phosphorus and potassium. Table 3 shows data which reveals the effects of fertilization of waste wine on accessible phosphorus arable layer of cambic chernozem and emphasize that: fertilization with wine lees at doses of 13 and 26 t/ha (equivalent to N_{100} and N_{200}) resulted in statistically significant increase of the content of available phosphorus.

For six years the average value of available phosphorus compared to the control increased by 0.62 to 1.00 mg/100 g (from 16.4 to 27.0 kg/ha).

Application of vinasse in the dose of 300 (K_{450}) and 600 (K_{900}) resulted in statistically significant increases in the values of accessible phosphorus content in all six years of experimentation (2011-2016).

Phosphorus average increase was 0.30 and 0.31 mg/100 g (8.1 to 8.4 kg/ha).

Table 3. Waste wine influence on accessible phosphorus content in layer 0-30 cm of cambic chernozem, P_2O mg/100 g soil. Technological-experimental Station "Codru"

Variant	Years						Average for 6 years	Increase compared to the control	
	2011	2012	2013	2014	2015	2016		mg/kg	kg/ha
Witness	2.08	2.11	2.54	2.26	2.22	1.79	2.17	-	-
Wine yeast, 13 t/ha per year	2.55	2.54	3.09	2.68	2.61	3.27	2.79	0.62	16.4
Wine yeast, 26 t/ha per year	2.80	2.68	3.25	2.81	2.79	4.67	3.17	1.00	27.0
Vinasse 300 m^3/ha per year	2.20	2.31	2.91	2.37	2.39	2.28	2.47	0.30	8.1
Vinasse 600 m^3/ha per year	2.31	2.39	3.26	2.46	2.53	1.95	2.48	0.31	8.4
DL 0.5%	0.19	0.18	0.32	0.10	0.16	0.15	0.15	-	-
Sx, %	11.4	12.8	11.5	10.4	8.2	10.3	8.9	-	-

Regarding accessible potassium content, increases were recorded only to the application of vinasse in the dose of 300 and 600 m^3/ha (Table 4).

Table 4. Waste wine influence on accessible potassium content 0-30 cm layer of cambic chernozem, K_2O mg/100 g soil. Technological-experimental Station "Codru"

Variant	Years						Average for 6 years	Increase compared to the control	
	2011	2012	2013	2014	2015	2016		mg/ 100 g	kg/ha
Witness	28	32	29	27	28	23	28	-	-
Wine yeast, 13 t/ha per year	32	36	33	31	34	49	36	8	183
Wine yeast, 26 t/ha per year	33	38	35	34	36	65	40	12	274
Vinasse 300 m^3/ha per year	39	41	41	40	38	27	38	10	229
Vinasse 600 m^3/ha per year	42	45	44	45	42	28	41	13	297
DL 0.5%	5.3	4.4	7.9	5.9	7.4	6.6	6.7	-	-
Sx, %	14.11	13.82	14.31	8.9	9.1	10.3	9.1	-	-

The ionic composition of the water extract. Application doses of wine lees (13 and 26 t/ha, equivalent to N_{100} and N_{200}) and vinasse (300 and 600 m^3/ha, equivalent K_{450} and K_{900}) for six years did not change the essential content of soluble salts, reaction of soil, nor the composition of the aqueous extract (Table 5). The composition of the soluble salts is constant, which is determined by the presence of calcium bicarbonate [Ca $(HCO_3)_2$] and to a lesser extent of magnesium sulfate ($MgSO_4$). Stability of saline indices and current reaction of cambic chernozem at action of wine lees and vinasse can be explained by the high buffering capacity of the soil.

Productivity of grape-vines. Results of research conducted over six years and applying of wine wastes during grape-vine cultivation proves that they act beneficially on plant productivity (Table 6). Application of wine lees at a dose of 13 and 26 t/ha annually ensured a significant increase of grape harvest on average in six years by 1.4-2.3 t/ha, with 15-25% more compared to unfertilized variant (9.3 t/ha).

Table 5. The ionic composition of the water extract of cambic chernozem on application of winery wastes

Variant	Dry resi-due %	pH	HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+
			me/100 g sol						
Witness	0.027	7.3	0.38	0.09	0.28	0.39	0.23	0.05	0.09
Wine yeast, 13 t/ha per year	0.031	7.0	0.25	0.08	0.21	0.28	0.20	0.05	0.02
Wine yeast, 26 t/ha per year	0.030	7.0	0.19	0.08	0.24	0.24	0.21	0.05	0.02
Vinasse 300 m^3/ha per year	0.037	7.2	0.,34	0.07	0.21	0.37	0.18	0.05	0.01
Vinasse 600 m^3/ha per year	0.038	7.2	0.20	0.08	0.23	0.39	0.17	0.05	0.02

Significant action on plant productivity of grape vines had vinasse at dose of 300 and 600 m^3/ha annually. Harvest growth averaged over six years was 0.9-1.0 t/ha or 10-11% more compared to the control.

Table 6. Wine wastes influence on grape Sauvignon harvest on cambic chernozem, t/ha. Technological-experimental Station "Codru"

Variant	Years						Average for 6 years		
							Yield	Increase for 6 years	
	2011	2012	2013	2014	2015	2016		t	%
Witness	9.8	7.6	10.6	9.8	10.8	7.4	9.3	-	-
Wine yeast, 13 t/ha per year	10.8	8.7	11.9	12.0	11.9	8.6	10.7	1.4	15
Wine yeast, 26 t/ha per year	10.9	8.8	14.1	13.9	12.8	9.0	11.6	2.3	25
Vinasse 300 m^3/ha per year	10.8	8.7	12.0	-	11.7	7.6	10.2	0.9	10
Vinasse 600 m^3/ha per year	10.6	8.5	12.6	-	11.8	7.6	10.3	1.0	11
DL 0.5%	0.60	0.64	0.94	-	0.67	0.92	0.85	-	-
P, %	14.3	15.1	17.2	-	14.6	15.3	14.8	-	-

CONCLUSIONS

Fertilization with wine wastes (wine lees and vinasse) resulted in a significant increase of organic matter content (0.12-0.37%). There was a significant increase in mineral nitrogen (0.30-4.00 mg/kg), mobile phosphorus (0.24-0.62 mg/100 g) and exchangeable potassium (6.0-12.0 mg/100 g). Wastes did not essentially change the content of soluble salts, soil reaction, aqueous extract composition. Stability of saline indices and current soil reaction of cambic chernozem on action of wastes is explained by the high buffering capacity of the soil.

Applying wine lees conducted to a significant increase in the production of grapes (Sauvignon) on average for six years 1.4-2.3 t/ha. Harvesting increase at the incorporation of vinasse was on average for six years 0.9-1.0 t/ha.

The mentioned wine wastes must be included in agricultural circuit as fertilizers.

REFERENCES

Gemtos T., Chouliaras N., Marakis St., 1999. Vinasse rate, time of application and compaction effect of soil proprieties and durum wheat crop. Journal of Agriculture Engineering Research, p. 283-296.

Luz R., Ersamo C., Julia M. et al., 2009. Recovery of organic wastes in the Spanish wine industry. Technical, economic and environmental analysis of the composting process. Journal of cleaner production, 17, p. 830-838.

Tejada M., Garcia-Martinez A., Parrado J., 2009. Effects of the vermicompost composted with beet vinasse of soil proprieties, soil losses and soil restoration. Catena, v. 77, p. 238-247.

***Statistical Yearbook of the Republic of Moldova, 2014. Chisinau, p. 295-302.

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THE EVALUATION OF BIOMASS OF THE *Sida hermaphrodita* AND *Silphium perfoliatum* FOR RENEWABLE ENERGY IN MOLDOVA

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Abstract

Perennial herbaceous crops can become the main basis for renewable energy production in agricultural ecosystems in future. To determine the plant species that are the most suitable for biomass production, their biological peculiarities and productivity, biochemical composition and thermophysical properties, social and ecological impact must be investigated thoroughly.

The local varieties of perennial energy crops: Energo, Sida hermaphrodita and Vital, Silphium perfoliatum registered in the Catalogue of plant varieties and patented in the Republic of Moldova, which were cultivated in the experimental land of the Botanical Garden (Institute) of the ASM served as subjects of study. Maize and sunflower (for biogas production) and wheat straw (for biosolid fuel) - control variants. It has been established that the gas forming potential of organic dry matter in silage varies from 458 l/kg in Sida hermaphrodita to 471 l/kg in Silphium perfoliatum. The best results of methane production were achieved by the silage of cv. Energo of Sida hermaphrodita – 4000 m^3/ha and cv. Vital of Silphium perfoliatum – 3675 m^3/ha, versus 3127 m^3/ha, maize silage, and 2881 m^3/ha, sunflower silage. The silage substrate of Sida hermaphrodita had higher content of methane (53.1%). The biomass of Sida hermaphrodita and Silphium perfoliatum was distinguished by high bulk density, moderate gross calorific values (18.3-18.7 MJ/kg.) and ash content (1.5-3.0%), but wheat straw – by low bulk density and low calorific value (17.0 MJ/kg) and high content of ash (5.1%). The potential of energy production of the local varieties of perennial energy crops was of 350-380 GJ/ha. The best results were achieved by cv. Vital, Silphium perfoliatum, due to its high productivity of dry biomass.

Key words: *biomass production, gas forming potential, Sida hermaphrodita, Silphium perfoliatum, thermophysical properties.*

INTRODUCTION

In the context of the increasing world population, which requires more and more resources, there comes a higher need of energy consumption that obligates us to look for alternative ways, to reduce the dependence on fossil fuels and to develop new technological processes of renewable energy production.

Biomass is a renewable energy source which is easily available around the world.

The increase in the biomass use for energy production can help reduce greenhouse gas (GHG) emissions and meet the targets established in the Paris Climate Conference (COP21), in December 2015. Energy from species plant biomass can be produced by different thermochemical (combustion, gasification, and pyrolysis), biological (anaerobic digestion and fermentation), or chemical (esterification) processes, where direct combustion can provide a near-term solution to the problem of energy (El Bassam, 2010).

Perennial herbaceous crops would be the main basis for renewable energy production in agricultural ecosystems and would play an important role in the reclamation of contaminated land in future. The investigation of local and introduced plant species, which are the most suitable as feedstock in an integrated multi-product biorefinery, is an important objective in the Botanical Garden (Institute) of the ASM (Teleuţă and Ţîţei, 2016; Ţîţei, 2015)

Some promising herbaceous perennial plant species belong to *Asteraceae* Bercht and *Malvaceae* Juss. families.

Sida hermaphrodita (L.) Rusby (Virginia mallow, Pennsylvanian malva, River mallow, Virginia fanpetals) fam. *Malvaceae* Juss., is a polycarpic perennial herb, originates from south-eastern parts of Northern America, where it naturally grows in moist riverine habitats. It is bushy, has dense root system, a few dozen of stems with a length of 400 cm and diameter of 5 to 35 mm. The plant is reproduced by root cuttings, stem cuttings or seeds. The species lives for 15-20 years, providing a good harvest on all kinds of lands. Its multi-directional cultivation appears to be an advantage of *Sida hermaphrodita*, as well as its great capacity of adaptation to changing climate and soil conditions, including chemically degraded areas. *Sida hermaphrodita* is a fodder, fibre and energy crop (Thomas, 1979; Rakhmetov, 2011; Tarkowski and Truchliński, 2011; Stolarski et. al., 2014; Jablonowski et al., 2016).

Silphium perfoliatum L., fam. *Asteraceae* Bercht. & J.Pres, known by the common names Sylph or Cap plant, belongs to the genus *Silphium* L., which includes 23 species. It is native to North America, East Coast of United States of America and Canada. *Silphium perfoliatum* L. is an erect herbaceous perennial plant with strongly 4-angled (square) stem (150-350 cm), flowers very similar to sunflower, measuring about 2.5 cm in diameter, produces from 20 to 30 seeds in each flower head. The plant has an extensive root system, is able to establish colonies due to its central taproot system and shallow rhizomes. *Silphium perfoliatum* was introduced as an ornamental plant in the Botanical Gardens of France and the UK in the second half of the 18th century, in the 20-21th century – in Russia, France, Poland, Romania and in other regions of the Earth – as a fodder, melliferos, medicinal and energy plant (Niqueux, 1981; Puia and Szabo, 1985; Boe et. al., 2012; Šiaudinis et. al., 2012; Stolarski et. al., 2014).

A high aerial biomass productivity of *Silphium perfoliatum* and *Sida hermaphrodita* plants was mentioned in differ studies. So, Medvedev and Smetannikova (1981) mentioned that the green mass yield of *Silphium perfoliatum* cultivated in Kirgistan on irrigated land in was 234 t/ha and Moscow region, Russia - 70 t/ha; Rakhmetov (2011) stated that in the conditions of Ukraine, *Sida hermaphrodita* could have a productivity of 123.9-187.7 t/ha natural fodder depending on the genotype.

Silages are the main feedstock for anaerobic digestion in European countries with a dynamic development of agricultural biogas plants (Klimiuk et. al., 2010; Kalac, 2011; Oleszek et al., 2013; Mast et. al., 2014)

The objective of this research was to evaluate silage as feedstock for biogas production based on the chemical composition and some thermophysical properties of the dry biomass from local varieties of introduced perennial species of *Silphium perfoliatum* and *Sida hermaphrodita.*

MATERIALS AND METHODS

The local varieties: *Vital* of cup plant, *Silphium perfoliatum*, and *Energo* of Virginia mallow, *Sida hermaphrodita*, created in the Botanical Garden (Institute) of the ASM, registered in the in the Catalogue of plant varieties (Catalogul soiurilor de plante, 2012; 2014) and patented by the State Agency on Intellectual Property (*BOPI 9/ 2016*) of the Republic of Moldova, which were cultivated in the experimental plot of the Botanical Garden (Institute) of the ASM, served as subjects of study. The most frequently used energy crops: maize – *Zea mays* and sunflower – *Helianthus annuus* (biogas production), wheat straw – *Triticum aestivum* (biosolid fuel) served as control variants.

The plant growth and development and their productivity were assessed according to methodical indications of Novoselov et al. (1983). The green mass of *Sida hermaphrodita* was harvested in the budding stage (the 1st mowing in June and the 2nd mowing in September), *Silphium perfoliatum* and *Helianthus annuus* – in the flowering stage (late July), maize – in kernel milk-wax stage (August). The yield was measured by weighing. The green mass was shredded and compressed in well sealed glass containers. After 45 days, the containers were opened, the biochemical composition of the silage was determined by Petukhov et al. (1989) and accordance with the Moldavian standard SM 108. The dry matter or total solid (TS) content was detected by drying samples up to constant weight at 105 °C; crude protein – by Kjeldahl method; crude fat – by Soxhlet method; crude cellulose – by Van Soest method; ash – in muffle furnace at 550°C; nitrogen-free extractive substance (NFE) was mathematically appreciated, as difference between organic matter values and analytically assessed organic compounds; organic dry matter, or volatile solids (VS), was calculated through differentiation, the crude ash being subtracted from dry matter. The biogas and biomethane, litre per kg of volatile solids (L/kg VS), were calculated using the gas forming potential of nutrients according to Baserga (1998) and the digestible index of nutrients according to Medvedev and Smetannikova (1981).

The dry stems of *Sida hermaphrodita* and *Silphium perfoliatum* were harvested manually in the first days of March. The stems of *Sida hermaphrodita* and *Silphium perfoliatum* and the wheat straw were chopped into chaff with the use of stationary forage chopping unit. The obtained chaffs of mean dimension from 7 to 35 mm, were milled in a beater mill equipped with a sieve with diameter of openings of 20 mm and 10 mm. Scientific researches on the dry biomass for the production of solid biofuel were carried out: the moisture content of plant material was determined by CEN/TS 15414 in an automatic hot air oven MEMMERT100-800; the content of ash was determined at 550 ºC in a muffle furnace HT40AL according to CEN/TS 15403; an automatic calorimeter LAGET MS-10A with accessories was used to determine the calorific value, according to CEN/TS 15400; the cylindrical containers were used to determine the bulk density, calculated by dividing the mass over the container volume; the briquetting was carried out by hydraulic piston briquetting press BrikStar, model 50-12; the mean compressed (specific) density of the briquettes was determined immediately after removal from the mould as a ratio of measured mass over calculated volume.

RESULTS AND DISCUSSIONS

We could mention that, in the conditions of the Republic of Moldova, in the first growing season, the cv. *Vital, Silphium perfoliatum,* passed 2 stages of ontogenetic development, the formation of plantlets and the juvenile phase, didn't develop shoots, but formed a rosette with 16-18 dark green triangular leaves, up to autumn frosts, the green mass productivity reached up to 23 t/ha of green mass. The cv. *Energo, Sida hermaphrodita,* in the first 45 days of vegetation had a slow rate of growth and development of aerial parts, and then, the rate accelerated. The development of flower buds started in mid-September and the stems were about 171 cm tall and 6-13 mm thick at base, the productivity of green mass was 28.3 t/ha or 6.2 t/ha dry matter, with high content of about 48 % leaves.

In the second year and in the further years of the vegetation, in spring, when the air temperature exceeded 6°C, plant development started from the generative buds of *Silphium perfoliatum* and *Sida hermaphrodita*, which went through all the stages of ontogenetic development, finishing with seed formation. A high growth rate of stems was observed during May and June (5-6 cm/day). In general, plants grew about 230-350 cm tall depending on the species. We observed that *Sida hermaphrodita* plants were significantly taller than *Silphium perfoliatum*. Our research data demonstrated that *Sida hermaphrodita* plants were characterized by intensive growth and development rates and harvesting stems in June allowed to obtain 59.5 t/ha of green mass. After the first harvest, *Sida hermaphrodita* plants had a high rate of revival and, in September, the stems reached 1.0-1.2 cm in diameter and 158-163 cm tall, the yield of green mass at the second harvest was 19.2 t/ha. The productivity of *Silphium perfoliatum* was of 79 t/ha natural fodder, *Zea mays* and *Helianthus annuus* yielded 40-45 t/ha green mass.

The quantities of biogas and the contained methane depend mainly on carbohydrates, fats and proteins contained in the substrate. Analyzing the results of the determination of the organic dry matter from the silage of the studied perennial species and its biochemical composition, we see how it differs from maize and sunflower (Table 1).

Table 1. Biochemical composition and gas forming potential of the silage from perennial species

	Zea mays	*Helianthus annuus*	*Sida hermaphrodita*	*Silphium perfoliatum*
Organic dry matter (ODM), g/kg	957.4	916.2	912.3	893.6
Digestible ODM, g/kg	695.6	693.5	579.3	593.6
Digestible proteins, g/kg	34.6	53.6	75.6	48.4
Digestible fats, g/kg	23.3	34.0	14.4	13.9
Digestible carbohydrates, g/kg	637.7	605.9	489.3	531.3
Biogas, l/kg ODM	557	559	458	471
Biomethane, l/kg ODM	292	294	243	245
Methane, %	52.4	52.6	53.1	52.4
Methane production, m^3/ha	3127	2881	4000	3675

It has been found that the silage made from the studied perennial species is characterized by a low content of organic substances (893.6-912.3 g/kg). The content of organic dry matter from *Silphium perfoliatum* silage was low, but its digestibility was higher. The silage made from *Sida hermaphrodita* contained a high amount of digestible proteins and fats, but an inferior level of digestible carbohydrates in comparison with *Silphium perfoliatum*.

Organic dry matter is an important factor influencing biogas and methane yield. The gas forming potential of digestible organic dry matter from silage substrate varied from 458 to 559 l/kg. Maize and sunflower silage had higher potential - 557-559 l/kg, but *Sida hermaphrodita* - a lower one – 458 l/kg, being directly proportional with the content of digestible organic dry matter.

The calculated methane content in the biogas ranged from 52.4 to 53.1%. The best methane content was achieved by *Sida hermaphrodita* silage, a lower one - by maize and *Silphium perfoliatum* silage.

The best results of calculated methane production were achieved by the silage from the cv. Energo of *Sida hermaphrodita* – 4000 m^3/ha and cv. Vital of *Silphium perfoliatum* – 3675 m^3/ha versus 3127 m^3/ha obtained from maize silage and 2881 m^3/ha from sunflower silage.

The literature suggests that for maize silage. silage the methane value is 330 l/kg VS (Klimiuk et al., 2010) and for sunflower silage 285-340 L/kg VS (Dandikas et al., 2014).

The biogas batch-tests of *Sida hermaphrodita* showed a potential of 435 l/kg ODM from silage made from biomass harvested in July (Oleszek et al., 2013), the Hohenheim Biogas Yield Test showed a specific methane yield of *Silphium perfoliatum* of 232-274 l/kg ODM depending on harvest time, methane yield per hectare was up to 4301 m^3/ha^{-1} (Mast et. al., 2014).

The stems of the studied perennial species dried quickly in autumn-winter. They were resistant couldn't be flattened easily and could be used to produce solid biofuels with high heating value. It is known that the heating value of solid biofuel depends on the humidity and mineral content. The leaves have higher ash content than the stems. The rate of tissue dehydration and fall of the leaves from stems were investigated in order to determine the optimal period of biomass harvesting. At the end of the growing season and with the establishment of temperatures below 0 C, the studied species differed in the rate of leaf fall and dehydration of tissues. The degree of foliage of *Silphium perfoliatum* at the end of the growing season (October) was about 35 %, while the degree of foliage of *Sida hermaphrodita* – 20 % (Table 2). Over 15-35 days, the stems of *Sida hermaphrodita* were completely defoliated, while the leaves of *Silphium perfoliatum* were kept for a long period of time (in March, dry leaves on the stems constituted 8 % of the biomass). The stems of *Sida hermaphrodita*, in the field, dehydrated faster than *Silphium perfoliatum.*

The bulk density of the chopped stems reflects on transportation and storage expenses. It was established that the bulk density of the chopped material of *Silphium perfoliatum* was higher (165 kg/m^3) but - of *Sida hermaphrodita* was lower (122 kg/m^3). The wheat straw was characterized by the lowest bulk density – 83 kg/m^3 (Table 3).

Table 2. Plant material moisture and leaves contents of the biomass *Sida hermaphrodita* and *Silphium perfoliatum*

Period	*Sida hermaphrodita*		*Silphium perfoliatum*	
	Moisture content, %	leaves content, %	moisture content, %	leaves content, %
7 October	58.37	20.12	71.25	30.94
27 October	58.37	8.00	68.92	26.96
10 November	33.69	0	59.10	15.25
20 November	25.10	0	45.00	13.03
18 December	21.30	0	23.82	11.57
30 December	21.03	0	21.70	10.03
16 January	16.89	0	19.60	9.00
5 March	15.89	0	11.63	8.14

Table 3. Bulk density of biomass and specific density of briquettes of *Silphium perfoliatum* and *Sida hermaphrodita*

Variants	*Triticum aestivum*		*Sida hermaphrodita*		*Silphium perfoliatum*	
	bulk density of biomass, kg/ m^3	specific density of briquettes, kg/ m^3	bulk density of biomass, kg/ m^3	specific density of briquettes, kg/ m^3	bulk density of biomass, kg/ m^3	specific density of briquettes, kg/ m^3
Chopped chaffs 7 -35 mm	83	715	122	553	165	594
Milled chaffs 20 mm	86	733	160	642	195	869
Milled chaffs 10 mm	93	740	173	747	208	882

Table 4. Ash content and calorific value of biomass of *Silphium perfoliatum* and *Sida hermaphrodita*

Indices	*Triticum aestivum*	*Sida hermaphrodita*	*Silphium perfoliatum*
ash content,%	5.08	1.52	3.03
calorific value, MJ /kg	17.0	18.7	18.3

Distinct differences in bulk density between chopped and milled chaffs were found. These differences amounted to 13-38 kg/m^3 in *Sida hermaphrodita* and 13-30 kg/m^3 in *Silphium perfoliatum,* but 3-10 kg/m^3 in wheat straw.

The specific density of briquettes made from chopped material of *Sida hermaphrodita* and *Silphium perfoliatum* was low 553-594 kg/m^3, but it increased significantly if milled chaffs where processed into briquettes, reaching values of 642-747 kg/m^3 and 869-882 kg/m^3, respectively.

The ash content of different types of biomass is an indicator of slagging behaviour of the biomass. The greatest amount of this component was contained in *Triticum aestivum* – 5.08 %, while the lowest, 1.5 %, in the biomass of *Sida hermaphrodita* and a moderate one 3.0 % – in *Silphium perfoliatum* (Table 4). According to Stolarski et. al. (2014) the ash content decreased during the dehydration of stems, in *Sida hermaphrodita* – from 3.09 % to 2.69 %, and in *Silphium perfoliatum* - from 4.23 % to 3.49 %. The ash content of wheat straw pellets reached 6.33 % and negatively influenced the combustion efficiency (Ivanova et. al., 2015).

The investigation showed that the biomass of *Sida hermaphrodita* and *Silphium perfoliatum* had moderate gross calorific values between 18.7 MJ/kg and 18.3 MJ/kg respectively, but wheat straw - very low ones (17.0 MJ/kg), probably because of the high content of ash.

In Poland, the respective gross calorific values of the biomass of *Sida hermaphrodita* and *Silphium perfoliatum* were 18.8 MJ/kg and 18.7 MJ/kg (Stolarski et. al., 2014).

The potential of energy production of local varieties of *Sida hermaphrodita* and *Silphium perfoliatum* was around 350-380 GJ/ha.

Similar results were presented by other authors (Franzaring et al., 2014; Stolarski et. al., 2014).

The energy yield for *Sida hermaphrodita* as a solid fuel accounts for a net calorific value of 440 GJ ha-1 (Jablonowski et.al., 2016).

CONCLUSIONS

The studied perennial species differed in the rates of growth and development, productivity and chemical composition of the harvested mass, which have influenced the methane yield.

The gas forming potential of organic dry matter in silage varied from 458 l/kg in *Sida hermaphrodita* to 471 l/kg in *Silphium perfoliatum*.

The best results of methane production were achieved by the silage of cv. Energo, *Sida hermaphrodita*, 4000 m^3/ha and cv. Vital, *Silphium perfoliatum*, 3675 m^3/ha in comparison with maize silage 3127 m^3/ha and sunflower silage 2881 m^3/ha.

The dry biomass of the studied perennial species: *Sida hermaphrodita* and *Silphium perfoliatum* was distinguished by high bulk density, moderate gross calorific values (18.5-18.7 MJ/kg) and moderate ash content (1.5-3.0 %), but wheat straw *Triticum aestivum* – by low bulk density (163 kg/m^3) and calorific value (17.0 MJ/kg) and high content of ash (5.1 %).

The potential of energy production constituted 350-380 GJ/ha GJ/ha. The best results were achieved by cv. *Vital* of *Silphium perfoliatum*, due to its high productivity of dry biomass.

REFERENCES

Baserga U., 1998. Landwirtschaftliche Co-Vergärungs-Biogasanlagen – Biogas aus organischen Reststoffen und Energiegras. FAT-Berichte, 512: 1-11.

Boe A., Albrecht K., Johnson P. et. al., 2012.- Genetics, breeding, agronomy, and pest management of cup plant (*Silphium perfoliatum*), a potential new biomass crop for the north central USA http://ncsungrant.sdstate.org/upload/Boe-Sun-Grant-Ann-Mt-Indianapolis-2012.pdf

El Bassam N., 2010. Handbook of bioenergy crops: a complete reference to species, development and applications. Earthscan London; Washington, 516.

Franzaring J., Schmid I., Bäuerle L., Gensheimer G., Fangmeier A., 2014. Investigations on plant functional traits, epidermal structures and the ecophysiology of the novel bioenergy species *Sida hermaphrodita* Rusby and *Silphium perfoliatum* L. J Appl. Bot. Food. Qual., 87: 36-45.

Kalač P., 2011. The required characteristics of ensiled crops used as a feedstock for biogas production: a review. Journal of Agrobiology, 28(2): 85–96.

Klimiuk E., Pokoj T., Budzyński W., Dubis B., 2010. Theoretical and observed biogas production from plant biomass of different fire contents. Bioresour Technol, 101: 9527–9535.

Ivanova T., Kavalek M., Havrland B., Kolaríkova M., Skopec P., 2015. Comparison of technologic parameters of pellets and other solid fuels produced from various raw materials. Agronomy Research, 13(2): 303–310

Jablonowski N.D., Kollmann T., Nabel M., Damm T., Klose H., Müller M., Bläsing M., Seebold S., Krafft S., Kuperjans I., Dahmen M., Schurr U., 2016. Valorization of Sida (*Sida hermaphrodita*) biomass for multiple energy purposes. GCB Bioenergy. doi:10.1111/gcbb.12346

Mast B., Lemmer A., Oechsner H., Reinhardt-Hanisch A., Claupein W. Graeff-Hönninger S., 2014. Methane yield potential of novel perennial biogas crops influenced by harvest date. Industrial Crop and Products, 58, 194-203

Medvedev P.F., Smetannikova A.I., 1981. The forage crops of European part of the USSR. Ed. Kolos. Leningrad, 336. [in Russian].

Novoselov Y.K., Kharkov G.D., Shekhovtsova N.S., 1983. Methodical instructions for conducting field experiments with forage crops. Ed. VNNIK, Moscow, 198. [in Russian].

Niqueux M., 1981 Une nouvelle plante fourragère: le silfe (*Silphium perfoliatum* L.). Fourages. 87 :119-136

Oleszek M., Matyka M., Lalak J., Tys J., Paprota E., 2013. Characterization of *Sida hermaphrodita* as a feedstock for anaerobic digestion process. Journal of Food, Agriculture & Environment, 11, 1839–1841.

Petukhov E.A., Bessarabova R.F., Holeneva L.D., Antonova O.A., 1989. Zoo technical analysis of the feed. Edit. Agropromizdat, Moscow, 239[in Russian].

Pichard G., 2012. Management, production, and nutritional characteristics of cup-plant (*Silphium perfoliatum*) in temperate climates of southern. Chile. Cien. Inv. Agr. 39(1): 61-77

Puia I., Szabo A.T., 1985. Culture experimentale d'une nouvelle espece fourragere- Silphium perfoliatum- dans le Jardin agrobotanquie de Cluj-Napoca. Notulae Botanicae Horti Agrobotanici XV: 15-20.

Rakhmetov J., 2011. Energy malva or Virginia fanpetals (*Sida hermaphrodita* Rusby). J. Zerno 6: 36-39 [in Russian].

Šiaudinis G., Jasinskas A., Šlepetienė A. Karčauskienė D., 2012. The evaluation of biomass and energy productivity of common mugwort (*Artemisia vulgaris* L.) and cup plant (*Silphium perfoliatum* L.)

in Albeluvisol. Žemdirbystė (Agriculture) 99(4): 357–362.
Stolarski M.J., Krzyzaniak M., Snieg M., Slominska E., Piórkowski M., Filipkowski R., 2014. Thermophysical and chemical properties of perennial energy crops depending on harvest period. Int. Agrophys., 28, 201-211.
Tarkowski A., Truchliński J., 2011. Nutritional value of Virginia fanpetals (*Sida hermaphrodita* Rusby) protein in evaluation of nitrogen fertilization effect on environment. New Medicine, 15(1), 8-11
Thomas L.K., 1979. Distribution and ecology of Sida hermaphrodita. A rare plant species. Bartonia 46, 51-59.
Teleuţă A., Ţîţei V., 2016. Mobilization, acclimatization and use of fodder and energy crops. Journal of Botany. 2016, 1(12), 112-120.
Ţîţei V., 2015. Promising perennial plant species for bioenergy production in the Republic of Moldova. Journal of Botany, 2(11): 127-131.
SM 108:1995, 1996. Siloz din plante verzi. Condiţii tehnice. Moldovastandart. 10.

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DETERMINATION OF WEED SPECIES AND DENSITY SEEN ON THE BANK OF IRRIGATION CANALS IN KAHRAMANMARAŞ PROVINCE OF THE MEDITERRANEAN REGION

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Abstract

The aim of this study was to determine the density of weed species seen around irrigation canals located in the district of Kahramanmaraş was made during the 2016 vegetation period of the species. This study caried out along the bank of irrigation channals in order to determine density of weed species in 8 district of Kahramanmaraş (Onikişubat, Dulkadiroğlu, Afşin, Andırın, Elbistan, Göksun, Pazarcık and Türkoğlu). The study was not conducted in Çağlayancerit, Nurhak and Ekinözü because lack of suitable agricultural plains and absense of irrigation channals. 31 different weed species belonging to 145 families were identified as far as studies in open channals in Kahramanmaraş. On average, 103.64 units/m^2 of weed has fallen in the square meter in the region. The district with the highest weed density is Onikişubat district (124.64 units/m^2). This was followed by Dulkadiroğlu (115.79), Göksun (110.10), Pazarcık (108.49 units/m^2), Türkoğlu (105.08 units/m^2), Andırın (104.92), Elbistan (81.87 units/m^2) and Afşin (78.26 units/m^2), respectively. In the study area, 1 of the weed species is fern (Pterydophyta), 29 of them are monocotyledone, and 115 are dicotyledone. Some weed species, which are detected intensively in the area, are; Bromus varvensis (9.17), Cynodon dactylon (8.56), Agropyron repens (8.48), Alopecurus myosuroides (8.35), Papaver rhoeas (8.06), Matricaria chamomilla (7.00), Sorghum halepense (6.63), Phragmites australis (5.37), Dactylis glomerata (2.96), Amaranthus retroflexus (2.90) and Avena sterilis (2.85). Off irrigation channals are only used in Onikişubat, Dulkadiroğlu and Türkoğlu districts agriculture areas. 62 weed species belonging to 18 families were determined according to mean of these districts where overall weed species intensity is 35.315 per m^2. Agropyron repen, C. dactylon, Alopecurus myosuroides, Bromus arvensis, Avena sterilis, Setaria verticillata, Dactylis glomerata, Matricaria chamomilla are intensive weed species (mean weed number 1-10 per m^2) in those districts were determined.

Key words*: irrigation channal, weed species, intensity.*

INTRODUCTION

The area that can be economically irrigated in Turkey is 8.5 million hectares. As of the end of 2014, a total of 6.09 million hectares were irrigated (Anonymous, 2014a). In order to prevent the loss of yield and quality in agricultural products, it is absolutely necessary to struggle with weeds, diseases and harmful. If there is no the struggle, the harvested product yield and quality loss can be 100%. According to a study by Rao (2000), 45% of the crop losses in agricultural production are from weeds, 30% from insects, 20% from diseases and 5% from other plant mites.

Many studies in Turkey have reported that irrigation water is important in spreading weeds and that many weed species are carried to irrigation channels and agricultural areas.

In the irrigation channels of weeds which are a problem in cotton, corn and soybean cultivation areas in Çukurova region and Harran plain. These weed species are; *Physalis* spp*., Cyperus rotundus, Prosopis farcta, Convolvulus arvensis, Xanthium strumarium, Cynodon dactylon.* Weed species spreading through irrigation channels in the Aegean region; *Physalis alkekengi, Matricaria chamomilla, Silybum marianum, Melilotus officinalis, Cynodon dactylon, Sorghum halepense, Chenopodium album, Amaranthus retroflexus* and *Rumex crispus* (Gönen, 1999; Güncan, 2002; Erbas and Dogan, 2015; Bükün, 2001; Tetik, 2010).

Worldwide, in this work, irrigation channels carried by rivers or irrigation water in agricultural areas and weed species reaching vineyards, gardens and fields are generally hydrophytes. These weed species can be transported at distances with irrigation water. These weed species include *Capsella bursa-pastoris* (L.) Medik., *Cyperus rotundus* L., *Paspalum paspaloides* (Michx.) Schrib., *Digitaria sanguinalis* (L.) Scop., *Sorgum halepense* (L.) Pers., *Portulaca oleracea, Myriophyllum aquaticum, Azolla filiculoides, Eichhornia crassipes, Lemna gibba, Myriophyllum spicatum, Potamogeton pectinatus* and *Lactobacillus* spp., *Spyrogira* spp. (Wilson, 1980; Dastgheib, 1989; Saavedra et al., 1990; Ferrero and Maggiore, 1992; Rojas and Agüero, 1996; Moreira 1998; Riis et al., 2001; Masaaki et al., 2002; Boedeltje et al., 2004; Jansson et al., 2005; Merritt and Wohl, 2006).

Since weed density is high during irrigation channels of Kahramanmaras agricultural area and there is no further study in this area. The aim of this study is to determination the species and density of weed species found in irrigation channels in Kahramanmaras province.

MATERIALS AND METHODS

Survey work was conducted in the districts of Kahramanmaras region (Onikisubat, Dulkadiroglu, Afşın, Andırın, Çaglayancerit, Ekinözü, Elbistan, Göksun, Nurhak, Pazarcık and Türkoglu). By the reason the fact that there are no irrigation channels in Çaglayancerit, Ekinözü and Nurhak districts, no surveys were conducted on these districts. Considering the distribution of irrigation channels, Kahramanmaras region is divided into 8 regions according to the provinces. Within each of the county boundaries, 3 x 1 m^2 quadrats per 300 m intervals within an area of 1 km length with intervals of 3 km along the irrigation canals were laid and weed species counted in the frame to represent the region in question. The number of siblings and the number of individuals in broad leaves were counted from foreign grasses in narrow foliage. The Turkish names of the weeds identified in Uluğ et al. (1993) and Anonymous (2014 b) are mentioned in the findings. Herbarium samples were taken from the unidentified weeds during the survey and then identified in the Herbology Laboratory of the Plant Protection Department of the KSU Faculty of Agriculture. Water weeds, which cannot be identified in nature as a source in weed species diagnostics, have been identified using Altınayar (1988) "Water Weeds" and Davis, (1975) "Flora of Turkey" books. In the case of weed density Güncan, 2001);

Density = calculated by formula B/n

Where,

B = total number of individuals in the sample,

n = number of samples

As suggested by Üstüner and Güncan (2002), the weed density scale is used as follows;

Density scale;

A. Very dense (average> 10)

B. Intensive (average 1-10)

C. Mid intensive (average 0.1-1)

D. Intensive (average 0.01 to 1)

E. Rare (average less than 0.01)

The surveys carried out in the Kahramanmaras region were carried out in accordance with the number of places and frames specified in Table 1. Kahramanmaras region, the skirts of the Ahir mountains in the north, Gaziantep in the south, Adıyaman in the east, Kayseri in the west and Islahiye and Osmaniye in the south and is an plain with a width of 204,000 ha. The Mediterranean is dominated by terrestrial and transitional climates.

Table 1. Surveys, sample area and number of frames scored in Kahramanmaraş region (Anonymous, 2016)

District	Open channel lengths (km)				Number of frames skipped (units)
	Main channel	Secondary channel	Tertiary channel	Pipe irrigation system	
Afsin	41	52	58	0	150
Andırın	44	37.9	53.3	0	135
Dulkadiroglu	50	77	100	20	227
Elbistan	24.2	60.8	31.2	0	116
Göksun	54	85.3	80.8	0	220
Pazarcık	72.4	80	77.3	0	229
Onikisubat	33	49	58	18.4	140
Türkoglu	55.4	76.5	32	17	163
Toplam	374	518.8	490.6	55.4	1380

RESULTS AND DISCUSSIONS

The weed species identified in the surveys conducted during irrigation channels in the vegetation area of Kahramanmaras region in the period of 2016 vegetation were classified according to their families. A total of 31 different families were identified in the region. These families: (*Leguminosae*), *Geraniaceae* (*Leguminosae*), *Bacillus* spp., *Pseudomonas* spp., *Labiatae* (*Lamiaceae*), *Malvaceae*, *Papaveraceae*, *Plantaginaceae*, *Polygonaceae*, *Portulacaceae*, *Primulaceae*, *Ranunculaceae*, *Rosaceae*, *Rubiaceae*, *Scrophulariaceae* (*Scrophyllaceae*), *Solanaceae* and *Zygophyhllaceae.*

The weeds species are determined 145. These 1 Pterydophyta, 29 of them monocotyledone, and 115 of them were dicotyledone. In the Kahramanmaras area, we found that weeds weighed 103.64 (unit/m^2) on average per square meter. While weed density (124.64 pcs m^{-2}) was highest in Onikisubat province, it was highest in Dulkadiroglu (11.79pcs m^{-2}), Göksun (110.10 plant m^{-2}), Pazarcık (108.49 pcs / 08 plant m^{-2}), Andırın (104.92 plant m^{-2}), Elbistan (81.87 plant m^{-2}) and Afşin (78.26 plant m^{-2}) (Figure 1). The results of surveys carried out in 8 districts representing Kahramanmaras region were evaluated separately.

Figure 1. Determination of weed density by 1 m^2 frame on irrigation canal edge

Afsin district

There are 102 different weed species from 24 families diagnosed during the open irrigation canals of the Afsin district farming area. In the district: *Alopecurus myosuroides* is very dense (average plant in m^2>10); *Papaver rhoeas, Agropyron repens, Bromus arvensis, Sorghum halepense, Cynodon dactylon, Matricaria chamomilla, Avena fatua, Amaranthus retroflexus, Echinochloa crus-galli, Phragmites australis, Chenopodium album, Setaria viridis, Dactylis glomerata, Sinapis arvensis, Hordeum vulgare, Phalaris canariensis, Lolium temulentum, Convolvulus arvensis, Rumex crispus, Matricaria perforata, Bromus tectorum, and Cuscuta campestris* species were found to be dense (mean plants 1-10 in m^2) (Figure 2).

Figure 2. *Agropyron repens* and *Bromus arvensis* on the edge of the irrigation channels

Andırın district

The weed species were determinede 97 different species from 29 families at the edge of Andırın, open irrigation canals were identified. In this district: *Agropyron repens, A. myosuroides, B. arvensis, Cynodon dactylon, Portulaca oleracea, Papaver rhoeas, Cyperus rotundus, Amaranthus retroflexus, Alopecurus myosuroides, Sorghum halepense, Setaria verticillata, Bromus tectorum, Dactylis glomerata, Matricaria chamomilla, Avena sterilis, Digitaria sanguinalis, Anchusa officinalis, Sinapis arvensis, Chenopodium album, Phalaris canariensis, Convolvulus arvensis, Rubus canasences* (Figure 3).

Figure 3. *Cynodon dactylon* and *Portulaca oleracea* L. on the edge of irrigation channals

Dulkadiroglu district

On the edge of the open irrigation canals of Dulkadiroglu district, 134 different weed species were found from 30 families diagnosed. In the district: *Agropyron repen, C. dactylon* is very intense while *Papaver rhoeas, Alopecurus myosuroides, Phragmites australis, Bromus arvensis, Avena sterilis, Setaria verticillata, Dactylis glomerata, Anchusa officinalis, Matricaria chamomilla, Amaranthus retroflexus, Sorghum halepense, Chenopodium album, Digitaria sanguinalis, Typha latifolia , Convolvulus arvensis, Lolium temulentum, Portulaca oleracea, Sinapis arvensis, Bromus tectorum, Phalaris canariensis, Cyperus rotundus, Cuscuta campestris, Poa trivialis* and *Aegilops cylindrica.*

There are 62 different weed species from 18 families diagnosed at the edge of closed irrigation channels. In the district: *Agropyron repens, C. dactylon Alopecurus myosuroides, Bromus arvensis, Avena sterilis, Setaria verticillata, Dactylis glomerata, Matricaria chamomilla, Chenopodium album, Digitaria sanguinalis, Convolvulus arvensis, Lolium temulentum, Papaver rhoeas, Portulaca oleracea, Sinapis arvensis, Bromus tectorum* and *Phalaris canariensis* (Figure 4).

Figure 4. *Phragmites australis* and *Convolvulus arvensis* on the edge of irrigation channals

Elbistan district

The weed species were found 108 from 27 families at the edge of the Elbistan irrigation channels. In this district; *A. myosuroides* is very dense, and *Cynodon dactylon, Bromus arvensis, Sorghum halepense, Papaver rhoeas, Matricaria chamomilla, Dactylis glomerata, Digitaria sanguinalis, Amaranthus retroflexus, Setaria viridis, Convolvulus arvensis, Agropyron repens, Avena fatua, Chenopodium album, Bromus tectorum, Matricaria perforate, Cuscuta campestris, Echinochloa crus-galli* and *Phragmites australis.*

Figure 5. *Alopecurus myosuroides* and *Setaria viridis*

Göksun district

There are 112 different weed species from 28 families diagnosed at the edge of the Göksun irrigation canals. In this region, *P. rhoeas* is very dense, *Alopecurus myosuroides, Bromus arvensis, Matricaria chamomilla, Setaria viridis, Equisetum arvense, Cynodon dactylon, Agropyron repens, Amaranthus retroflexus, Echinochloa crus- galli, Dactylis glomerata, Lolium temulentum, Digitaria sanguinalis, Sorghum halepense, Sinapis Arvensis, Anchusa officinalis, Bromus tectorum, Avena fatua, Phragmites australis, Cuscuta campestris, Portulaca oleracea, Convolvulus arvensis, Poa trivialis, Rumex crispus, Chenopodium album* and *Aegilops columnaris.*

Figure 6. *Papaver rhoeas* and *Equisetum arvense*

Pazarcık district

There are 110 different weed species from 28 families diagnosed at the edge of the Pazarderian irrigation canals. In this region, *A. myosuroides* is very dense, and *Agrobyron repens, Bromus arvensis, Phragmites australis, Sorghum halepense, Papaver rhoeas, Cynodon dactylon, Avena sterilis, Setaria verticillata, Dactylis glomerata, Digitaria sanguinalis, Aegilops columnaris, Sinapis arvensis, Rumex crispus, Matricaria perforata, Phalaris canariensis, Bromus tectorum, Portulaca oleracea, Convolvulus arvensis and Cuscuta campestris were found intensely* (Figure 7).

Figure 7. *Phragmites australis* and *Sinapis arvensis*

Onikişubat district

There are 128 different weed species from 30 families diagnosed at the edge of the open watering canals of the village of Onikişubat. In the district: *Sorghum halepense, Agropyron repens, Cynodon dactylon are very dense; Bacillus arborescens, Amaranthus retroflexus, Aegilops cylindrica, Cuscuta campestris, Bacillus arborescens, Bromus arvensis, Bromus arvensis, Alopecurus myosuroides, Avena sterilis, Setaria verticillata, Bromus tectorum, Lolium temulentum, Dactylis glomerata, Digitaria sanguinalis, Rumex crispus, Chenopodium album, , Typha latifolia, Anchusa officinalis, Aegilops columnaris, Poa trivialisve Cyperus rotundus* were found intensely. There are 58 different weed species from 15 families diagnosed at the edge of closed irrigation channels. In the district, it has been determined that the species of *Agapyron repens, C. dactylon Alopecurus myosuroides, Bromus arvensis, Avena sterilis, Setaria verticillata, Dactylis glomerata, Matricaria chamomilla, Chenopodium album, Digitaria sanguinalis, Convolvulus arvensis, Lolium temulentum, Papaver rhoeas, Portulaca oleracea and Sinapis arvensis* are intense.

Figure 8. *Phragmites australis* and *Sorghum halepense*

Türkoglu **district**

Türkoglu district, 105 different weed species from 28 families diagnosed at the edge of open irrigation canals were encountered. In this district: *Matricaria chamomilla, Bromus arvensis, Agropyron repens, Phragmites australis Very dense; Sorghum halepense, Papaver rhoeas, Alopecurus myosuroides, Cynodon dactylon, Avena sterilis, Matricaria perforata, Cyperus rotundus, Sinapis arvensis, Chenopodium album, Dactylis glomerata, Rumex crispus, Bromus tectorum, Portulaca oleracea, Digitaria sanguinalis, Setaria verticillata, Anchusa officinalis, Cuscuta campestris* and *Convolvulus arvensis*.

There are 51 different weed species from 13 families diagnosed at the edge of closed irrigation channels. In the district, it has been determined that the species of *Agropyron* *repens, C. dactylon Alopecurus myosuroides, Bromus arvensis, Avena sterilis, Setaria verticillata, Dactylis glomerata, Matricaria chamomilla, Chenopodium album, Digitaria sanguinalis, Convolvulus arvensis, Papaver rhoeas* and *Sinapis arvensis* (Figure 9).

Figure 9. *Anchusa officinalis* and *Aegilops columnaris*

CONCLUSIONS

In the Kahramanmaras region, 145 weed species and an average of 103.64 (plant m^{-2}) weeds were found to fall. In terms of the weed density determined by the unit area in the region: *Bromus arvensis* (9.17), *Cynodon dactylon* (8.56), *Agropyron repens* (L.) P.Beauv. (8. 48), *Alopecurus myosuroides* (8.35), *Papaver rhoeas* (8.06), *Matricaria chamomilla* (7.00), *Sorghum halepense* (6.63), *Phragmites australis* (2.75), *Dactylis glomerata* (2.96), *Amaranthus retroflexus* (2.90), *Avena sterilis* (2.85), *Setaria verticillata, Portulaca oleracea* (2.00), *Digitaria sanguinalis* (1.94*), Setaria viridis* (1.80), *Chenopodium album* (1.65), *Convolvulus arvensis* (1.57), *Sinapis arvensis* (1.57), *Cyperus rotundus* (1.49), *Bromus tectorum* (1.39), *Anchusa officinalis* (1.36), *Cuscuta campestris* (1.08) and *Equisetum arvense* (1.06 plant m^{-2}) were found to be dense.

In the open irrigation channels, the number and density of weed species, especially seen on the soil surface and along the secondary channels, were determined at the highest level. In addition, since there is no continuous water in these irrigation channels, weeding of the weed in the canal was found to be considerably high as the soil was accumulated in the soil of the canal (Figure 10). This reduces the speed and the flow of irrigation water. In addition, because weed seeds will be poured into the canal, they cause direct transport to the fields.

Figure 10. Problems of gravel and soil residues that accumulate in irrigation channels

The density of weed seen along the irrigation channels at certain height from the soil surface was found to be slightly lower. Moreover, since many weed species are short in length due to their irrigation canal height, it will not be possible to transport seeds, stolons and rhizomes with such irrigation canals.

The closed-pipe irrigation system is only available in Onikisubat, Dulkadiroglu and Türkoglu districts. According to the average of these 3 groups, 62 weed species of 18 families were identified. The density of weed species in the square meter is 35.31 plant m^{-2}. According to the open irrigation channels, the weed density in the tubular irrigation system is determined at the lowest level. Because there is no water leakage in the closed pipe system, the weed output is at the minimum level in the soil. In addition, there has never been any spread of weed seeds with closed-pipe irrigation system (Figure 11).

Figure 11. Overview of the closed pipe system

In a study conducted in America; During the irrigation season, 77 species of weed were identified in the irrigation channels sampled with plastic sieves for years (Kelley and Burns, 1975). In Spain, 23 families and 63 weed species were identified in irrigation channels. The most common families were Asteraceae 62.4% and Poaceae 18.9% followed by Rosaceae (4.4%) and Fabaceae (3.7%). The most important weed species were *Conyza* spp*., Sonchus oleraceus and Picris echioides, Amaranthus hybridus, Bromus* spp*., Hordeum murinum* and *Poa annua* were found to be very common (Catalán et al. 1997). Zuo RanLing et al. (2007) also found that the seeds of 21 weed species belonging to 14 families were distributed to irrigated water and rice fields in the study conducted in China. The most important families are Gramineae, Primulaceae, Polygonaceae and Chenopodiaceae. Li and Qiang, 2009 have identified 74 species of weeds belonging to 20 families in rice fields. These families are Poaceae (15), Asteraceae (11) and Polygonaceae (9).

As a result of the surveys conducted in Lower Seyhan, a total of 21 water weed species belonging to 14 plant families were identified (Soyak and Uygur, 2009). In the study conducted in Adana region, Amaranthaceae 1, Asteraceae 3, Chenopodiaceae 1, Euphorbiaceae 1, Fabaceae 2, Poaceae 10, Portulaceae 1, Urticaceae 1, Verbenaceae 1 were determined. As a result of the counts, 27 weed species belonging to 16 families were identified. The most frequently encountered species were *Portulaca oleracea* (38.89%), *Echinochloa colonum* (33.33%), *Amaranthus viridis* (30.00%), *Cynodon dactylon* (30.00%) and *Cyperus rotundus* (26.67%) were identified as the most common species at the canal edge (Tetik and Uygur, 2010).

With other studies on spreading of weed seeds with irrigation channels in the world and Turkey; Wilson, 1980; Saavedra et al., 1990; Ferrero and Maggiore, 1992; Cuevas, 1993; Rojas and Agüero, 1996; Miller, 1996; Catalán et al., 1997; Moreira, 1998; Zuo RanLing et al., 2007; Li and Qiang, 2009; Soyak and Uygur, 2009; Tetik and Uygur, 2010; Erbaş and Doğan 2015 with similar.

There are many biotic and abiotic factors affecting weed density. Abiotic factors such as irrigation systems, wind, agricultural methods, soil chemical and physiological characteristics, climate factors and Biotic factors such as human, animal, insect and birds play an important role in the spread of weed seeds.

REFERENCES

Anonim, 1997. Technical Instruction of Integrated controlling in Citrus Gardens, Ankara, 73s.

Anonymous, 2016. Data of Statistic Office, DSİ VI. District Management - Adana.

Anonim, 2014a. Kahramanmaras Irrication Channals. http://www.dsi.gov.tr/.Kahramanmaras.

Anonim, 2014b. Turkish Plant Names. [www.bizimbitkiler.org.tr/v2/turkce.php]

Altinayar, G., 1988. Aquatic Weeds. T.C. Ministry of Public Works and Settlement, DSI, Directorate of Operation and Maintenance, Ankara / Türkiye, 231s.

Boedeltje G., Bakker J.P., Brinket A.T., Groenedael J.M.V., Soesbergen, M., 2004. Dispersal phenology of hydrochorus plants in relation to discharge, seed release time and buoyancy of seeds: the flood pulse concept supported. Journal of Ecology 92: 786-796.

Bükün B., 2001. Determination of Economic Loss of Problematic Physalis spp Threshold and Critical Period in Cotton Sowing in Harran Plain Areas of. pHd Theisesi, Plant Protection Department, Adana, 110 s.

Catalán B., Aibar J., Zaragoza C., 1997. Weed Seed Dispersal through Irrigation Channels. / Diseminación de las semillas de malas hierbas a través de los canales de riego. Proceedings of the 1997 Congress of the Spanish

Cuevas A., 1993. Paspalum hydrophylum Henr., a New Weed Problem in Rice Crops. / La invasora Paspalum hydrophylum Henr., neuva maleza problema en cultivo de arroz. Arroz 42 (384), 1993, 40-43.

Dastgheib F., 1989. Relative importance of crop seed, manure and irrigation water as sources of weed infestation. Weed Research 29: 113 ark.116.

Davis P.H.,1975. Flora of Turkey and the East Aegean Islands., Vol. 5:890

Erbaş F., Doğan M.M.N., 2015. Weed Species at The Irrigation Channel Banks Of Aydin Plain and A Newly Introduced Species For Aegean Region: Chinese Lantern (Physalis alkekengi L.) Adnan Menderes University Agriculture Faculty Journal 2015; 12(2) :73 - 82

Ferrero A., Maggiore T., 1992. Dissemination of Weeds by Irrigation. Mededelingen van de Faculteit Landbouwwetenschappen, Universiteit Gent 57 (3b), 1992, 1093-1098.

Gönen O., 1999. Germination Biology of Weeds of Cukurova Region Summer Weed and Determination of Morphological Characters for Computer-assisted Growth. Phd Theises, Institute of Science, Plant Protection Departmant, Adana, 233 s.

Güncan A., 2001. Weeds and Principles, Selçuk Univ. Agriculture faculty, Textbook., Konya.

Güncan A., 2002. Weeds and Control Principles, Selçuk University., Agricultur Faculty, Konya, page 239.

Jansson R., Zinko U., Merritt D.M., Nilsson C., 2005. Hydrochory increases riparian plant species richness: a comparison between a free-flowing and a regulated river. Journal of Ecology 93: 1094-1103.

Kelley A.D., Bruns V.F., 1975. Dissemination of Weed Seeds by Irrigation Water. Weed Science, 23:486-493.

LI R.H., Qiang S., 2009. Composition of Floating Weed Seeds in Lowland Rice Fields in China and the Effects of Irrigation Frequency and Previous Crops.

Masaaki T., Hiroaki W., Kazuyuki I., 2002. Distribution of a naturalized weed, Barbarea [fa1]vulgaris R. Br. in the Tohoku area of Japan. Journal of Weed Science and Technology. 47:235-241.

Merritt D.M., Wohl E.E., 2006. Plant dispersal along rivers fragmented by dams. River Research and Applications 22: 1-26

Miller S.D., 1996. Weed Control Research Agronomic Crops. University of Wyoming Agriculture Experiment Station, College of Agriculture.

Moreira F.C., 1998. Aquatic weed assemblages in an Iberian drainage channel system and related environmental factors. Weed Research 38: 291-300.

Rao V.S., 2000. Princliples of Weed science. Science Publishers; 2 Sub edition, ISBN 1-57808-069-X, 555p.

Riis T., Sand-Jensen K., Larsen E.S., 2001. Plant distribution and abundance in relation to physical conditions and location within Danish stream systems. Hydrobiologia 448: 217-228.

Rojas M., Agüero R., 1996. A Survey of Weeds Associated with Irrigation Canals and Adjacent Inundated Rice Fields at Finca El Cerrito, Guanacaste, Costa Rica. Agronomia Mesoamericana 7 (1), 1996, 9-19.

Saavedra M., Garcia-Torres L., Hernandez-Bermejo E., Hidalgo B., 1990. Influence of Environmental Factors on the Weed Flora in Crops in the uadalquivir. Weed Research (Oxford) 30 (5), 1990, 363-374.

Soyak A., Uygur S., 2009. Determination of aquatic weed species, their densities and possible biological control agents in lower Seyhan plain, Master Theises, Science Institute, Plant Protection, Adana, 117 s.

Tetik Ö., Ve Uygur N., 2010. Determination of Weed Species Transported By Irrigation Water And Found At The Edges Of Irrigation Channels On Agricultural Area In Cukurova Lower Seyhan Plain. Çukurova University, Science Institute, Plant Protection Master Theises.

Uluğ E., Kadioğlu İ., Üremiş İ., 1993. Weeds and Some Properties of Turkey. T.C. Ministry of Agriculture and Rural Affairs, Directorate of Plant Protection Research Institute, Publication number:78. Adana.

Üstüner T., Güncan A., 2002. A Research on weed species which are problem, importance, biology of germination and control possibilties of them in potato fields in Nigde province. Ph. D Thesis, Department of plant protection, Selcuk University, Konya, Turkey.

Wilson R.G., 1980. Dissemination of weed seeds by surface Irrigation Water inWestern Nebraska. Weed Science, 28:87-92. www.cukurovataem.gov.tr

Zimdahl R.L., 1980. Weed crop competition: A review. International Plant Protection Center, Oregon State Univ., Corvallis, Oregon, USA. P. 404.

Zuo R., Qiang S., Li R., 2007. Relationship between Weed Seeds Dispersed by Irrigation Water and Soil Weed Seedbank of Paddy Field in Rice-Growing Region. Chinese Journal of Rice Science 21 (4) Hangzhou: China National Rice Research Institute (CNRRI), 2007, 417-424.