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PATTERNS OF SOIL FORMATION AND DISTRIBUTION IN ARID MOUNTAINS OF THE PAMIR

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Abstract

Some new scientific concepts about the genesis of soils in arid mountains of dry subtropical zone of Pamir were established. It was revealed that the main soil-forming processes, under influence of which developed all the soils of the Pamir are humus accumulation, argilization and leaching under the leadership of the humus-accumulative process. It was showed the leading role of humidity and duration of the biologically active period in the formation of plant landscapes and soil types in all vertical zones as well as the important role of thermal regime in the soil formation of cold and very cold thermal zones that differ by fulvate composition of humus and reddish color profile.

Key words*: arid, distribution soil, mountains, Pamir, humus.*

INTRODUCTION

General schemes of the distribution of soils and vegetation as dependent on the spresding of the sum of active temperatures and the degree of the climatic moistening (the Ivanov-Vysotskii humidity factor) in the Pamir Mountains are suggested. It is shown that the development of particular types of soils and vegetation communities in all vertical thermal belts, except for the cold belt, is mainly controlled by the humidity factor (Kann, 1965; Kuteminski & Leontieva, 1966).

MATERIALS AND METHODS

About 1000 soils' profiles were made across vertical topographical profiles on mountains' slopes of North and South exposition in the lower, middle and upper part of the main river basins of West Pamir.

The analysis (more than 100000) were made according to the accredited classic methodology. Generalization and statistical processing of the high quantitative mass of analytical material let us receive the information about the compound and proprieties of West Pamir soils and draw out the main legitimates of their formation (Cherbari, 2001).

RESULTS AND DISCUSSIONS

The modified idea of Sokolov I.A. (1978) and Fridland V.M. (1979) about the possibility of soil classification using several components: ecological-geographic, regime and profile components of soil classification (Table 1).

Table 1. The components of classification

Ecological-geographic	Regime	Profile genesis
1. Mountain chain 2. Type of vegetation	Facies soils subtypes by sum of tempe-ratures >10°C	1. Types of soils 2. Subtypes of soils

Pamir's' mountain system is unique for investigation of objective laws of soils geographical placing depending on thermal and humid conditions.

Here, on relatively compact mountain territory which is situated in latitude dry subtropical belt, all vertical thermal belts are present: from subtropical to very cold.

Within the most belts conditions of humidity, for the reason of phenomenon of rain shadow, change from extra arid (80-100 mm precipitation per year) to arid humid (1000-1500 mm/year). Rain and snow fall in winter and spring periods; summer is very dry.

The hydrothermal parameters of every subtype of soils have been got by the method of comparison of soil maps, year precipitation and sum of the active (more than 10°C) temperatures. Constructing coordinate graph where value of coefficient humidity according to formula Ivanov-Visotsky is put on axis of abscises, and sum of the active temperatures is put on axis of ordinate, and putting on graph the hydrothermal characteristic of every subtype of soil, we have got a system of closed areal (fields) which describes hydrothermal conditions of existence of every soil.

The system of hydrous rows (sectors of humidity) determines spectrum of subtypes of soils depending on humidity within the one thermal belt, but the system of thermal rows (vertical thermal belts), within the one hydrous row, determines spectrum of soils subtypes depending on thermal regime of territory.

The general scheme of distribution of zonal soils subtypes on territory of Pamir-Alay depending on hydrous and thermal conditions is presented in the Table 2.

Table 2. Vertical and horizontal arrangement of soil systems in arid mountains of the Pamir depending on the thermal and humid conditions

<table>
<tr><td rowspan="3">Altitude climatic (thermal) belts (t°>10°C)</td><td colspan="7">Coefficient humidity</td></tr>
<tr><td>>0.1</td><td>>0.1-0.2</td><td>0.2-0.3</td><td>0.3-0.5</td><td>0.5-1.0</td><td colspan="2">1.0-1.5>1.5</td></tr>
<tr><td colspan="7">Soils (Humus, % in horizon Ah)</td></tr>
<tr><td>Very cold
(t°>10°C)</td><td colspan="2">No</td><td colspan="3">Reddish light brown cryodesertic or Cryo Regosol (1-2%)</td><td colspan="2">Snow belt</td></tr>
<tr><td rowspan="2">Cold
(0-900°C)</td><td colspan="2" rowspan="2">Grey pale desert or Yerma regosols (<1%)</td><td colspan="3">Reddish brown semidesertic</td><td colspan="2" rowspan="2">Reddish dark brown steppe
(5-10%)</td></tr>
<tr><td>Light
(1-2%)</td><td>Typical
(2-3%)</td><td>Dark
(3-5%)</td></tr>
<tr><td rowspan="2">Cold temperate or moderately cold
(900-2000°C)</td><td rowspan="2">Idem</td><td colspan="3">Brown semidesertic</td><td rowspan="2">Dark brown steppe
(5-10%)</td><td colspan="2" rowspan="2">Dark brown and Black brown under xerophilous sparse forest or Phaeozems (7-15%)</td></tr>
<tr><td>Light
(1-2%)</td><td>Typical
(2-3%)</td><td>Dark
(3-5%)</td></tr>
<tr><td>Warm temperate or moderately warm
(2000-3100°C)</td><td>Idem</td><td>Idem</td><td>Idem</td><td>Idem</td><td>Idem</td><td colspan="2">Dark brown and Black brown under xerophilous sparse forest or Phaeozems (6-12%)</td></tr>
<tr><td>Very warm
(3100-3800°C)</td><td>Idem</td><td>Idem</td><td>Idem</td><td>Idem</td><td colspan="2">Brown under xerophilous sparse forest or cambisol xeroforest (5-10%)</td><td>No</td></tr>
<tr><td rowspan="2">Subtropical
(3800-4900°C)</td><td rowspan="2">Grey pale or grey brown desertic (<1%)</td><td colspan="3">Serozems or Grey semidesertic</td><td rowspan="2">Kastanozems

(2.5-5%)</td><td rowspan="2">Idem</td><td rowspan="2">No</td></tr>
<tr><td>Light
(1-2%)</td><td>Typical
(2-3%)</td><td>Dark
(3-5%)</td></tr>
<tr><td>Subtropical hot
(>4900°C)</td><td>Idem</td><td>Idem</td><td>Idem</td><td colspan="4">No</td></tr>
</table>

A comprehensive study of the composition and properties of soils was carried out on two soil catena. The first soil catena is located in the arid part of the Western Pamir on the Shugnan Ridge in the basin of the river Regista near Khorog, in the altitude range from 2000 to 4500 m. The second soil catena is located on the Darvaz Ridge in the arid-humid part of the Western Pamir, elevations from 1300 m near the village Kalaikhum to 3600 m in the Khaburabad Pass region.

The fractional composition of iron is determined in the soils of the river Vanch area developing in conditions of humidification from extra-arid (precipitation for the year consist 200-230 mm, Humidity coefficient (HC) = 0.11) to arid-humid (precipitation per year 1000-1500 mm, HC = 2.5).

The study of the key issues of the genesis and geographical location of the soil was carried out by comparing the average indicators of the composition and properties of different soil subtypes of shadow slopes, since on these slopes the vertical zone is more contrasting than on the sun slopes.

The influence of slope exposure on the genetic features of the soil is revealed by comparing the average composition and soil properties of the northern and southern slopes of the three vertical belts of the Darvaz Ridge (arid and arid-humid moistening).

Change of thermal conditions with altitude is the main factor of vertical zonality of soils. Vertical thermal belts are uninterrupted, but their upper boundaries are so much the higher than climate becomes more arid.
Within thermal belts humidity is the main factor of forming of different soil systems. Soils of shadow and sun slopes form independent, attended vertical rows of soils.
In the result, the list content of the soils focuses on description of laws of formation and spatial distribution of soils across this mountainous region, as well as problems of their classification and diagnosis.
Some new scientific positions about the genesis of soils in arid mountains of dry subtropical zone are established. It was revealed that the main soil-forming processes, under influence of which develop of all the soils of the Pamir are humus accumulation, glayization and leaching under the leadership of the humus-accumulative process.
It is showed the leading role of moisture and duration of the biologically active period in the formation of plant landscapes and soil types in all vertical zones as well as the important role of thermal regime in the soil formation of cold and very cold thermal zones that differ by fulvate composition of humus and red color of soils.
It was established a weak effect of the parent rock on genetic features of full formatted soils of any vertical zone in arid and sub-arid climate (the limiting factor - moisture) and its growing influence in the arid-humid conditions and moderate temperature regime.
Substantiated the differences in the structures of vertical belts of soils in different parts of the region associated with increasing aridity from east to west and from south to north; the schemes of soil-geographical zoning are given.
In addition, to better understand the patterns of spatial distribution of automorphic soils attached to the Pamir´s ridge, the structure of vertical belts of soils in South-Western, Central and Northern zone of Tajikistan.
The main genetic features of the arid soils of the Western Pamir are determined by a system of humus status. The direction and type of humus formation in soils depends on the amount of plant litter entering them and the hydrothermal conditions of its mineralization and humification. The lack of moisture limits biological processes in all mountains belts, low temperatures limit the productivity of vegetation, the activity of microorganisms and humus formation only in cold belts. The peculiarity of the process of humus formation in arid soils is the wide ratio of reserves of underground and above-ground mass of vegetation (60-100 cm) and the narrow ratio of reserves of humus and underground plant mass.
In the vertical soil-climatic zones, except for the cold ones, the following pattern is observed: the factors leading to an increase in the amount of humus in the soils, which determine its higher quality. In cold zones, soils have a homogeneous composition of humus (fulvate type), regardless of its total amount, since the formation of complex humic acids is limited by the lack of heat.
The humus reserves in the soils of the Western Pamir in the 0–100 cm layer vary from very low (less than 50 t/ha) in the soils of the extra-arid deserts (the amount of precipitation is 50-80 mm) to high (500-600 t/ha) in arid-humid soils of the high-grass meadow steppes of the moderately cold belt (the amount of precipitation is 1000-1500 mm).
The humus type of the soils of the Western Pamir is different: *fulvate, saturated with bases, enriched with nitrogen* - in the gray-pale desertic; *fulvate, slightly unsaturated iwith bases, medium-enriched with nitrogen* - in the reddish-brown soils of the cold and very cold belts; *humate-fulvatny, saturated with bases, medium-enriched with nitrogen* - in brown semi-desertic and gray-brown; *fulvate-humate saturated or slightly unsaturated with bases, medium-enriched with nitrogen* - in brown typical, brown steppe, dark brown xerophilous light forest and meadow-steppe; *humid, saturated with bases* - in black-brown xerophilic woodlands and black-brown meadow-steppe soils (Figures 1 and 2).
In all soils, except extra-arid ones, brown humic acids predominate in the humus composition, which indicates the widespread distribution of brown soil formation in the mountains in various forms of its manifestation.
A feature of all the soils of the region is the relatively low amount of absorbed bases, which varies from 4-5 mg-eq. in extra-arid gray-pale

desertic sandy-loamy to 15-25 mg-eq. in arid-humid dark brown and black-brown xerophilous light forests and meadow-steppe heavy loamy, which is associated with a low content of silty in the soils and, therefore, colloidal fractions.

The composition of absorbed bases is dominated by calcium and magnesium cations, and only in arid-humid soils of the temperate zones and in soils of the cold belt, a small amount of absorbed hydrogen appears (0.1-1 mg-eq.). Not only chemical, but also their physical properties of soils are associated with the genesis.

Fully developed soil slopes can be in equilibrium with the factors-soil formers only having certain physical properties that determine their stability in relation to the slope processes in specific hydrothermal conditions.

A significant impact on soil formation in the mountains of the Western Pamir has an exposure of the slopes. The soils of the shadow and solar slopes of the same altitude level differ among themselves at the level of the facies subtypes and form independent, interconnected rows of vertical zones.

The horology of the zonal types and subtypes of the soils of a region is determined by the hydrothermal conditions of their development. With the belt distribution of temperature regimes over the vertical profile of the mountains and the presence of a wide range of degrees of moisture within each thermal belt, the zonal fully developed soils of the Western Pamir are bio-axial organic-mineral systems, the level of organization of which is determined by the amount of heat and moisture entering in them. Each zonal soil type and subtype corresponds to a strictly defined of hydrothermal area.

The moisture of winter precipitation has an important role in soil formation in the Western Pamir: during the snowmelt in the soil profile it creates increased moisture and temporary leaching; contributes to the process of leaching of soil from easily soluble salts and carbonates; causes the manifestation of the process of iron-siallitisation; leads to the emergence in different soils of a hydrothermal regime similar in general during the period of biological activity, which determines the uniformity of their humus composition.

Strengthening the anthropogenic and technological impact on the soil cover of the Western Pamir leads to disruption of the established biosphere equilibrium and negative consequences.

Figure 1. Reddisch light brown cryodesertic or Cryo Regosol

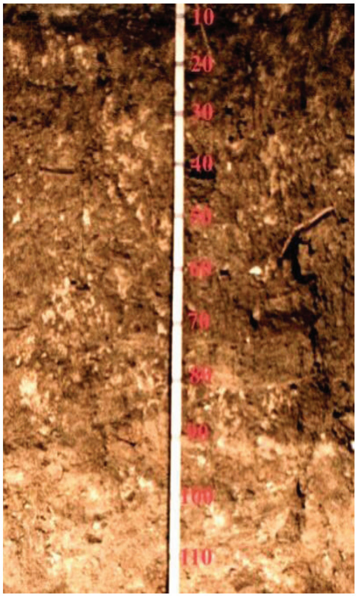

Figure 2. Reddisch dark brown steppe

Soil protection in the region should be considered as a single system of measures aimed at the protection, qualitative improvement and rational use of its land resources.

CONCLUSIONS

The main physico-geographical peculiarity of the Western Pamir is not only the combination of high-altitude and aridity, but also in the fact that in the general aridity of climate all vertical thermal belts are distinguished - from the subtropical to the very cold, and within most belts there is a very wide the range of humidification levels ranges from extra arid (80-100 mm of precipitation per year, hidrotermic coefficient less than 0.1) to arid-humid (800-1500 mm of precipitation per year, hidrotermic coefficient - 1-3). Such a variety of hydrothermal regimes in a limited area is unique and does not occur in any mountain system of the World.

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COMPARATIVE EVALUATION OF THE AGREGATIVE STRUCTURE OF ORDINARY CERNOZIOMS WITH DIFFERENT DEGREE OF EROSION FROM THE NEGREA VILLAGE

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Abstract

Soil is a limited means of production in space that cannot be multiplied as other means of production. The purpose of our research is to highlight the various aggregate particles of the ordinary chernozems in Negrea village, subject to the erosion process. Thus, we can appreciate the suitability of soils for different uses and recommend measures to mitigate the negative consequences. It is necessary to emphasize that any eroded soil is a result of a balance between the permanent process of pedogenesis and the process of its physical deterioration through erosion (Canarache, 1990; Cerbari, 2010; Kacinskii, 1958). The diversity of the natural conditions of solification and their interaction with the anthropic factors led to the formation on the researched territory of a soil with variable and complex character. A particular feature of the soil cover is the absolute predominance of ordinary chernozems in its structure (Kuznetova, 1979). The complexity of the soil cover structure, the diversity of the destructive influence of natural factors (Jigău et al., 2002; Jigău, 2008) the intensity of anthropogenic activity determined the widespread manifestation of land degradation processes in agricultural fields. According to dry curing data, the studied soils are characterized by favorable, predominantly satisfactory agronomic structure, and reduced hidrostability. Exceptions are made only by not eroded ordinary chernozems and mollic delluvial soil. Their structure, according to dry data, is appreciated as good and the hydrostability of their structure, according to wet milling data, is classified as satisfactory. The characteristic of the not eroded ordinary chernozem is the possibility of accumulation of comparatively large amounts of precipitation water as a positive factor contributing to the reduction of the soil erosion hazard (Cojocaru, 2016).

***Key words**: aggregative structure, ordinary chernozem, soil erosion process.*

INTRODUCTION

Aggregate soil condition is the most important condition for soil fulfillment of biosphere functions, including fertility, human health, implementation of major cycling phenomena in the biosphere (water, energy, gas, material cycles), biodiversity and many other soil functions.

Due to soil aggregate soil stability, it has the property of erosion resistance, mechanical agrotechnical influences, repackaging, dense waterproof horizons and other natural effects and anthropogenic phenomena.

Soil aggregates constituting a certain hierarchical level of soil must possess resistance to water impact, ie water resistance (or water resistance is an obsolete term) as well as resistance to mechanical influences in the form of resistance to normal or tangential pressure applied (pressure). The specific soil phenomenon, in the form of the aggregate soil structure, has always occupied and continues to occupy one of the main locations in the exploratory research of soil researchers, soil physicists and natural scientists in general.

The origin, formation, aggregate stability and processes of loss of aggregate structure, its degradation are the processes that directly affect the complex physicochemical and biological complex processes in the soil and, at the same time, have a real direction.

However, the generally accepted and comprehensive theory of forming an aggregate and, in addition, of structure management, has so far not existed. Until now, the mechanisms that determine such an important property of aggregates as water resistance are unclear.

Despite the fact that a large number of works (Antipov-Karatayev et al., 1948; Williams, 1936; Kaczynski, 1965; Voronin, 1984). Water resistance of aggregates with organic matter of the soil, its quantity and quality, is not yet a satisfactory hypothesis explaining the mechanisms of this link, and therefore the main purpose of this work was to study and quantitatively describe the water resistance processes and the resistance of soil aggregates to mechanical stress. , these were the objectives of the paper and the objectives.

Work on stability of aggregates under different natural conditions, conditions of formation in different types of soil formation (chernozem and types of soil formation), as well as the anthropogenic impact (the characteristic rotations of arable crops in the chernozem and forest soils gray).

Of great importance for modern agrophysics is the fight against physical degradation of soil. Habitat disorder under the influence of anthropogenic factors and, therefore, soil degradation in agroecosystems. Changes in environmental ecology lead to chemical physical, chemical and physical properties of the soil and, as a consequence, reduce fertility.

The restoration of degraded soils should include first the restoration of natural mechanisms causing sustainability of agroecosystems (Kuznetsova, 1990; 1999). Although the soil structure does not belong to factors that directly determine crop yield, it plays an important role in water and air mode, root growth, availability and activity of macrophage batteries.

The favorable structure for plant growth can be defined with regard to the presence of pores for water storage in the area, the pressures available for crops, pores for water and the air and pores in which the roots can grow (Oades, 1991).

The study of physical soil degradation processes (soil compaction, loss of water resistance, dust growth etc.) is an urgent scientific problem of agrophysics. Under the degradation of the physical state of the soil it refers to a constant change of physical properties, leading to deterioration of water, air, nutrients and other regimens.

Considering that most of the physical properties of soils are not independent quantities, but they are dependence on properties (eg humidity at moisture pressure, moisture penetration resistance etc.) or some distributions (pore size distribution, mass of elemental particles per diameter etc.), the analysis and the quantitative comparison of these dependencies (distribution) is difficult, especially if the experimental procedure for their determination leads to a variation of the values. The study of the soil cover structure can be considered as the theoretical basis for large-scale mapping of the soil. It provides a rationale for the concept of “map soil precision”, standards for the number of discounts per unit area, division of territory into complexity categories. For this type of evaluation and comparison, the approximation parameters of the experimental dependencies have recently been widely used (Poluektov et al., 2006; Shein et al., 2007).

Description of structural separation according to S.A. Zaharov classification, V.A. Kovda noted that the most valuable, which contributes to a favorable combination of properties that determine the optimal development of the soil biota and root system of plants and their level of productivity, are the granular, granular, granular and nutty structure, of higher horizons. It is characteristic of soils of chernozem, meadows and sludge. Instead, the quality of the structure depends on a combination of a complex of factors determined by the organisms that live in the soil, especially plants and micro-organisms.

Soil structure is an important component that affects physical properties and soil regimes (Roar, 1965; Bahtin, 1971; Panfilov, 1971; Karpachevski, 1999; Suyundukov, 2001; Tatarintsev et al., 2003).

Soil aggregates of between 10 and 0.25 mm are considered to be agronomically valuable: a granular form, resistant to water erosion. Less than 0.001 mm soil particles are not considered, they have a negative impact on the soil.

According to V.R. Williams, N.I. Savvinov, pieces with a diameter of 1 to 10 mm are considered the most valuable (Milanovsky et al., 1993). Soils with high content of water-resistant structures have an increased absorption capacity, while reducing energy costs for the work (Suyundukov, 2001).

- contributes to the optimal ratio of the solid, liquid and gaseous layers of the upper layer soil, favoring the development of the grass root system and the vital activity of soil biota; - water-resistant structural units reduce soil consistency, helping to save energy and resources in soil processing;
- structural soil is characterized by high water permeability, improving water absorption and

preventing surface leakage and soil washing; - optimal soil structure that ensures high porosity and high non-capillary friability, reduces water movement and evaporation, reduces moisture consumption and prevents the development of salinisation processes;
- in the structural soils, a positive air regime is created for the formation of roots, soil algae and microorganisms;
- water-resistant granular aggregates resist water deflation and erosion. The size and quality of soil structures depends on the soil particle ratio and properties (Voronin, 1986). Mechanical elements consisting of particles of different sizes represent the solid phase of the soil. Different ratios of granulometric components affect physico-physical, physicochemical, physico-mechanical properties and other properties (Braunack, 1989). The structural and aggregate state also determines the degree of soil erosion resistance (Cojocaru, 2016). So, according to. Khaziyev F. Kh. et al. (Kay et al., 1999) in the chernozem of average average water resistance of eroded aggregates from 5 to 24% less than in non-degraded soil. When it enriches the upper layers of soil with fresh organic matter, it becomes more resistant to wind erosion due to refilling of adhesives (Antipov-Karatayev et al., 1948). Kozlov V.P. (Kaurichev et al., 1972) found that the water resistance of a soil rich in colloids saturated with exchangeable calcium is much higher due to good aggregation. That is, the quality of the structure depends on the composition of the absorbent complex and the particle size distribution.
High carbonate content in structural aggregates leads to lower soil leakage resistance (Cerbari, 2010). Carbonates contribute to a significant decrease in soil cohesion, having a negative effect on the formation of large aggregates. The coalescence of powdered soil aggregates, calcium carbonates prevents the formation of a macrostructure (Canarache, 1990), whose quantity and quality determines soil erosion resistance (Canarache et al., 2005). The larger the aggregates in the valuable agronomic fraction, the greater their stability (Williams, 1936). The erosion resistance of the aggregates also depends on the genetic identity of the soil. So experiments have established that for the destruction of an aggregate size of 3-5 mm of gray forest soil requires an impact of 10-300 drops of water for the same chernozem soil aggregates - about 2,000. Machining, which affects its structural state, also determines erosion resistance. Thus, the most important property of the aggregates is their water resistance, which has a direct effect on erosion control, soil stability. Therefore, all factors that influence the formation of a solid structure act simultaneously as factors that determine the degree of soil resistance to erosion processes.
However, using this type of approach, the limits of its use, the scientific use of approximation parameters is a pressing scientific issue.

MATERIALS AND METHODS

The study of the physical properties of soils and structural aggregates was performed on the example of ordinarz chernozem in Negrea village.
The properties of selected soil samples were determined by classical soil methods. An aggregate analysis of the soil ("dry" and "wet") was performed. Aggregate (structural) analysis makes it possible to determine the relative content of aggregates in the soil, consisting of a mixture of different particles. During the analysis it is not recommended to grind and apply a vigorous rotation of the sites. This will lead to aggregate destruction and biased results.

Principle 1. *Determination of soil structural composition by dry sieving according to N.I. Savvinov.* From an agronomic point of view, the grain structure is granular with the size of aggregates of 0.25 to 10 mm, with porosity and water resistance. Such a structure determines the most favorable air-water regime of the soil. Determination of the soil's structural composition is the sifting of soil samples by means of a special set of sites with different holes in diameter. Such sites put each other together and quarrel the soil through all the sites at once.
Reagents and equipment: 1) a sieve column with a diameter of 10, 7, 5, 3, 2, 1, 0.5, 0.25 mm with a pallet; 2) cups of porcelain or aluminum; 3) technical-chemical balances.
Process of the paper. We take an average sample of 0.5-2.5 kg of a dry airless, dry air

sample. Carefully select pebbles, roots, and other inclusions. The medium sample in small portions (100-200 g) is sieved through a sieve column, avoiding vigorous stirring. The aggregates in the sieve are transferred into individual cups. Each fraction is weighed on the scales. When the webs are deactivated, each of them is struck slightly on the edge with the palm to release the blocked aggregates. When the entire average sample is sifted and distributed in fractions, each fraction is weighed at the analytical balance and its percentage is calculated. The results are written as a Table 1.

Principle 2. *Aggregate "wet sieving" analysis according to N.I. Savvinov*. Determining the number of water resistant units in the selected structural units. They are called water resistant units that resist water erosion.

Reagents and equipment: 1) a set of 5 sites with a diameter of 20 cm, height of 3 cm, with holes from top to bottom 3; 2; 1; 0.5; 0.25 mm, fixed with metal plates; 2) water tank; 3) a cylinder of one liter of water and a stopper; 4) clock glass; 5) large and small cups of porcelain; 6) water bath; 7) analytical balance.

Process of the paper: we make a sample of the soil from the fractured structural fractions. To do so, the number of structural units (in g) of each fraction (> 0.25 mm) weighed on the scale is equal to half the percentage of this fraction in the soil. Assembled sites are installed in a water tank so there is a 5-6 cm water layer above the top of the site. We run the sample into the drum and saturate it with water, which we lightly roll over the walls of the cylinder (we force the air from the ground). Leave the drum alone for 10 minutes, then fill with water. To completely remove the air, the cylinder is covered with a clock glass and sloped in a horizontal position, then positioned vertically. Then close the cylinder with a stop (ensure that there is no more air under it), turn it quickly with your head down.

We maintain this position until most of the aggregates decrease. Then rotate the cylinder and wait until the soil reaches the bottom. This is repeated ten times. At the last turn, we leave the cylinder up, transfer it to the site set, and sink it into the water over the top sieve. Under water, open the drum plug and, without breaking the water, gently distribute the soil on top of the top. Within one minute the cylinder is closed with a plug in the water and taken out. I'm sick of the soil under water: we raise the set of water from the site without exposing the remaining aggregates on the upper sieve with a quick movement, lowering it down. In this position, keep pressed for 2-3 seconds, then slowly and quickly. Agitate the sieve 10 times, then remove the upper set 2 and shake the smallest remaining water 5 times. Aggregates left on the site are washed with a stream of water in large porcelain cups and excess water in the cups is emptied. From the large cups, the aggregates are washed in pre-weighed small cups, then dried in a water bath to a dry air and weighed.

The mass of fractions, multiplied by 2, gives the percentage of aggregates with large volumes of water of a certain size. The percentage of aggregates <0.25 mm is determined by subtracting from 100 the percentage of the fractions obtained. The results of the determination of water resistance of soil aggregates are recorded in a table.

According to the aggregate analysis results, the structural coefficient (K) is calculated:

$$K = A/B.$$

where:

K is the structural coefficient;

A - sum of aggregates from 0.25 to 10 mm (aggregates of agronomic value);

B - sum of aggregates <0.25 mm and blocks> 10 mm, %.

According to the number of air dry and water resistant aggregates with an optimal size, Dolgov S.I. and Bahtin P.U. proposes the following scale for assessing the structural state of soil presented below.

Table 1. Scale for assessing the structural state of the soil

Aggregate content 0.25-10 mm, % from the dry soil to the air		Assessment of structural condition	
Dry sieving	Wet sieving	after the state of the soil	in points
> 80	> 70	excellent	5
80-60	70-55	good	4
60-40	55-40	satisfying	3
40-20	40-20	unsatisfactory	2
< 20	< 20	very unsatisfactory	1

The water resistance of the structure is the main factor determining soil erosion resistance. Soil disturbance of the balance of humic compounds and cations reduces the formation of water-resistant aggregates. According to Shein E.V. et al. (2001), low content of organic matter (less than 2%) in the soil generates small aggregates and at higher levels large aggregates of over 3 mm are formed. In soil destruction, the percentage of water erosion is 56%, wind - 28%, chemical degradation - 12% and physical - 4% (Lal, 1991).

The intensity of the erosion manifestation depends to a certain extent on the hydrothermal regime of the cold season, as well as the underlying soil properties (Vadyunina et al., 1986; Voronin, 1984, 1986).

RESULTS AND DISCUSSIONS

For agriculture, the soil should not only have a good structure but also a structure that will last for a long time, for example, the structure is of high quality and stability, water resistance and mechanical stability (Barlow et al., 2002). This author classifies the structure's stability in two main types: (a) the soil's ability to maintain its structure under the action of water; and (b) the wet soil's ability to maintain its structure under the influence of external stress mechanisms. The first type of structure stability is usually estimated using wet sieve techniques to determine cumulative water stability, as suggested (Kay et al., 1999; Milanovsky et al., 1993).

Structural stability under the influence of external loads can be determined in the compressibility of experiments (Oades et al., 1991) and the shear force (Gedroits, 1926). Further studies (Braunack et al., 1989) have shown that organic substances, consisting mainly of hydrophobic components, are more efficient and as long-lasting aggregation factors, compared to the hydrophilic components of root exudates or polysaccharides from plant tissues.

The territory of Negrea village is not an exception, which can be characterized as an area with an ecologically intense situation. The analysis of the aggregate structure of the ordinary chernozem on dry and wet sieving method is presented in Figures 1-7.

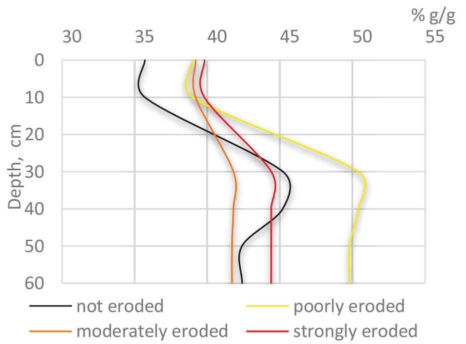

Figure 1. The structural composition of the aggregates > 10 mm (*dry sifting*)

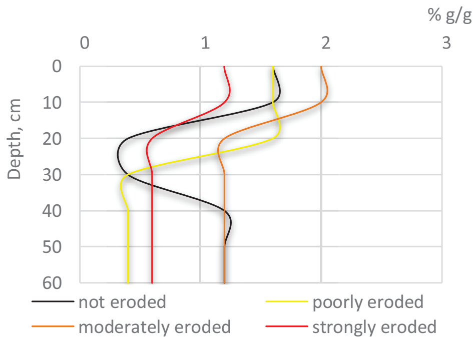

Figure 2. The structural composition of the aggregates < 0.25 mm (*dry sifting*)

A number of properties, such as contraction, swelling, penetration resistance etc., despite their name, imply the dependence of these moisture properties, ie the physical dependence of the soil (Shein, 2005). Quantifying and comparing these dependencies is difficult. Thus, numerous functions are known to approximate the main hydrophysical characteristics (OGH) and moisture conductivity function (Shein, 2005; Poluektov et al, 2006); tries to use functions of different types for the quantitative description of granulometric and microaggregate compositions (Shein, 2005; Berezin, 1983); aggregation shrinkage (Berezin, 1995) and a number of other soil properties.

However, the conditions for the competent application of this approach, the limits of use, the scientific use of approximation parameters is a pressing scientific issue.

In most cases, regression analysis is used to evaluate the relationship (Dmitriev, 1995). How is the response model regression analysis based on two components: deterministic, describing the dependence of the mean response on the explanatory variables (arguments or predictors) and the random component, describing the deviations of the observed response from this dependence.

The enormous loss of productive land due to various types of degradation (Lal, 1991), dehumidification (Klimentyev, 1997) dictates the necessity of conserving agri-food resources, including soils, to ensure food security (Berezin, 1983; Canarache, 1990; Kay, 1990; Kaurichev et al., 1972; Milanovsky et al., 1993).

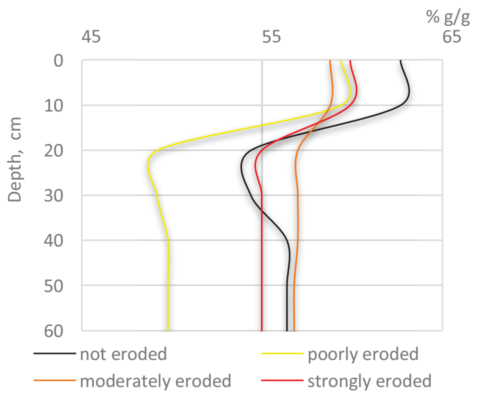

Figure 3. The structural composition of the aggregates sum 10 - 0.25 mm (*dry sifting*)

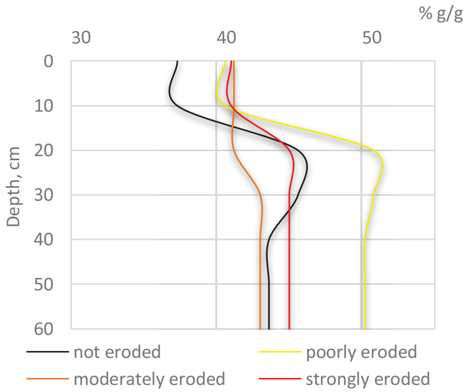

Figure 4. The structural composition of the aggregates sum > 10 - < 0.25 mm (*dry sifting*)

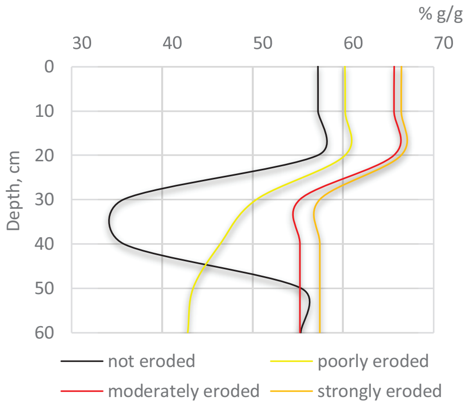

Figure 5. The structural composition of the aggregates < 0.25 mm (*wet sifting*)

The main factors that cause the degradation of the soil cover in the Republic of Moldova are dehumidification and destruction of the structure, repackaging due to intensive use of arable land and meadows because of the erosion process.

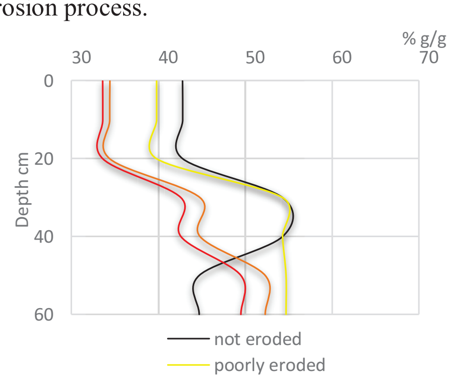

Figure 6. The structural composition of the aggregates sum 10 - 0.25 mm (*wet sifting*)

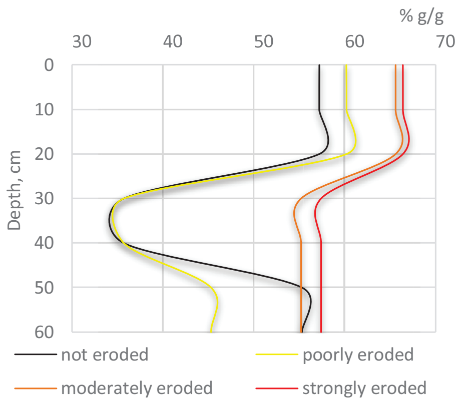

Figure 7. The structural composition of the aggregates sum > 10 - < 0.25 mm (wet sifting)

The reason for this is a significant deterioration of the agroecosystem of the territory, mainly represented by agricultural land, which for a long time has been exposed to an excessive anthropogenic impact due to the high degree of development of the land.

Increased anthropogenic stress can lead to deterioration of agrophysical properties and disruption of the soil profile, which is considered as soil physical degradation (Shcherbakov, 2000; Shein, 2005). Under these conditions, soil conservation becomes the most important task of agroecology, for which it is necessary to protect it from the development of degradation processes, as well as the creation of a balanced ratio between mineral nutrients and organic matter (Dmitriev, 1995; Kachinsky, 1958; Kuznetsova, 1979; 1998; Jigău, 2008). Of all the factors, the most damaging effects on the soil are erosion processes, which can lead to a high degree of physical degradation - the complete destruction of the soil as a natural object.

This situation is observed (Figures 1-7) and in our case, according to the results obtained in Negrea village. Chernozems are unique natural formations characterized by high fertility and are therefore almost always shown and are actively used for agricultural crops. At the same time, there are various processes in soils, usually associated with the deterioration of chernozem soil structure, compaction, disaggregation and other processes called physical degradation of soil during agricultural development.

It should be noted that there are significant differences in study objects, both in morphology and in physical properties (aggregate structure). The structure of the upper part of the arable layer is quite typical for the not eroded ordinary chernozem (Figure 1) - generally it can be characterized as a granular arable layer being dust. The data on dry and wet sieve aggregate analysis (using the Savvinov method) reveals an accentuated difference in the water content of the structure of the investigated aggregates in Negrea village (Cojocaru, 2016). If the majority of the units are not water resistant and the percentage of impermeable units > 0.25 mm, the structure refers to “satisfactory” or “good”, then for the common chernozem with different degrees of erosion the percentage of units that does not resist water is insignificant. The analysis of the soil's structural condition makes it possible to observe that for a typical area of Central Moldova with unordered chernozems, the amount of valuable agronomic aggregates varies from 71.56% to 68.34%, with a maximum content of 71.56% of this fraction in a layer of 10-20 cm, and those with different degrees of erosion the first third of the soil profile decreases, together with a relative increase in the content of compacted aggregates. On the eroded lands there was a decrease in the value of the agronomic aggregates (55.98%-59.78%) compared to the area of the non - eradicated ones.

CONCLUSIONS

The main factors that cause the degradation of the soil cover in the Republic of Moldova are dehumidification and destruction of the structure, repackaging due to intensive use of arable land and meadows because of the erosion process.

For agriculture, the soil should not only have a good structure but also a structure that will last for a long time, for example, the structure is of high quality and stability, water resistance and mechanical stability

The territory of Negrea village is not an exception, which can be characterized as an area with an ecologically intense situation. The analysis of the aggregate structure of the ordinary chernozem on dry and wet sieving method.

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THE CHARACTERISATION OF FOREST SOILS FROM IALOMIȚA COUNTY

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Abstract

Forests occupy approximately 27% of Romania's total surface. Forest soils from Ialomița County were characterized based on a large number of soil analysis obtained during the last 26 years (namely 127 soil profiles and 335 pedogenetic horizons). These soils are characteristic to the field area from the silvosteppe areal and have developed under a humid regime (phaeozem, chernozem, preluvisol, luvisol, fluvisol). Chernozem and cambic phaeozem have a weak alkaline reaction and a B cambic horizon (Bv) resulted from the clay's concentration, while carbonates are concentrated in depth. Fluvisols have a large development in the Danube's meadow, especially in its affluent, namely Ialomiţa River's meadow. The parental material is represented by sands, clay sands and slime. Furthermore, organic matter in humification progress is also present. Luvisols and preluvisols are moderately acid soils in the Ao and Bt horizons, mesobasic in Ao and Bt and with a high cationic exchange capacity. They are also moderately humiferous, well supplied with nitrogen and with a good cationic exchange capacity.

Key words*: forest soil, phaeozems, soil properties, Ialomița County.*

INTRODUCTION

There are numerous definitions for the term "soil", but not one that is generally accepted. As such, Hilgard (1914), defines soil as a more or less mellow and friable material from which plants, through their roots, are extracting food and which ensures growth conditions for plants. This definition is only one from the many definitions that consider soil as a mean of vegetal production. Soil is a product of several factors: the influence of climate, relief, organisms, and the soil's parent materials interacting over time.
Forest soils are regarded as the main element of the forest sites, being a strong correlation between the types of the forests and their productivity with the types of the soils. In this regard, the concept of the zonality of the soils was introduced one century ago in Romania by Gheorghe Murgoci (Stănilă, 2016).
Moreover, in order to have a clear classification of the soils across Romania, three soil classification systems were developed in our country during the last four decades, namely SRCS-1980 (valid for the timeframe 1980-2002), SRTS-2003 (used in the timeframe 2003-2012) and SRTS-2012, in use starting from 2013 (Ţărău et al., 2012; Vlad et al., 2015). Based on data from the National Statistical Institute, the forest area from Ialomița Forest District occupies a surface of 26208 ha in 2015 (www.insse.ro). The surface of state forests administered by Romsilva National Forest Administration through its three Forest Districts (Slobozia, Urziceni, Fetești) is of 22233 ha www.rosilva.ro).
The purpose of the present paper is to describe and present the characteristics of soil types identified in Ialomița Forest County.

MATERIALS AND METHODS

Ialomița County is located in the eastern part of the Romanian Plain, being also situated on the lower reach of the Ialomița River. It is bordered by Brăila, Buzău, Prahova, Ilfov, Călărași and Constanța counties (Figure 1).
Soil samples gathered in the period 1989-2015 from three Forest Districts from IalomițaCounty Forest Administration were analyzed for the present paper.

Figure 1. Geographical localisation of Ialomița County within Romania source

A silvicultural management plan is realized for each forest district once every 10 years. As such, the analyzed properties were: pH, humus content, nitrogen content, carbonates content, the basis exchange capacity (SB), hydrogen exchange capacity (SH), total cationic exchange capacity (T), base saturation degree (V) and texture. All these analysis are centralized in the analysis bulletins of each forest district and are part of an extended national database realized by INCDS „Marin Drăcea", based on forest management plans. The methods used in the analysis of soil samples are accredited national and international methods (Dincă et al., 2012; Edu et al., 2013).

The present paper is based on the analyses realized for 127 soil profiles and 335 pedo-genetical horizons.

RESULTS AND DISCUSSIONS

Types of soil from Ialomița County

The most widespread types of soils are the ones from Cernisols class that occupy 71% of the soils from this County, followed by Luvisols class with 20% and Protisols class with 12%. As types of soils, the most widespread is phaeozems (50%), followed by chernozems (21%), fluvisols (aluvisols) (12%), preluvisols (10%) and luvisols (5%) (Figure 2). Other types of soils (solonchaks and vertisols) represent 2% of the region's total forest soils.

At a national level, dystric cambisols occupies the 1st place as spread in forest soils (2292385 ha, meaning 35%), luvisols the 2nd place (1440052 ha, meaning 22%), eutric cambisols occupies the 3rd place (with a total area of 869909 ha, meaning 13%), while preluvisols the 5th place (335050 ha, meaning 5%) (Dincă et al., 2014).

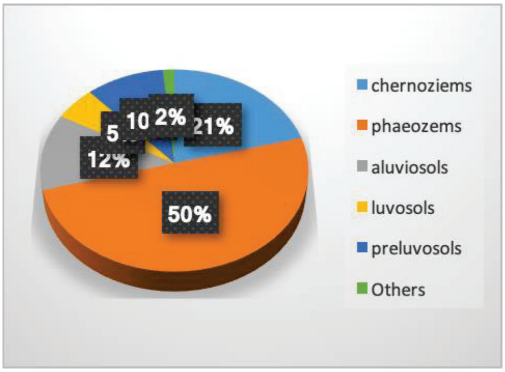

Figure 2. The predominance of forest soils identified in Ialomita County

In Balta Borcea impounded compound, the main soil types are fluvisols and gleysols (Mihalache et al., 2009). Chernozems is the agricultural soil characteristic for the analysed area (Gherghina et al., 2010).

Soil solution reaction

The soil's solution reaction (pH) was calculated differentially on pedogenetic horizons for the most widespread types of soils (Figure 3).

Fluvisols has an average pH of 8.05 in the Ao horizon and 8.18 in C, being a moderately alkaline soil, while chernozems registers 7.81 in Ao and 8.37 in A/C, being a moderately alkaline soil (with the highest values). Phaeozems has an average pH in the Am horizon of 7.92 and 8.12 in the C horizon, while luvisols registers 6.36 in Ao, 5.42 in El and 6.42 in Bt - moderately acid. However, preluvisols is a moderately acid soil in the Ao horizon (pH = 6.34) and Bt (pH = 6.46).

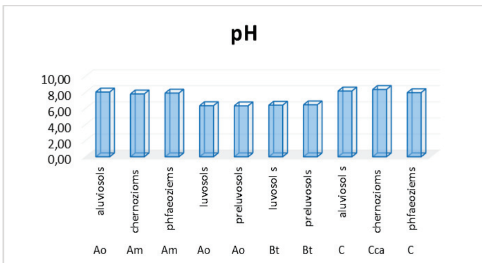

Figure 3. pH variations for the most widespread forest soils from Ialomița Country

In Giurgiu County, phaeozems has an average pH of 6.9 in the Am horizon and 7.35 in the A/C horizon, while chernozems reaches 7.53 in the Am horizon and 8.12 in the A/C horizon (Crişan et al., 2017a).

Soil base saturation

The degree of base saturation is one of the soil's most important chemical indicators, that is strongly correlated with the soil's reaction (Spârchez et al., 2011; Târziu et al., 2004). The values of this indicator are determined either by calculation in the case of acid soils - as a percentage report between the content of exchangeable basis (SB, me/100 g soil, determined through the Kappen method) and the total cationic exchange capacity (T = SB + A), or by determining T_{Na} (Bower method), in the case of alkaline soils.

Based on these parameter, luvisols and preluvisols are eubasic soils (Figure 4).

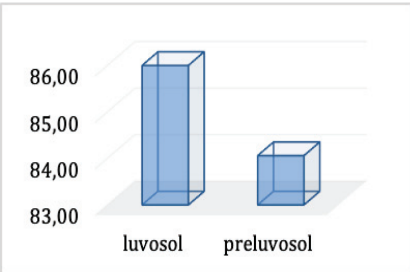

Figure 4. Base saturation degree variation for the most widespread soils from Ialomita County

In Arad County, forest soils (chernozems, luvisols and preluvisols) are also eubasic (Cântar & Dincă, 2018).

The total cation exchange capacity

The total cation exchange capacity (T) was determined through the Bower method and was calculated for each type of soil as an average profile value (Table 1).

Table 1. Total cation exchange capacity and average humus and nitrogen content for forest soils from Ialomiţa County

Fluvisols	Chernozems	Luvisols	Preluvisols	Phaeozems
Total average cation exchange capacity per type of soil (T, me/100 g soil)				
-	-	24.08	25.42	-
Average humus content (%)				
1.99	2.23	4.05	3.40	2.11
Average nitrogen content (%)				
0.10	0.11	0.21	0.17	0.11

For Timiş County, forest fluvisols have a T of 34.5, while luvisols records a value of 23.0 and preluvisols 23.3 (Crişan et al., 2017b).

Humus

The humus content (H, %) was determined through humid oxidation (the Walkley - Black method) for each type of identified soil from the A horizon (Table 1, Figure 5). Fluvisols, phaeozems and chernozems are moderately humiferous soils, while luvisols and preluvisols are humiferous soils. The quantities of humus from this county are similar with the average values calculated for forest soils for the entire country (Dincă et al., 2012). The average humus quantities recorded here are similar with the ones recorded for the entire Romanian Plain (Stănilă et al., 2014).

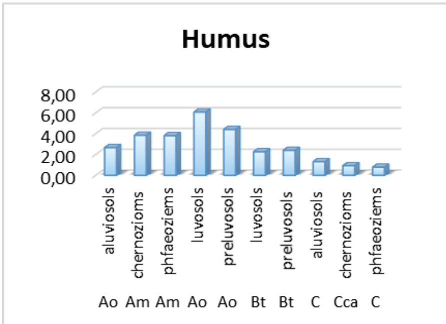

Figure 5. The variation of humus content for the most widespread forest soils from Ialomiţa County

Nitrogen

As in the case of the humus content, the nitrogen was also calculated only for the first horizon as both elements are accumulated through the decomposition of organic matter at the surface and in the first centimeters of the soil's profile.

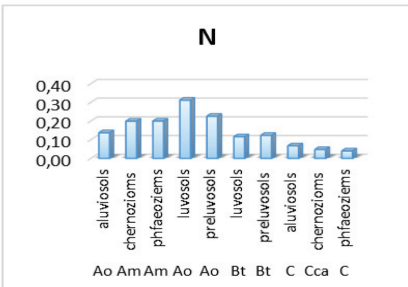

Figure 6. The variation of nitrogen content for the most widespread forest soils from Ialomiţa County

The lowest quantity of nitrogen was found for fluvisols and phaeozems, which are a well-supplied soil with nitrogen, while all the other soil types were very well supplied with nitrogen.

Carbonate content

The content of hardly soluble carbonates is determined in soils with a pH greater than 7, influencing the pH of soils and originating from parental rocks or deposited from groundwater.

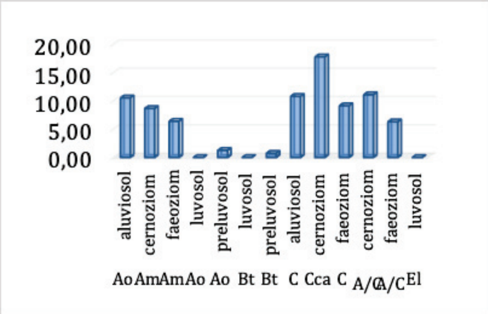

Figure 7. Carbonate content variation for the most widespread forest soils from Ialomița Country

The highest content of carbonates was contained by chernozems, in the Cca horizon (17.79%), while the smallest quantity was observed for preluvisols in Bt (0.75%).

CONCLUSIONS

The majority of the forest soils across Ialomița County belong to Cernisols and Luvisols classes. The most representative forest soils were phaeozems and chernozems, followed by fluvisols, preluvisols and luvisols.

Fluvisols, phaeozems and chernozems are moderately humiferous soils, while luvisols and preluvisols are humiferous soils.

The forest soils from this county are alkaline, from the ones that registered a great pH value (fluvisols, chernozems and phaeozems), to the moderately acid ones (luvisols and preluvisols).

In regard with the base saturation values, the forest soils were eubasic (luvisols and preluvisols).

The soils vary from moderately humiferous (fluvisols, phaeozems and chernozems) to humiferous (luvisols and preluvisols).

The lowest quantity of nitrogen was found for fluvisols and phaeozems, which are a type of soil well-supplied with nitrogen, while all the other soil types were very well supplied with this element.

The content of carbonate is highest in chernozems and smallest in preluvisols.

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ASSESSMENT OF SOIL NUTRIENTS AVAILABILITY OF AN EXPERIMENTAL FIELD USED IN ORGANIC VEGETABLE CROPS FROM BUZĂU COUNTY, ROMANIA

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Abstract

Macro and micronutrients status of soil is very important not only for plant grows and development (function of plant enzymes and biochemical processes and integrity of plant cells) but is also an indicator for soil fertility. Deficiency of nutrients in soil can lead to the crop yield reductions, while the excess can affect the plant quality and health. In this context, the aim of the study was to evaluate the macro and microelements (Na, Mg, K, Ca, Fe and Se) content in an organic experimental field from Buzău region, using ICP-MS method. The results reveal positive correlation between nutrients content and soil profile. Soil nutrient availability has a significant impact on organic crop production.

***Key words**: ICP-MS, macronutrients, micronutrients, soil availability, soil fertility.*

INTRODUCTION

The chemical composition of plants reflects their requirements for environmental factors.
Carbon, hydrogen and oxygen represent over 90% from plant composition, being taken by plants from the atmosphere and water.
The rest of the elements are taken by the plants from the soil, as follows: 4.4% - the sum - N, P, S and K; 2.7% of the Na, Ca, Mg, Cl and 0.2-0.3% sum of microelements (Fe, Mn, Cu, Zn, B, Mo etc.).
Ca, Mg, K, Na, Cl in plants, participate in specific reactions related to enzyme formation and activation, which regulates the osmotic cell pressure, sweating, carbohydrate circulation and translocation. They participate in the synthesis of organic compounds (chlorophyll, carbohydrates, and proteins).
Fe, Cu, Mn are the important constituents of enzymes, participating in their formation and activation. They play a role in the resistance of plants to unfavourable conditions and in the formation of vitamins, pigments.
Zn and Mo are part of the organic complexes, chelates and regulators of oxidoreduction process in plants.
Plants can be found in the following states with nutrients: poor, normal, abundant, excess, and toxic), depending on the level of soil nutrition, physical and chemical properties, and climatic conditions.
In neutral and alkaline soils the permanent load is compensated by basic cations (Ca^{2+}, Mg^{2+}) (Lacatusu, 2016).
Very important for plants is the amount of essential nutrients in the soil, supply of soil with nutrients. It is a close link between the amounts of nutrients available to the plant (Florea, 2008).
Rich nutrient conditions reveal that vegetation grown in fertile soil can be more efficient in sequestering carbon, thereby combating greenhouse gas effects and global warming (Zhang et al., 2019).
The upward transport of nutrients by plants depends not just on the ratios of uptake to availability for each nutrient, but also on aboveground allocation (the greater the aboveground allocation by plants, the faster the upward transport).
Rooting depth could determine the total pool of nutrients subject to upward transport by plants, with pools below the maximum rooting depth

being relatively undepleted (Jobbagy et al., 2001)

There are strong relationships between soil physical properties and soil chemical properties. The nutrients held by the soil in this manner are called "exchangeable cations" and can be displaced or exchanged only by other cations that take their place. Soils with high cation exchange capacity (CEC) not only hold more nutrients, they are better able to buffer or avoid rapid changes in the soil solution levels of these nutrients.

For plant growth, most soil scientists agree that 50% pore space, 45% mineral matter, and 5% organic matter make up an ideal ratio.

Soils properties vary with the soil depth. Top soil is usually more fertile than the other layers and has the greatest concentration of plant roots. How much and when to apply fertilizers should be based on observing plant performance, a reliable soil test, and an understanding of the factors that affect growth: light, water, temperature, pests, and nutrition

The accumulation of extractable N, P, and exchangeable K, and the depletion of exchangeable Ca^{2+}, Mg^{2+}, and Na^{+} found under shrub canopies in arid ecosystems was determined also shown by Schlesinger et al. (1996) and Jobbagy et al. (2001).

For efficient fertilizer use and the resultant reduction of their loading on the environment, precise evaluation of nutrient availability and a better understanding of the nutrient dynamics in soil, which is primarily mediated by microorganisms, would be indispensable. Microorganisms can be highly responsive to nutrient availability (Fujita et al., 2019).

The soil content in different elements influence also the soil life evolution. Soil potassium content positively influence the abundance of soil fungi, either saprotrophic or ectomycorrhizal, as well as the presence of soil bacteria (Koorem et al., 2014).

The current research paper presents the soil nutrients analysis of the organic research field of the Vegetable Research and Development Station Buzău, offering valuable insights for further research studies on vegetables crop technologies. It also came into the help of farmers located in this famous vegetable basin, offering practical information about the fertilisation plan they should consider.

MATERIALS AND METHODS

The experiment was conducted in the organic research plot from Vegetable Research and Development Station Buzău, România (lat.:45.16108714 N and long: 26.82423914 E, alt: 92 m), in 2018. The soil belongs to the soil class of Calcaric alluvial soils, usually found on fluvial deposits (Mușat et al., 2018). The ground water is lower than 3 m.

Three soil surveys were taken up to a depth of 125 cm, with soil samples collected in plastic bags, than dried in the laboratory and milled.

The nutrients content analysis were made in the Research Centre for Study of Food and Agricultural Products Quality, University of Agronomic Sciences and Veterinary Medicine of Bucharest. For soil samples preparation (mineralization by microwave digestion) and quantification at ICP-MS (with MassHunter Workstation software), was followed the protocols used by Dobrin et al., 2018. The calibration curve was made with ICP-MS multi-element calibration standard that contain the following concentrations of the elements: 1000 µg/ml of Ca, Fe, K, Na and 10 µg/ml of Fe and Se in 5% HNO_3 (Yamanaka K. et al., 2014; Wilbur S. et al., 2015).

RESULTS AND DISCUSSIONS

The highest content of Mg (Figure 1) was found in 40-60 cm soil profile, like Fe and Se content (Figures 4, 5).

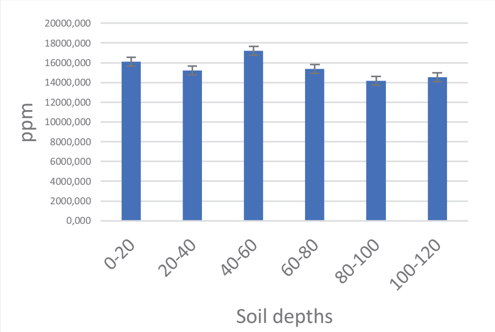

Figure 1. Magnesium content in soil profiles

Potassium it is an important macroelement that helps plants overcome drought stress, improves winter hardiness, increases disease resistance, improves the rigidity of stalks.

It was find the highest content in 0-20 cm soil profile, having decrees to 100-120 cm soil profiles (Figure 2).

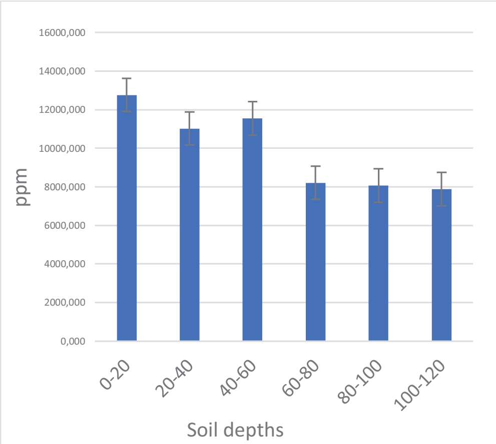

Figure 2. Potassium content in soil profiles

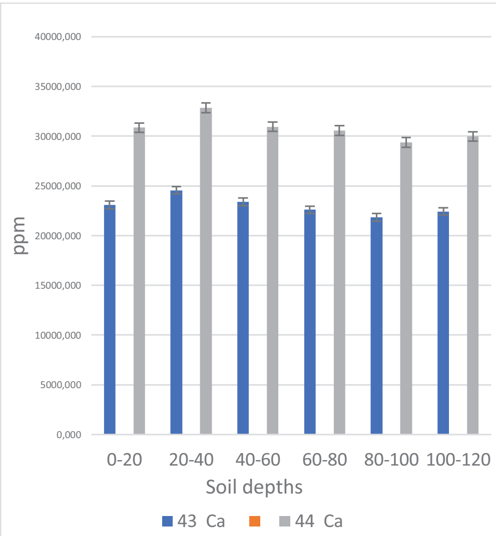

Figure 3. Calcium content in soil profiles (different isotopes)

The highest content of Ca was found in 20-40 cm soil profile (Figure 3).

Calcium it is an important macroelement, helps to bind organic and inorganic substances.

It is important in the development of a good soil structure, and for plants represent an important structural component of cells, present in cell walls, essential for growth of shoot and root tips

Microelements content

Iron it is a relatively immobile microelement being very important for the maintenance of chlorophyll.

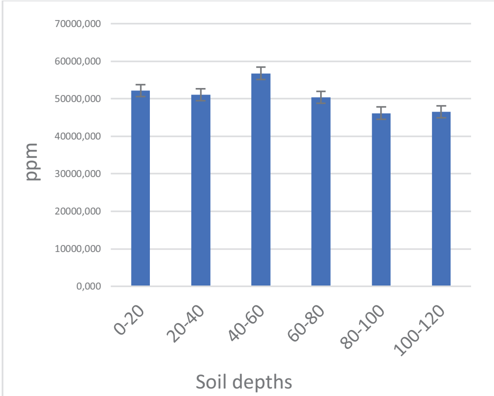

Figure 4. Iron content in soil profiles

As iron, selenium content, for its three isotopes (Figure 5), had the highest content for the 40-60 cm depth.

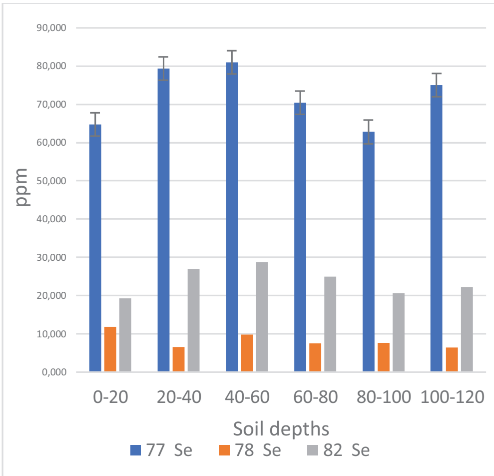

Figure 5. Selenium content in soil profiles (different isotopes)

It was find a very strong positive relationship between Na-K content (r = 0.947), Mg-Fe (r = 0.980). A strong correlation between Mg-K (r = 0.759), Na-Se (r = 0.782), K-Fe(r = 0.766), K-Se (r = 0.749) (Table 1).

It was find also a very strong positive relationship between all the soil profiles regarding nutrients composition (r = 0.998) (Table 2).

Table 1. Correlation between soil profile and nutrients content

Soil profile	*0-20*	*20-40*	*40-60*	*60-80*	*80-100*	*100-120*
0-20	1					
20-40	0.998	1				
40-60	0.998	0.995	1			
60-80	0.996	0.998	0.997	1		
80-100	0.996	0.9992	0.995	0.9995	1	
100-120	0.995	0.998	0.994	0.9993	0.999	1

Table 2. Correlation between macro and microelements content and soil profile

	23 Na	*24 Mg*	*39 K*	*43 Ca*	*44 Ca*	*56 Fe*	*77 Se*	*78 Se*	*82 Se*
23 Na	1								
24 Mg	0.592	1							
39 K	0.947	0.759	1						
43 Ca	0.523	0.455	0.656	1					
44 Ca	0.477	0.365	0.590	0.985	1				
56 Fe	0.561	0.980	0.766	0.577	0.497	1			
77 Se	-0.017	0.436	0.197	0.680	0.608	0.515	1		
78 Se	0.782	0.682	0.749	0.012	-0.049	0.585	-0.310	1	
82 Se	-0.144	0.494	0.146	0.615	0.576	0.614	0.884	-0.276	1

CONCLUSIONS

The results reveal positive correlation between nutrients content and soil profile. Soil nutrient availability has a significant impact on organic crop production. It was found that experimental field from Buzau have a very important content both in macro and microelements.

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SUSTAINABILITY MODELS OF FORMATION PROCESS AND ACCUMULATION OF HUMUS IN CONDITIONS OF ADAPTIVE - LANDSCAPE - AMELIORATIVE AGRICULTURAL BIOTECHNOLOGY

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Abstract

Arable chernozems in the Carpatho-Danubian-Pontic space have entered in a new natural-anthropogenic evolutionary phase caused by the reduction to the minimum of formation process and humus accumulation in their evolution, reflected in the degradation of function and physical regimes. Reducing its role is caused by unidirectional modification, the biotic and abiotic factors responsible for the formation process and accumulation of humus, hydrothermal and aerodynamic regimes, reduction of bioenergetic resources, quantitative reduction and qualitative degradation of soil biota, reduction of biological nitrogen reserves in the soil. Restoring its priority role in the evolution of chernozems requires unidirectional optimization of specified factors. Our research during the period 2010-2018 showed that to achieve this objective more indicative are adaptive - landscape - ameliorative agrobiotechnologies and the main component are: use of tillage systems selected according to physical state of soils, restoration of soil biota through the systematic administration of biohumic products in soils.

Key words*: arable chernozems, formation process, humus accumulation.*

INTRODUCTION

In the chernozems pedogenesis the place and role of formation process and humus accumulation are determined by its functions in genesis, evolution and reproduction of chernozems and natural fertilizers:
- **ensuring** and reproduction of trophic chains of all soil microorganisms responsible for the realization of the whole chains of hierarchical process of decomposition - transformation and organic substances synthesis;
- **quantitative interaction** - balanced of the carbon circuits and nitrogen and their sequestration in humic substances;
- **ensuring the carbon** and nitrogen circuit content within the soil system - biotic components of landscape;
- **ensuring biogeochemical** circuits of biophile elements;
- **ensuring structural** - functional organization processes of soil ecosystem;
- **current evolution** stage of natural - anthropic pedogenesis in the Carpathian-Danubian-Pontic space is characterized by unidirectional reduction of soil biogenesis as result of humus formation process in the evolution of soils and their natural fertility.

The main causes of reducing the priority role of formation process of humus are:
- **disturbance**, anthropic degradation of pedofuctional framework (pedofunctional regimes) in continuation of humus formation process;
- **low energy** quality and a small variety of humus sources;
- **deficiency** of necessary biological nitrogen to carry out the process of humus formation;
- **accelerated** intensity of organic decomposition processes (in the absence of detrital humiferous) with the “antropised” humus formation less polymerized and condensed;
- **stressing** state of soil biota as result of “chaotic” dynamics of the component quantities and in terms of organic residues storage;
- **considerable reduction** of microbial biomass in soil from 28-30 kg to 1-2 t/ha as renewable active humus source;
- **spatial incoherence** of deposition area of organic residues and the one with optimal

conditions for carrying out humus forming processes due to the intensive degradation of arable layer;
- enhancement of mineralization processes of humic substances as a result of soil work and increase of aeration degree;
- decomposition and humus biodegradation as result of intensification of toxigenic microflora activity.
Under these conditions the trend of humus state of arable chernozems in the region implies two parameters: a) critical content, b) minimum permissible content. Critical content - content under which functional features (including agronomic) deteriorate and soil resistance at agrogen pressures and makes up 4%.
Minimum permissible content - content (2.5-3%) under which the positioning parameters and structural - aggregate, the volume and structure of porous space are valuable which are insignificantly different from those characterized by the parental rocks.
In condition where the humus content is reduced below the critical content in soils, the process of over - cultivation is established, and it presents values below the minimum allowable values in soils is established aridization - functional desertification.
According to the latest calculation 7.4-8.6% of arable chernozems in the Republic of Moldova is characterized by humus content 4-5% and is 17.7-18.2%. Prevailing soils with moderate humus content (3-4%) which makes up 42%. Only 1.4 of arable chernozems contains more than 5% humus.
Thus, more than 80% of the arable soils in Moldova are subjected to over - cultivation and about 38% carry the features of aridization - functional desertification and requires adaptive - landscape - ameliorative systematic action in order to restore the priority role of formation process and humus accumulation. This paper is dedicated to assessing the trend evolution of soils humus state within agrobiotechnology models adapted to the specific condition of agrolandscape.

MATERIALS AND METHODS

The research was conducted during 2010 - 2018 in the southern part of Moldova in SA "AXEDUM" SRL. Soils within the agricultural holding SA "AXEDUM" SRL are represented by typical low humus chernozems with Aar - AB - Bca - Cca formed on clay loamy with loessidal features. Effervescence is attested in the AB horizon and the illuvial carbonated horizon in the depth at range 97-113 cm. Based on soil prospecting 4 lands were selected with an area between 47-62 hectares.
Field activities included annual harvesting on soil samples of 30 individual samples from elementary plots with area 10-12 ha (depending on the geomorphological conditions). From the samples collected an average sample with a mass of 3.0-3.5 kg was formed.
The humus content was determined by TINAO methods in 5 repetitions. Depending on the state of soil and landscape conditions there were developed and implemented 4 models of adaptive - landscape - ameliorative agrobiotechnologies:

1. Traditional - plowing with alternation of depth performing works for incorporation of organic residues in the rotation of 4 crops (peas - wheat - sunflower - corn).
2. Agrophytotechnical - based on ensuring the presence of fresh organic matter in soils and an optimal hydrothermal and biochemical medium for the humification process. Perspective are the models that include practicing the occupied field that involves cultivation of vetch, facelia, yellow mustard with their incorporation into the soil in the flowering phase.
3. Resource conservative - restoration and bioenergetics support of soil microbiocenosis and intensification of carbon sequestration processes by structural - aggregation of soil substance. According to more recent research in this respect are based agrobiotechnologies on the practice of green field and application of soil algae processes with the nitrogen sequestrated algae species, gen. Nostoc, Anabaena, Cylindrospermum (Jigau et al., 2018a; 2018b).
4. Resource productive - based on bioenergetics restoration and support of soil microbiota responsible for ensuring the whole decomposition chain - transformation - humification of organic matter by administration of biohumic preparations.

RESULTS AND DISCUSSIONS

Starting from results of previous research (Jigau et al., 2017; Jigau et al., 2018) present paper follow a line of investigation that includes two distinct components:

a) Evaluation of biohumic substances in the perspective of promoting resource productive models and resource productive adaptive - landscape - ameliorative biotechnologies;

b) Evaluation of development trend of humus state of arable chernozems within adaptive - landscape - ameliorative agrobiotechnology models.

In the last 15-20 years biohumic preparations have gains a wide spread on the agricultural market in Moldova. Most of these are of native origin and are obtained in well - known biotechnology worms composting.

In contrast to these of biohumus production technology in SA "AXEDUM" SRL the natural model of humification process, including insurance, is taken and supporting processes of decomposition - transformation - humification of organic substances and provides for the production of two solid, liquid and biohumic substances. According to our calculations on 1 t of organic waste from the poultry factory within this biotechnology of 600 kg humic organic matter is obtained, which contains on average 53.4% organic substances and 46.6 mineral substances (Table 1).

Table 1. Content of macro- and microelements in biohumus (solid fraction) (data belongs to SA "AXEDUM" SRL)

Parameters	Units of Measure	Organic substances content
pH		7.8
Mineral substances content	%	46.6
Organic substances content		53.4
Total nitrogen content		1.55
Total phosphorus content		1.70
Total potassium content		1.85
N - NO_3 content	mg/kg	1071
Total calcium content		380
Total magnesium content		264
Mobile copper content		2.05
Mobile zinc content		7.6
Mobile manganese content		9.30
Mobile iron content		5.30

Organic content in biohumus is 6-8 times higher in compost. At the same time, the biohumus, is richer in nitrogen, phosphorus and total potassium. Biohumus is a good source of microelements (Zn, Cu, Mn), but also calcium. The content of the last one is sufficient to compensate the amount of calcium alienated with crops. We also draw attention to the increased magnesium and iron content which are responsible for the production of chlorophyll and photosynthesis. In contrast to compost biohumus is a biologically active substance, one gram of biohumus contains up to 20 meridic colonies of microogranisms responsible for the humification of organic substances. This allows us to consider that under the presence of fresh organic matter the biohumus in the soil contributes to the restoration of soil microbiota that provides the humification process and the priority role of the formation process of humus in the development of agrogen chernozems. Liquid biohumic substances represent a specific group substances bioroutinist organic - mineral (Tables 2, 3).

Table 2. Microbiological composition of liquids biohumic substances (data belongs to SA "AXEDUM" SRL)

Parameters	Native solution	Extract with solution 0.1 N KOH
Total number of microorganisms, thousands	5969	6660
Bacteria that decompose organic substances easily accessible, thousands	2227	2459
Bacteria that decompose organic substances hardly accessible, thousands	970	702
Total number of microorganisms that assimilate mineral substances, thousands	2390	2426
Actinomycetes, thousands	654	504
Micromycetes, thousands	146	151

Table 3. Content of macro- and microelements in the composition liquid of biomus substances (data belongs to SA "AXEDUM"SRL)

Native fraction		Extract in solution 0.1 N KOH	
Parameters	Content	Parameters	Content
Organic substances content, %	23.98	Organic substances content, %	17.77
Total nitrogen content, mg/kg	49600	Total nitrogen content, mg/kg	7892
Nitric nitrogen content ($N - NO_3$), mg/kg	318.0	Nitric nitrogen content ($N - NO_3$), mg/kg	43
Total phosphorus content (P_2O_5), mg/kg	24355	Total phosphorus content (P_2O_5), mg/kg	2100
Mobile phosphorus content (P_2O_5), mg/l	137.2	Mobile phosphorus content (P_2O_5), mg/l	51.8
Total copper content, mg/l	0.69	Total copper content, mg/l	0.22
Total zinc content, mg/kg	0.93	Total zinc content, mg/kg	0.18
Total manganese content, mg/kg	0.59	Total manganese content, mg/kg	0.26
Calcium content, mg/l	345	Calcium content, mg/l	115
Magnesium content, mg/l	153	Magnesium content, mg/l	51
Mobile potassium content, mg/l	1758	Mobile potassium content, mg/l	5394

In the native fraction the content of organic substances is about 24%, which is rich in nitrogen (50 mg/kg). Due to the increased nitrification capacity the nitric nitrogen content ($N-NO_3$) is 318 mg/l. Total phosphorus content is 24 g/kg and the mobile one more than 130 mg/l. The content of mobile potassium (K_2O) is more than 1.7 mg/l.

Liquid biohumic substances are an important source of physiological microelements: the total copper content is 0.69 mg/l; zinc is 0.93 mg/l and manganese 0.59 mg/l. The calcium content is 345 mg/l and magnesium is 153 mg/l. The fraction of humic substances extracted in 0.1 n KOH solution has the same properties but with other quantitative expression (Table 3).

The content of organic substances is 16%, total nitrogen - 8 g/kg, $N-NO_3$ - 51.3 mg/l. The concentration of physiologically active microelements and alkaline - earth metals are 2-3 times lower than the native solution. Due to the particularities mentioned, the fraction of liquid humic substance is the fraction of liquid humic substances from the natural fertilizer which ensures visible multilateral effects: vigorous growth of plants, intensifying the photosynthesis process, increasing the resistance of crops to pathogens and pest, increasing harvest and quality.

Despite the fact that liquid biohumus substances contain large amounts of carbon, nitrogen, phosphorus, potassium and their administration in a quantity of 5-7 l in the soil does not directly affect their content in the soil. Therefore, the positive effects induced by them are based on other mechanisms. In this regard, we believe that liquid biohumus preparation (BIOVIT.md) lead to the restoration of soil biota and the intensification of biochemical processes in particular of humification process is perceived as a biophysical - chemical transformation process of organic residues with formation of stable humic substances which is achieved with the participation of saprophytic biota (Popov, 2004).

The process is carried out in several stages each link of this chain finalizing with the formation of stable groups of biohumic substances. According to Grishina (1986) these substances are represented by humic acids and humin. Agreeing with Orlov’s specified mechanisms determine the unidirectional character of the humification process in the sense of accumulation of humic substances in the soil (Orlov, 1986).

Monitoring this process in various models of agricultural biotechnology has shown that the systematic administration of biochemical products leads to the intensification of humification process (Table 4).

The maximum effects are attested in the case of resource reporductive model which is based on the combined use of liquid biohumus and solids in two rates.

In our opinion administration in rate prevent development which mineralizes newly formed humic substances. Due to this fact, in the case of resource productive model, there is a significant increase of organic matter content in a short period of 9 years (Table 4).

Table 4. Content and organic matter resources of typical low humus chernozems under various models of agricultural biotechnology (SA "AXEDUM"SRL, Cimişlia) (agrogen layer, mean values)

Model of agrobiotechnology, agrobiotechnological elements (9 years)	Soil layer, cm	Organic matter content, %	Addition based on the traditional model, %	Reserves of organic matter, t/ha
Traditional, plowing with incorporation of vegetal debris at various depths (9 years)	0-10	3.81 ± 0,06	-	40.0
	10-20	3.74 ± 0,04	-	38.3
	20-30	3.71 ± 0,03	-	36.4
	30-40	3.63 ± 0,02	-	35.4
	40-50	3.31 ± 0,02	-	34.0
	Layer 0-50	-	-	184.1
Agrophytotechnical combined system with incorporation of vegetal remains (9 years)	0-10	3.93 ± 0.06	+ 0.12	42.7
	10-20	3.87 ± 0.04	+ 0.13	41.3
	20-30	3.81 ± 0.04	+ 0.10	40.0
	30-40	3.65 ± 0.03	+ 0.02	35.8
	40-50	3.31 ± 0.02	-	34.0
	Layer 0-50	-	-	193.0
Resurce conservative Mini-Till system of work. Green field. Administration of biomumic products (BIOVIT.md) (9 years)	0-10	4.11 ± 0.13	+ 0.30	46.4
	10-20	4.07 ± 0.10	+ 0.33	44.8
	20-30	3.95 ± 0.06	+ 0.24	43.3
	30-40	3.62 ± 0.02	-0.01	41.4
	40-50	3.31 ± 0.02	-	34.0
	Layer 0-50	-	-	209.9
Resource productive Mini-Till system of work. Green field, biohumus administration, administration BIOVIT.md (9 years)	0-10	4.67 ± 0,11	+ 0.86	53.0
	10-20	4.60 ± 0,09	+ 0.79	50.9
	20-30	4.28 ± 0,06	+ 0.54	50.6
	30-40	3.98 ± 0,06	+ 0.30	48.2
	40-50	3.68 ± 0,07	+ 0.37	44.2
	Layer 0-50	-	-	247.3

CONCLUSIONS

Biohumic products obtained on the basis of natural humification process model have increased potential to restore soil biota responsible for the humification process. Systematically managing them in two rates ensures unidirectional realization the humification process and the increase in the content and reserves of organic matter.

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SUPPLYING SOIL IN HUMUS APPLICATION OF WASTE FROM THE PRODUCTION OF ALCOHOLIC BEVERAGES

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Abstract

Organic fertilization is the main agro-technical measure by which the humus regime in the soil is positively influenced. Organic fertilizers are sources of raw material for nutrient humus, but also for the synthesis of stable humus. Both contribute, along with other links of plant culture technology, to maintaining or increasing the humus content of cultivated soils. The article reflects the supply of delluvial chernozem with humus in the application of wine lees, vinasse (waste from winemaking plants) and cereal borhot (waste from the Ethanol Alcohol Production Facility). It has been established that the waste has significantly enriched the soil with humic organic matter. The specific humus increase in the pore layer from 1 ton of waste incorporated as fertilizer was for: wine yeast - 95-99 kg, vinasse - 5-7 kg, cereal borhot - 24-29 kg. The influence of waste on the quality of humus in the soil has been determined and the balance sheet has been calculated.

***Key words**: chernozem, wastes, wine yeast, vinasse, grain mashes, humus, soil.*

INTRODUCTION

Organic soil consistency plays a very important role in its physico-chemical and biological functions, serving as an energy and nutritional source for microbial flora and a factor on which the soil fertility status is largely dependent. Humus is the most important deposit and, at the same time, the most important source of carbon and nutrients. Soil utilization and exploitation in agriculture accelerates the processes of decomposition of accumulated organic matter, thus contributing to diminishing their fertility. This process has a universal character and is intense in the first years after the land reclamation. During 100 years Moldavian chernozems lost about 25 percent of accumulated organic matter (Krupenikov, 2008).

In the last 5 years, the amount of organic fertilizer has decreased by 60 times and is 0.1 t/ha, the surface of the alfalfa has decreased by 4-5 times, the vegetal remains on large surfaces are burning. As a result, the balance of humus in the soil is negative (- 0.7 t/ha), and with erosion losses we have an even greater reduction (- 1.1 t/ha) (Andrieş, 1999; 2005). According to the latest estimates, 26 million tons of humus (19 t/ha) are lost on agricultural land annually. Forecasting calculations show that, if the present situation is maintained, by 2025 the humus content in the soils of Moldova will decrease to a critical level of 2.5-2.8% (Andrieş et al., 2002).

The special importance of the humic state of soils for their productive level as well as for the state of the environment implies the necessity to research new organogenic material in order to determine the evolution of carbon in the agricultural exploited lands by applying accessible and satisfactory precision methods. Organic waste from the soil can be recycled from the production of alcoholic beverages: wine lees, cereal grains, etc.

The literature on waste mentioned above is little or totally lacking. It is worth mentioning that this waste is a very important source for increasing carbon reserves - which serves as a material for the formation of humus and humic acids that improve the nutritional regime of agricultural crops and consequently soil fertility.

The main purpose of the researches was to estimate the humification coefficient of the waste from the production of alcoholic beverages applied as fertilizer and their influence on the humus balance in the soil.

MATERIALS AND METHODS

The studies and researches were carried out during the period 2011-2018 at the Codru Technology and Experimental Station located in the commune of Codru, Chisinau, in two experiments on cambic luto-argilos chernozem. The scheme of experiments is shown in Tables 1 and 2. The chemical analyzes performed have determined the total humus (Tyurin method), humic acids, fulvic acids and humins (Kononova-Belcikova method), optical density of the humic acids (Plotnikova-Panamariova method) and mobile humus content (Tyurin method). The statistical processing of the data was done after B.A. Dospehov.

RESULTS AND DISCUSSIONS

Changing humus content from soil to waste

Organic soil is the most important component of fertility (Tyurin, 1937). Soil humus performs extremely important functions by participating in adsorption processes - desorption of ions necessary for plant nutrition, formation of clay-clay complexes, promoting aeration, penetration and retention of water in the soil, serving as an energy source for microorganisms, increasing the capacity water infiltration and decreases leakage, favors deep root penetration, and reduces human effort to perform soil work (Alexandrova, 1980).

Modification of soil humus content is the result of two processes with opposite features: on the one hand, mineralization of a fraction of the soil humus takes place in order to provide the microorganisms and plants grown with nitrogen and other necessary elements; on the other - the humus restoration takes place taking into account the remaining vegetal remains in the soil and the organic substances added as fertilizer (Tyurin, 1956).

Research by numerous scientists has shown that the application of organic fertilizers leads to the quantitative and qualitative promotion of soil humus. These are due to organic compounds from biodegradation of fertilizers (Lixandru et al., 2012). For different types of organic waste, there is a question of the accessibility of the humic value of organic matter.

Long-term experiments with different organic waste have a positive effect on soil humus content (Tables 1, 2).

Table 1 shows the data showing the influence of wine waste on humus content in the 0-30 cm layer of cambic chernozem and highlights the following:

Table 1. The influence of waste on the humus content in the 0-30 cm layer of cambic chernozem, % from the table. Technological-experimental station "Codru"

Variant of experience	Average for years 2011-2018	The increase compared to the control	
		%	kg/ha
Control	4.14	-	-
Wine yeast (N_{100}), 13 t/ha per year	4.28	0.14	3724
Wine yeast (N_{200}), 26t/ha per year	4.43	0.29	7714
Vinas (K_{450}), 300 m^3/ha per year	4.39	0.25	6650
Vinas (K_{900}), 600 m^3/ha per year	4.50	0.36	9576
LSD 0.5%	0.12	0.120	3024

Administration of doses of wine yeast (13 and 26 t/ha, equivalent to 100 and 200 kg N/ha per year) leads to a significant increase in humus content. The growth of humus versus control on an average of eight years was 0.14 and 0.29% or 3724 and 7714 kg/ha, respectively.

Applying the 300 (K_{450}) and 600 m^3/ha (K_{900}) wineries leads to statistically significant increases in humus content in all years of experimentation (2011-2018), where the increase on the average averaged 0.25 and 0.36% or 6650 and 9576 kg/ha.

The influence of corn mash on the humus content of the cambic chernozem is shown in Table 2 and highlights the following:

Table 2. Influence of cereal boron on humus content in the 0-20 cm layer of cambic chernozem, % of soil mass. Technological-experimental station "Codru"

Variant of experience	Average for years 2012-2018	The increase compared to the control	
		%	kg/ha
Control	2.96	-	-
Corn mash (N_{120}), 47 m^3/ha per year	3.07	0.11	2772
Corn mash (N_{240}), 94 m^3/ha per year	3.14	0.18	4536
LSD 0.5%	0.09	0.09	2268

Corn mash fertility in a dose equivalent to 120 and 240 kg N/ha led to a significant increase in humus content in the soil. The values of the humus content increase in seven years of experimentation averaged 0.11 and 0.18% or 2772 and 4536 kg/ha.

Table 3. Influence of yeast and wine yeast on the composition of humus in cambic chernozem. Technological-experimental station "Codru", 2018

Variant of experience	C, %				C_{AH} / C_{AF}	E_{AH}, mg/ml	C_{AHM}	G_H, %
	Total	AH	AF	H				
Control	2.27	0.81	0.28	1.18	2.93	27.5	0.78	36
Wine yeast (N_{200}), 26 t/ha per year	2.37	0.82	0.34	1.21	2.43	28.4	0.71	35
Vinas (K_{900}), 600 m^3/ha per year	2.35	0.79	0.31	1.24	2.51	28.0	0.73	34
LSD 0.5%	0.36	0.13	0.03	0.27	0.61	1.85	0.12	-

Table 4. Influence of cereal mash on the composition of humus in cambic chernozem. Technological-experimental station "Codru", 2018

Variant of experience	C, %				C_{AH} / C_{AF}	E_{AH}, mg/ml	C_{AHM}	G_H, %
	Total	AH	AF	H				
Control	1.75	0.73	0.23	0.79	3.28	27.7	0.67	41
Cereal mash (N_{240}), 100 m^3/ha per year	1.74	0.74	0.23	0.77	3.21	26.4	0.67	43
LSD 0.5 %	0.14	0.22	0.09	0.054	0.09	0.79	0.032	-

Table 5. Influence of waste from the production of alcoholic beverages on the soil humus balance in the plowed layer determined by the direct method in the laboratory experiments

Variant of experience	Initial content until the foundation of the experience	The eighth year of experimentation	Balance of humus		
			in years 7-8		annual t/ha
	ha		t/ha	%	
Control	169.6	170.8	- 1.2	- 1	- 0.4
Wine yeast (N_{200}), 26 t/ha per year	184.7	177.6	+ 7.1	+ 4	+ 2.4
Vinas (K_{900}), 600 m^3/ha per year	185.1	176.8	+ 8.3	+ 5	+ 2.8
Cambic cernoziom ("Codru", station, Codru commune)					
Control	74.6	76.1	- 1.5	- 2	- 0.8
Cereal mash (N_{240}), 100 m^3/ha per year	79.1	74.1	+ 5.0	+ 6	+ 2.5

Table 6. The share of humidity and mineralization in 7-8 years of organic matter incorporated into the pore layer with different wastes, kg. Technological-experimental station "Codru", 2018

Variant of experience	Carbon in the soil			Humus obtained from 1 t of waste
	introduced with fertilizers	humifiable	mineralized	
Control	-	-	-	-
Wine yeast (N_{200}), 26 t/ha per year	6084	2981	3684	159
Vinas (K_{900}), 600 m^3/ha per year	4620	2171	1820	8
Control	-	-	-	-
Cereal mash (N_{240}), 94 m^3/ha per year	2980	1669	480	46

Influence of waste from the production of alcoholic beverages on the quality of soil humus. The three groups of humus-forming substances are: humic acids, fulvic acids and humus. The research carried out at station "Codru" on cambic chernozem (Tables 3, 4) demonstrates that the application of yeast, wine and cereal boron does not produce appreciable effects on the composition of organic matter in the soil.

Balance of humus in the soil at the application of waste from the production of alcoholic beverages. In order to maintain the humus in the soil at levels corresponding to maximum possible crops, it is necessary to know, on the one hand, the evolution of its annual mineralization process, on the one hand, the restoration of vegetable residues and the possible addition of organic fertilizers. This means determining the difference between the annual humus gains resulting from the decomposition of rootstocks, stubble, plus organic fertilizers, and annual humus losses through organic carbon mineralization. The balance is usually expressed in kg of humus per hectare.

We mention that the current state of soil fertility is unsatisfactory and on some of the land - critical. The balance of humus is negative. Humus - one of the main signs of soil fertility as a result of erosion and dehumidification is decreasing. Taking into account the current state of the soil cover, the low level of fertility in the experiments of the laboratory. "Organic fertilizers and soil fertility", it was studied the modification of the humus content in the soil at the application of various wastes from the production of alcoholic beverages.

The application of wine waste (wine and wine lees) led to the creation of a positive humus balance of respectively 2.4 and 2.8 t/ha annually (Table 5). The corn borer applied at a dose of 100 t/ha (equivalent to N_{240}) produced a humus balance of 2.5 t/ha annually.

The share of the humidity and mineralization in the 7-8 years of the organic matter incorporated into the pore layer with different waste from the production of alcoholic beverages is shown in Table 6 and shows the following: from 1 t of wine sprouts incorporated in the soil 159 kg humus, wine - 8 kg and cereal bore - 46 kg.

CONCLUSIONS

Wines, wine and cereal borers experimented in medium doses as organic fertilizers have significantly enriched the soil with humic organic matter. The specific humus increase in the pore layer from 1 tonne of waste incorporated as organic fertilizer consisted of: 95-99 kg wine yeast; 5-7 kg vinas and 24-29 kg grain mash. The degree of humification of the organic matter introduced with the waste was relatively constant, oscillating within 30-42%, with a weighted average humification coefficient of 0.36.

Therefore, 36 percent of the organic material incorporated with the wastes listed in 7-8 years turned into luminescent and fulvic acids. In the process of humification the addition of organic matter to the waste accumulated predominantly with humic acids, which is characteristic for the chernozem soils. The ratio of humic acids: fulvic acids in the experiments performed oscillated between 2.4-3.3.

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RESEARCH OF TERRAINS IN KARNOBAT PLAIN AND ASSESSMENT OF THEIR SUITABILITY FOR PERENNIAL PLANTATION GROWTH

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Abstract

The study was carried out on terrains located in Ginot and Vodenichane villages, on a total area of 152.2 hectares. As a result of the study in the investigated terrains, were established the following soil differences - Pelic vertisols, Peli-gleyic vertisols, Chromi-eutric cambisols, Eutric regosols, Rankers.
The lands of Ginot village occupies a total area of 39 hectares in the high western part and 10 hectares in the lower eastern part, which borders the river Tarnavska. In the western part the terrain was well drained, including the areas of the relatively shallow gully in a direction from the northeast to the southwest.
The following massifs were studied on the land of the village of Vodenichane: M 160 occupied a high and generally drained terrain, where the deep and well developed soils occupy about 24% and the rest occupied with shallow and stony soils; M 100 is a complex landscape which can be divided into drained and not drained parts. The slightly drained and not drained part of the terrain occupied an area of 9 hectares in the eastern part of the site; M 210 - the whole area was a low not drained or slightly drained area. The groundwater level was high.

***Key words**: soils, erosion, fertilization, amelioration.*

INTRODUCTION

The aim of the study was to make soil characteristics of terrains located in Karnobat plain and to assess their suitability for growth of perennial plantations. The areas are on the periphery of a powerful Andesite basin. However, the distribution of the Andesite mantle is limited by the Pre-Balkan depth gap and the main soil-forming rocks of the study area are limestone, partly carbonate pliocene clays and deluvial transfer products originate from limestone rocks. The origin of deluvial materials and pliocene clays determine a relatively heavier soil texture of the soil variations in the area.
In order to properly solve a number of production problems related to the efficient use of agricultural lands, it is necessary to know the physico-geographic features of the area where the soil-climate and the microclimatic conditions of the plots determine the different development, growth and specific qualities of the cultivated crop (Almaliev et al., 2016).

MATERIALS AND METHODS

The study was carried out on terrains located in Ginot and Vodenichane villages, on a total area of 152,2 hectares. In the course of this study, soil samples were taken from the terrain by soil probe, the sample points was located within the boundaries of the terrain in a square. The soil samples were taken at three depths of 0-25; 25-50 and 50-75 cm.
After standard preparation, the soil samples were analyzed to establish the following parameters: soil texture with photo sedimentograph (Trendafilov et al., 2017), Hydrological characteristics of the soil (Trendafilov et al., 2017), Soil density by the paraffin method, relative density - picnometric, pH in aqueous extraction (Arinushkina, 1970), total and alkaline earth carbonate - gasometer by Schäniger method (Arinushkina, 1970), active calcium precipitate with $(NH_4)_2C_2O_4$ by Druinnot-Gallet (NO1085/NFX31-106), humus content by Turin method (Trendafilov et al., 2017), water-soluble salts (BDS ISO 11265: 2002), total nitrogen in the soil (BDS ISO 11261: 2002), the mobile forms of phosphorus and potassium (GOST 26209-91/01.07.93).

RESULTS AND DISCUSSIONS

As a result of the study in the investigated terrains, were established the following soil differences - Pelic vertisols, Peli-gleyic

vertisols, Chromi-eutric cambisols, Eutric regosols and Rankers.
Part of the studied soils (Pelic vertisols, Peli-gleyic vertisols, Chromi-eutric cambisols) in terms of its morphology have a well-developed and deep soil profile specific of the respective soil diversity. The other soil differences - Eutric regosols, Rankers are underdeveloped soils formed on solid silicate rocks (andesite).

Chromi-eutric cambisols
The average content of physical clay is an indicator that largely determines not only the normal development of the vine plants, but also the quality of the obtained wines. At a depth of 0 to 75 cm it was about 47%. The content found in this indicator showed, that the soil texture was not a constraint on the suitability of the soil for growth of vineyards.
The average soil pH found for the entire studied object was slightly acidic about 6.7. Therefore, the established pH was within the optimum range and will allow for the normal growth of the root system.
The content of calcium carbonate ($CaCO_3$) in the top soil horizons was very low - on average about 0.26% and increased in profile depth. The highest $CaCO_3$ values within the entire object were about 16%. The average content of active calcium in Chromi-eutric cambisols was very low - 1.20%. The data from the soil analyzes showed, that the carbonate content in the soil did not require a pad with very high resistance to alkaline earth carbonates and active calcium.
The humus content of the top soil horizon of Chromi-eutric cambisols was about 2.60% and assessed as average. At a depth of 50-75 cm it decreased to about 0.40%. It can be expected, that relatively low humus content will be found in the deep ploughed soil horizon - about 1.50%.
The soil is poorly stocked with phosphorus and relatively well with potassium. The apply rate of triple superphosphate for stock fertilization before deep plough was about 1.3 t/ha. Pre-fertilization with potassium was not necessary.

Pelic vertisols
The physical clay content of up to 75 cm depth was about 53%. These values showed that the soil texture was a significant limitation factor on the suitability of the soil for vineyards growth in most of the area occupied by Pelic vertisols and this require appropriate ameliorative activities.
The pH indicator for the entire object was about 7.1. The established soil reaction was not a restriction on the vine growth.
The total carbonates average for the object was about 6.25%. The active calcium content average for the area occupied by Pelic vertisols was 3.25%. The maximum value of active calcium for the studied soil variety was about 20.15%. The diversity of indicator values found within the object was very high. The chlorosis rate index at a depth of 50 cm in some of the samples reached 30 and in this case, it was not necessary to select a pad with a high chlorosis resistance.
The humus content in the top soil horizon of the studied Pelic vertisols was about 3.3% and was estimated as high. At a depth of 50-75 cm humus content decreased to 1.0%. It can be expected that an average humus content of about 2.3% will be found in the tillage horizon, which was estimated as good.
The soil was relatively well stocked with absorbable phosphorus and potassium. The phosphorus rate before tillage was about 700 kg/ha of triple superphosphate. Stock fertilization before planting with potassium was not necessary. After stock fertilization, phosphorrous fertilizers should not be applied until the fourth year, when the vines start partial fruitfulness.

Eutric regosols
The average physical clay content at depths of up to 75 cm was about 50% and decreased in the depth of the profile. At a depth of 50-75 cm clay content was sandy clay loam and was not limitation factor on the suitability of the soil for vineyards growth.
The average pH value found for the entire studied object was 7.0 and was not a limitation factor for the normal growth of the vine.
The content of $CaCO_3$ in the top soil horizons was very low - about 0.50%. At a depth of 50-75 cm, it was average about 11% and varies up to12%. The amount of active calcium reached a maximum of 16%. The low content of easily absorbable iron, combined with the relatively high content of active calcium, results in a high chlorose force index. This requires the choice

of a pad that is characterized by high chlorosis resistance.
The humus content in the top soil horizon of Eutric regosols was about 2.10%, which was estimated as average. The humus content decreased to 0.40% to a depth of 50-75 cm. It can be expected low humus content of the tillage horizon about 1%.
The soil was well reserved with phosphorus and potassium. The applied rate before tillage was about 300 kg/ha of triple superphosphate. Stock fertilization with potassium was not necessary.

Peli-gleyic vertisols
The average content of physical clay up to 75 cm depth was about 64%. The established values of this indicator was reason to conclude that the soil texture was a very substantial limitation factor for the vineyards growth. Peli-gleyic vertisols occupy a very small area. It was necessary to apply appropriate ameliorative activities to improve the general physical condition of the soil.
The pH indicator for the entire studied object was an average of about 7.0. The soil reaction found in the analysis was within the optimum range for the normal growth of the root system of the vine.
The content of calcium carbonate in the horizon with a depth of 25-50 cm was average about 8.5%. Total carbonates averaged about 3%.
The average active calcium content was very low - about 1.0%, varies up to 2.0%. The chlorose force index was very low, up to a maximum of 8.
The amount of organic matter in the top soil horizon of Peli-gleyic vertisols was about 3.70%, which was estimated as high. At a depth of 50-75 cm the humus content decreased to an average of 1.0%. It can be expected that the average of humus content of the tillage horizon will be around 2.60%, which can be estimated as good.

Rankers
The average content of physical clay at a depth of 0 to 75 cm was 34.2% and decreases to the depth of the profile. Soil texture in the topsoil and subsoil horizons was sandy clay loam. The texture coefficient was an average of 1.07.
The total soil porosity was assessed as satisfactory. The optimal field moisture was low - an average of 20.72%. In the topsoil horizon optimal field moisture was higher - 22.52%.
The average value of the $pH_{(H2O)}$ indicator found for the entire study object was 6.68 with a confidence interval of 6.36 to 6.99.
Content of total alkaline-earth carbonates was not found.
The active calcium content was not determined due to deficiency of $CaCO_3$.
The humus content of the topsoil horizon of the studied Rankers (shallow, poorly developed on silicate rocks) was 1.30% and was estimated as low. The humus content decreases to 0.63% at a depth of 25-50 cm and to 0.18% at a depth of 50-75 cm.
The soil was poorly stocked with total nitrogen in the studied Rankers. The established content of absorbable phosphorus determines the soil as a average stocked with phosphorus. The soil was well stocked with absorbable forms of potassium.

CONCLUSIONS

The lands of Ginot village occupies a total area of 39 hectares in the high western part and 10 hectares in the lower eastern part, which borders the river Tarnavska. In the western part the terrain was well drained, including the areas of the relatively shallow gully in a direction from the northeast to the southwest.
Restrictions on the land use in this outline derive from the shallow soil profiles and the near situated to the surface soil-forming rock, especially in the part of the terrain bordering the forest to the south.
The shallowest lands within this sub-object occupy an area of 3.5 hectares, representing about 18% of the entire object. This area should be abandoned as unsuitable for the growth of perennial crops, except for some species that have a low strictness with regard to profile depth. In areas where Peli-gleyic vertisols was distributed, it was necessary to carry out a deeply ameliorative soil loosening, one way in the direction of the slope, from the west to the east, to the river Tarnavska.
Part of the lands in the Vodenichane village occupied a high and generally drained terrain where the deep and well-developed soils were about 24% and the rest was occupied with

shallow and stony soils - Eutric regosols and Rankers. Limitation of the suitability of the terrain for crops growth was the pinching of groundwater in its central part. This was related to the formation of a continuous or periodic surface runoff in the path of the deep-cut gully crossing part of the object in a direction southeast to the northwest where the water flowed into a roadside drainage channel. The usage of the terrain requires the repair of the route of surface runoff in order to minimize the area of the terrain affected by lateral spills of surface running water. In order to be efficiently used, the area occupied with Peli-gleyic vertisols, require performing the following ameliorative activities: - construction of a drainage system, deep ameliorative loosening in the direction of the machine movement, coordinated with the routes of drainage suction, current alignment.

The suitability of the listed soil differences for the growth of perennial crops was limited. This is due to a variety of factors came from the soil profile speciality, the degree of drainage and the peculiarities of the landscape. Despite the fact that they belong to different taxonomic units and differ significantly in regard to their formation, composition and properties, within the study the listed soil differences were united as soils requiring ameliorative intervention before their use for the needs of vineyards growth in the area (Trendafilov et al., 2016). Profile depth and the high degree of rockyness in part of the studied terrains were a limitation for their usage of perennials growth with a deep root system. A particularly strong limitation of land use had in the area occupies by Rankers.

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SPECIFIC INVESTMENT FOR GROWING THE *Hedera helix* L. VARIETY USED TO IMPROVE DEGRADED LAND

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Abstract

The main objective of this study is to determine the input costs of growing ivy (Hedera helix L.), the biological material that will be used for degraded land improvement. 244 woody cuttings were planted in plastic pots with a depth of 10 cm and a diameter of 5 cm. Three substrates were used: peat, garden soil and a mixture of peat and garden soil at a ratio of 1: 1. For the peat substrate version, the rooting percentage of ivy cuttings (34.5%) was the largest registered. The costs for peat versions involved 12.59 lei per substrate. The total input costs totalled 40.59 lei for198 samplings; out of the total costs, the highest were for substrate pots. Under the conditions of this study, the input cost per cultivated ivy sample was 0.17 lei. The ivy samples recommended for degraded land improvement by vegetation covering installations are samples with soil garden + peat, due to substrate costs and rooting percentage. The lowest input costs were obtained for soil garden, but these options also registered the highest biological material losses.

Key words: *culture substrate, economic efficiency, ivy, soil erosion, slope.*

INTRODUCTION

English ivy (*Hedera helix* L.) ginseng family Araliaceae is native to most of Europe and western Asia (Marin, 2001; Ferris, 1968; Kaufman et al., 2007; Stănescu et al., 2014; Scott, 2010; Lust, 2014; Santier, 2014; Wichtl, 2004; Crivellaro et al., 2013) and is a very decorative vine that has two growth forms. In the juvenile stage, it is an evergreen, perennial vine growing as long as 100 ft. (30 m) or as tall as the structures or trees on which it climbs (Bossard et al., 2000; Woodward et al., 2011; Ditomaso et al., 2007).

Adventitious root is produced by climbing plants to cling to a support. Ivy produces short roots that cling to a wall or to tree bark, which enables the ivy to climb. The plant does not need a thick stem to support it (Bird, 2014; Knight, 2007).

It can also be used for erosion control and slope stabilization or to cover large areas, because of its propensity to root at leaf nodes, although its shallow root system renders it ineffective. It kills other ground-growing plants, leaving a bare soil surface that offers little resistance to water flow (Woodward et al., 2011; Mayer, 2010; Clarke et al., 2006; Sool, 2005; Stavretovic, 2007).

Leaves are simple, alternate, ovate or chordate, lobed or not, apices acute or obtuse, venation palmate, the upper surfaces glossy while the undersides are hairy or scaly (Knight, 2007). Maturing at about 10 years into erect plants or branches with unlobed leaves and terminal flowers clusters that yield blackish to purplish berries (Miller et al., 2010; Derickx et al., 2013; Woodward et al., 2011). Hundreds of cultivars vary in leaf size and color (Kaufman et al., 2007). English ivy is long-lived with reports of one plant over 400 years old.

MATERIALS AND METHODS

The cuttings 244 woody cuttings were planted in plastic pots with 10 cm depth and having a diameter of 5 cm. It was used three substrates: peat, garden soil and a mixture of peat and garden soil in ratio of 1: 1 (Figure 1).

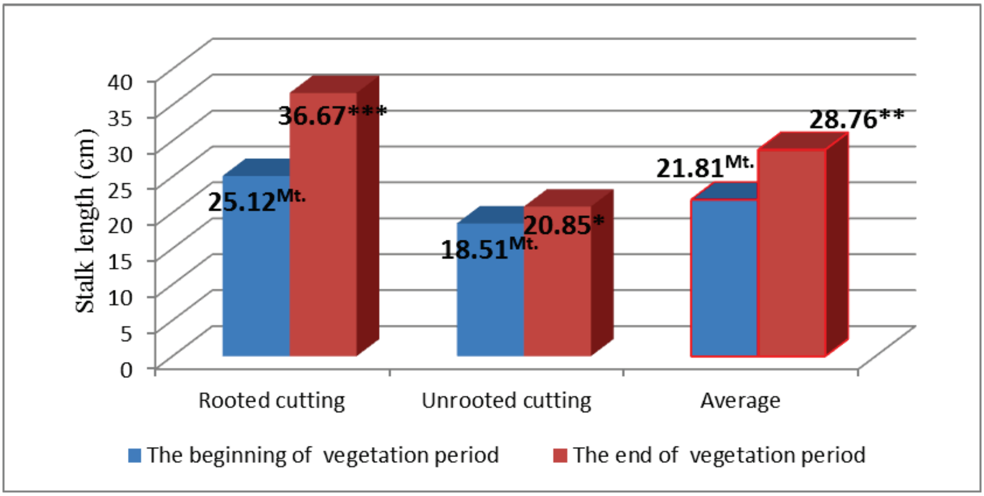
The plants were placed outside in an area. The plants were watered only on days when rainfall was not recorded.

The amount of water used in a 6 months period was 246 liters.

Figure 1. General aspects from experimental field

RESULTS AND DISCUSSIONS

In the Figure 2 are represented values by regarding rooted cutting and unrooted at the beginning the end of the period vegetation regarding to the growths of the length stalk of species *Hedera helix*. It is observed that at the beginning of the period vegetation to sample witness it's recording an average difference of 21.81%. For the end of the period vegetation it's recording an average of 28.76 and the significance from the point of view statistically it is distinguished significant.

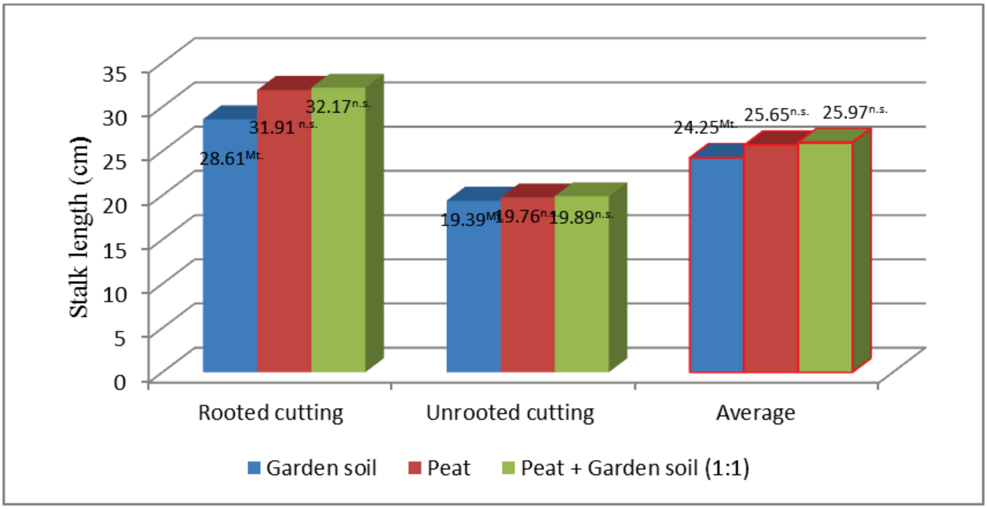


LSD (p 5%)	1.55
LSD (p 1%)	3.58
LSD (p 0.1%)	11.38

Figure 2. Stalk length to the specie *H. helix* regarding rooted cutting and unrooted at the beginning the end of the period vegetation

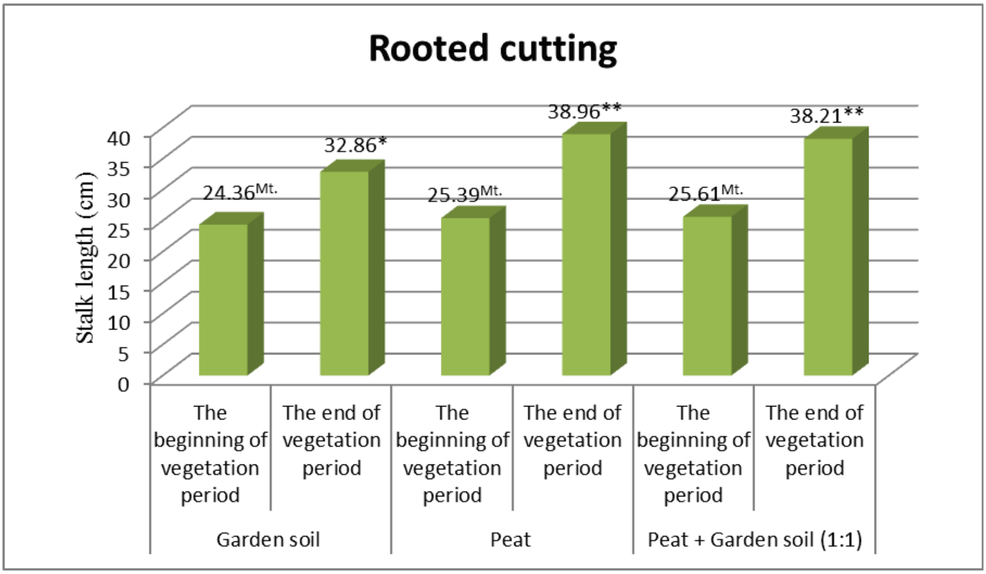
In the Figure 3 are are represented values by regarding rooted cutting and unrooted to the three substrates. It is observed the most rooted cutting it was recorded at substrates formed from peat + garden soil with 32.17% and the lowest percentage was recorded to the one formed by garden soil.

In the Figure 4 are represented values by regarding rooted cutting to stalk length of *Hedera helix*. It is observed the most increase a stalk was recorded at a substrates formed from peat with 38.96 cm and significance it is distinguished significant. To the substrate formed by garden soil increase stalk it was of 32.86 cm from the point of view statistical it is significant.



LSD (p 5%)	5.14
LSD (p 1%)	7.47
LSD (p 0.1%)	11.21

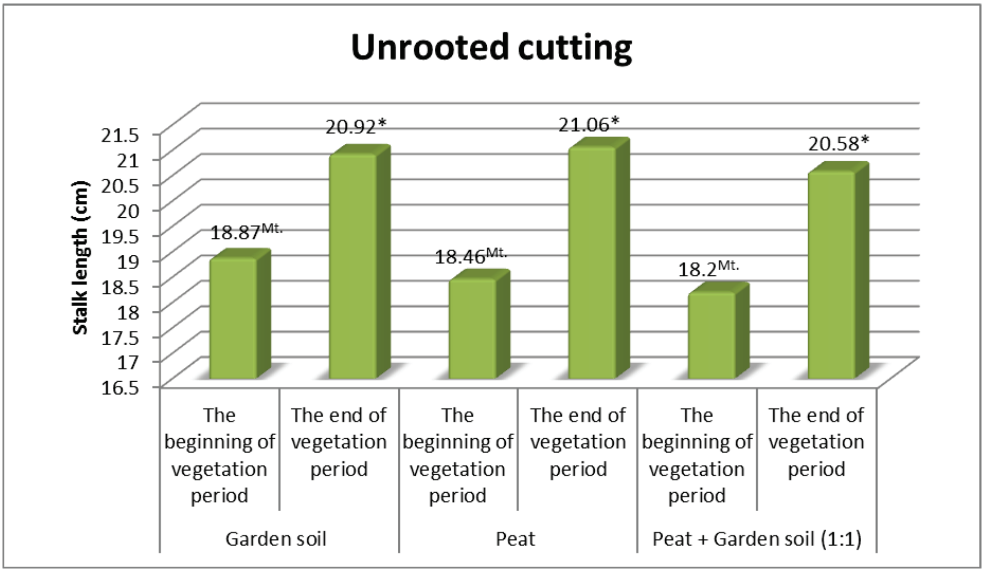
Figure 3. Stalk length to species *Hedera helix* regarding rooted cutting and unrooted to the three substrates



LSD (p 5%)	7.27
LSD (p 1%)	10.57
LSD (p 0.1%)	15.85

Figure 4. Stalk length to species *H. helix* regarding rooted cuttings to the tree substrates

In the Figure 5 are represented unrooted cutting to stalk length of *Hedera helix* at the beginning and the end of the period vegetation to the three substrates. It is observed the most regarding unrooted at substrates formed peat and soil garden. In the Figure 6 are represented average regarding rooted cutting and unrooted to the three substrates.



LSD (p 5%)	1.54
LSD (p 1%)	2.25
LSD (p 0.1%)	3.37

Figure 5. Stalk length to species *Hedera helix* regarding unrooted cuttings to the tree substrates

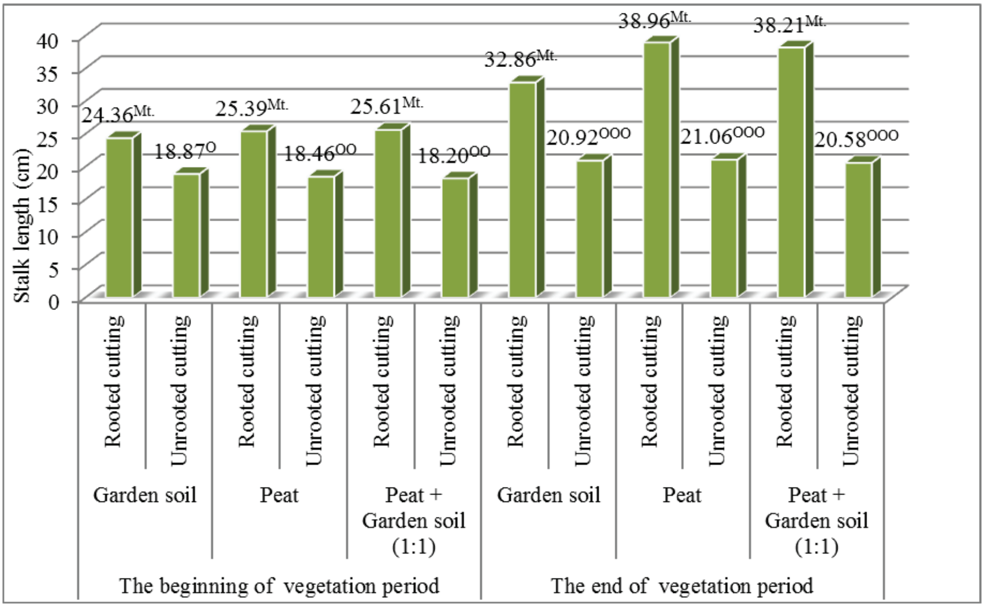


Figure 6. Stalk length of species *Hedera helix*

CONCLUSIONS

The total input costs cumulated 40.59 lei per 198 samplings, from total costs the highest costs were with substrate pots (in total 28 lei). In the conditions of this study resulted 0.17 lei input cost per cultivated ivy sample. The ivy samples recommended for degraded land improvement through cover vegetation installation is the samples from variants with soil garden + peat (1: 1), due to substrate costs and rooting percentage. The lowest input costs were obtained for variants with soil garden (input cost for soil garden = water cost + substrate pot cost), but for this variants was recorded the highest biological material losses.

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INFLUENCE OF FERTILIZATION ON SOIL FERTILITY AND PRODUCTION ON LAND AFFECTED BY DEGRADATION

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Abstract

Soil fertilization and fertility are terms that reflect some of the most influential factors on agricultural production. Corollary to this principle, the paper is intended to be a preliminary study focusing on the use of fertilizers in different doses and reports for agricultural crops in order to improve soil fertility and produce high yields. The experience organized on areas affected by soil degradation took place over two years, and the results obtained prove that the fertilization and modification decision was one scientifically correct and led to superior production in comparison to the unfertilized sample.

***Key words**: fertilization, fertility, fertilizer, degraded soil.*

INTRODUCTION

The soils in Romania as well as those from different European countries are in a continuous process of degradation. Worldwide, the decline in soil fertilization can be noticed, 60% of the soils having low or very low fertility, 29% moderate fertility and only 11% high fertility (Hera, 2002). The decline in soil fertility is produced over time as a result of different phenomena and anthropogenic factors. One of the soil degradation factors in Romania is soil reaction. Particularly, the acidic reaction of soils present in our country's soils is considered to be of strong pH or moderate acid, spreading on 28% of the agricultural area. In the case of strong acid pH, at values below 5.8, in these soils there is also aluminum, often above the limit of phytotoxicity (Davidescu, 1981).

The soils affected by degradation, under the influence of acid reaction, are deficient in macro-elements. They undergo different processes (fixation and relegation) and the mobile forms become totally insufficient for normal plant nutrition.

The paper presents the results of a field experience on a soil surface affected by phenomena of acidification, as a result of the fertilizations, on the one hand analysing their impact on the state of ensuring the soils with nutrients and on the other hand being interested in their effect on the production.

MATERIALS AND METHODS

In order to analyse the impact of fertilizers on the soil fertility status, in 2016, an experience on degraded chernozem cambic soil was organized in a site belonging to a family association in Letcani, Iasi County.

The territory under analysis has an area of 20.7 ha and the soil under analysis has a pH between 5.4 and 5.8, respectively, a strongly acidic reaction. The initial soil condition was poor for assimilable nitrogen but also for phosphorous and assimilable potassium.

For fertilizations there were used urea (46.6% a.s.) as nitrous fertilizer, fractionally administered, concentrated superphosphate (45% a.s.) as a phosphate fertilizer and 50% potassium salt as potassium fertilizer.

The fertilizer doses have been set according to the expected harvest and soil condition with the three macro elements, namely IN, P-AL and K-AL.

Experience has been carried out over two years, in a wheat-maize rotation.

For the maize crops, the nitrogen factor N had graduations: 50, 100, 150, 200 kg/ha, phosphorus factor - P - 40, 90, 140, 190 kg/ha, and potassium - 60, 110, 160, 210 kg/ha. At the wheat culture, the graduations were: N - 40, 80, 120, 160, for P - 30, 70, 110, 150 and for K - 50, 100, 150, 200 kg/ha a.s.

In the autumn of 2015, 60 t/ha of manure were handled and the calcareous fining was done using 120 t/ha of $CaCO_3$.

At the laboratory dosages there were determined: pH, potentiometric method, ammoniacal forms - colorimetric method with Nessler reagent and nitric form, colorimetric method with phenol 2.4 disulfonic acid, phosphorus - colorimetric determination with $SnCl_2$ and accessible potassium, flame photometry method.

RESULTS AND DISCUSSIONS

In the climatic conditions of Letcani-Iasi, the optimization of vegetation factors at wheat and maize was considered appropriate to be done by a balanced fertilization system, which would lead to the improvement of soil fertility status, but also to the obtaining of stable productions.

From the analysis of data regarding the fertilizer application, on the state of insurance with mobile forms of soil nutrients in wheat culture (Table 1), it is found that they increase in relation to the dose and the association of fertilizers. Applied unilaterally, the nitrogen yields increases from 18 ppm in the unfertilized control variant to 41 ppm for the N_{160} variant, which is optimal (Davidescu, 1980). In combination with phosphate fertilizers, the nitrogen evolves to 47 ppm for the $N_{160}P_{150}$ variant, while the phosphorus increases from 12 ppm P-AL unfertilized variant to 35 ppm, the $N_{160}P_{150}$ variant, a value considered by the specialized literature as the optimal assurance, for field crops.

Fertilizing with nitrogen, phosphorus and potassium makes significant increases in soil macronutrient content, assimilable forms. Thus, with the maximum dose of $N_{160}P_{150}K_{200}$, there is an increase of up to 49 ppm for nitrogen - over optimal, 37 ppm P-AL - slightly over optimal and 204 ppm K-AL - optimal.

For the maize crops (Table 2), the fertilizer doses used improve the soil nutrient assurance condition even more than at the wheat culture. Nitrogen increases from 45 ppm NH_4^+ + NO_3^- - N_{200} variant (normal content) at 52 ppm for the variant in combination with phosphate and potassium fertilizers in doses of $N_{200}P_{190}K_{210}$.

Table 1. The impact of fertilization on the mobile forms of nutrients in the wheat culture

Doze of fert. kg a.s./ha	NH_4^++ NO_3^- ppm	P-AL ppm	K-AL ppm
N_0	18	12	77
N_{40}	25	13	67
N_{80}	28	14	78
N_{120}	36	13	79
N_{160}	41	15	79
N_0P_0	18	12	77
$N_{40}P_{30}$	29	18	71
$N_{80}P_{70}$	38	22	78
$N_{120}P_{110}$	42	29	79
$N_{160}P_{150}$	47	35	80
$N_0P_0K_0$	18	12	77
$N_{40}P_{30}K_{50}$	33	25	85
$N_{80}P_{70}K_{100}$	40	27	159
$N_{120}P_{110}K_{150}$	43	32	179
$N_{160}P_{150}K_{200}$	49	37	204

The assimilable phosphorus grows in the same way, in relation to the dose administered and in complexation with the nitrogen and potassium fertilizers. There are highlighted progressive increases of this macronutrient of 12 ppm P-AL - unfertilized variant to 39 ppm for binary variants. $N_{200}P_{190}$ and ternara - $N_{200}P_{190}K_{210}$, exceed the optimal concentration by 4 ppm.

Table 2. Impact of fertilizations on the assimilable forms of nutrients in maize cultures

Doze of fert. kg a.s./ha	NH_4^++ NO_3^- ppm	P-AL ppm	K-AL ppm
N_0	18	12	77
N_{50}	27	12	77
N_{100}	30	13	78
N_{150}	35	13	79
N_{200}	45	14	79
N_0P_0	18	12	77
$N_{50}P_{40}$	30	17	78
$N_{100}P_{90}$	38	34	80
$N_{150}P_{140}$	44	38	79
$N_{200}P_{190}$	49	39	80
$N_0P_0K_0$	18	12	77
$N_{50}P_{40}K_{60}$	33	20	90
$N_{100}P_{90}K_{110}$	45	28	149
$N_{150}P_{140}K_{160}$	48	33	190
$N_{200}P_{190}K_{210}$	52	39	221

The potassium fertilizer used to raise soil concentration from 77 ppm K-AL - unfertilized variant at 80 ppm - $N_{200}P_{190}$

variant, low soil concentration at 221 ppm K-AL - variant $N_{200}P_{190}K_{210}$, value which surpasses the optimum by 21 ppm.

From the analysis of the results it is clear that, at both wheat and maize crops, the limits of normal concentration of nitrogen, phosphorus and potassium, accessible forms are reached, in the intermediate variants, which explains the synergy between them.

The application of fertilizers, especially those of nitrogen and phosphorus, is one of the most important means of increasing agricultural production. In particular, on these soils affected by acidification processes, an optimal fertilization system implies dependence on pedoclimatic conditions, but also the calculation of optimal economic dosages, leading to high and stable production. Equally, establishing fertilizer assortment and balance fertilizer ratios represent objective necessities, id we take into consideration the deterioration of the fertility status of these soils and a series of unfavourable physical-chemical attributes of these soils, such as a degree of high compaction, an inadequate water capacity, poor aeration porosity, etc.

Analysing the results obtained from fertilizations, we could notice their contribution as a limiting factor, to the order of the size of the crops.

In the two years of the analysis and taking into account the different climatic conditions of the area, the average production obtained without application of fertilizers was at the level of 1520 kg/ha in wheat and 1950 kg/ha in maize culture (Tables 3, 4)

The administration of singular nitrogen has led to relatively small increases at the wheat culture (Table 3). These increases have progressively increased up to a dose of 120 kg/ha a.s., when the production flattens. In combination with phosphorus, the nitrogen leads to higher yields of 120 kg/ha N and 110 kg/ha P, providing a yield of 695 kg/ha harvest. The relationship of inter-conditionality and synergism of the three fertilizing elements, nitrogen, phosphorus and potassium, results in 120 kg/ha N, 110 kg/ha P and 150 kg/ha K, to produce maximum yields of 2375 kg/ha, with a crop yield of 855 kg/ha. However, the highest production yield kg/kg of administered fertilizer a.s. can be noticed at the unilateral application of nitrogen, of 4.46 kg gain/kg of fertilizer in the case of 120 kg/ha a.s.

Table 3. Impact of fertilization on yields of wheat crops

Variant	Production kg/ha	Difference + kg/ha	Production gain Kg/kg s.a
N_0	1520	-	-
N_{40}	1595	75	0.93
N_{80}	1860	340	4.25
N_{120}	2056	536	4.46
N_{160}	1935	415	2.59
N_0P_0	1520	-	-
$N_{40}P_{30}$	1645	125	1.78
$N_{80}P_{70}$	1954	434	2.89
$N_{120}P_{110}$	2215	695	3.02
$N_{160}P_{150}$	2134	614	1.98
$N_0P_0K_0$	1520	-	-
$N_{40}P_{30}K_{50}$	1854	334	2.78
$N_{80}P_{70}K_{100}$	1986	460	1.84
$N_{120}P_{110}K_{150}$	2375	855	2.25
$N_{160}P_{150}K_{200}$	2200	650	1.27

At the maize crops, there is somewhat the same trend. The maximum yields are obtained with the dose of 200 kg/ha and 2518 kg/ha, but also with the variants of $N_{150}P_{140}K_{160}$ and $N_{200}P_{190}K_{210}$, where the production yields are of 649 and 740 kg/ha respectively.

Table 4. Impact of fertilization on productions of maize crops

Variant	Production kg/ha	Difference + kg/ha	Production gain kg/kg a.s.
N_0	1950	-	-
N_{50}	1975	25	0.50
N_{100}	2025	75	0.75
N_{150}	2289	339	2.26
N_{200}	2518	568	2.84
N_0P_0	1950	-	-
$N_{50}P_{40}$	2044	94	1.04
$N_{100}P_{90}$	2090	140	0.73
$N_{150}P_{140}$	2547	597	2.05
$N_{200}P_{190}$	2425	475	1.21
$N_0P_0K_0$	1950	-	-
$N_{50}P_{40}K_{60}$	2167	217	1.46
$N_{100}P_{90}K_{110}$	2220	270	0.90
$N_{150}P_{140}K_{160}$	2599	649	1.44
$N_{200}P_{190}K_{210}$	2690	740	1.23

It is important the fact that, just like at the maize culture, the fertilizing elements can increase the effect, and lead to higher harvests than when single nitrogen is administered.

If another indicator is considered, kg gain/kg of a.s. administered in the wheat culture, the N_{120} variant results in an increase of 446 kg/kg of a.s., while in maize cultures the administration of 200 kg/ha of nitrogen leads to an increase of 2.84 kg/kg of fertilizer a.s.

CONCLUSIONS

Corollary of the study, it can be stated that in the case of soils with acidification tendency, along with calcareous finishing and organic fertilization, chemical fertilization plays a decisive role in the equilibrium nutrient balance in soil, leading to optimal levels in soils and to obtain relatively stable production.

The administration of singular nitrate fertilizers leads to the production of similar or even higher productions than the administration of fertilizers in the NP relationship. However, it is avoided raising the threshold of nitrogen fertilizers, knowing their action in the sense of acidification of the soil solution.

The export of nutrients with the crops and the adequate non-fulfillment of nutrient requirements according to the specific consumption of the species, causes the crops to flatten after a certain dose of fertilizers.

For wheat production, production is flattened after administration of $N_{120}P_{110}K_{150}$, but the most effective harvest gain kg/kg of fertilizer a.s. administered, the variant $N_{120}P_{110}$, respectively, 3, 08 kg/kg 1 kg a.s.

For corn crops, the maximum yield is obtained with the $N_{200}P_{190}K_{210}$ variant, but the production gain kg/kg of fertilizer a.s. is at the $N_{150}P_{140}$ variant, ie 2.05 kg gain/kg of NP a.s.

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A SIMPLE METHOD FOR SUNFLOWER *IN VITRO* REGENERATION STARTING FROM MERISTEMATIC TISSUES

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Abstract

Sunflower, an important agronomic species, also considered the symbol of summer in gardens, is often the subject of biotic stress. The breeding for resistance involving biotechnological tools require well established protocols for in vitro regeneration. Sunflower is, however, well known as a species recalcitrant to in vitro regeneration. The best responsive tissues originate from immature embryos. Tissues of other sources are usually characterized by poor regeneration or require intermediary steps of culture for gaining morphogenetic potential. Here we present a new method for in vitro culture of sunflower involving meristematic tissues resulted from mature embryos. The advantages of this method stand out - it requires mature embryos which are easy to obtain and consist in only two steps of culture on simple media. The regeneration potential of this type of explants is high - up to 100% of the explants regenerate plants. We can conclude that the method developed here for in vitro sunflower regeneration holds promises for solving the regeneration problems of sunflower and can be applied, with slight optimization, for other plant species.

Key words: *meristem, organogenesis, rhizogenesis, sunflower, ungerminated mature embryo.*

INTRODUCTION

Sunflower is one of the most important oil-producing crops, ranking on the fourth place after soybean, rapeseed and groundnut in term of production per year (Dagustu, 2018).
The main interest in sunflower is the oil, used primarily as edible oil. In the near future, it is seen as a renewable source of biodiesel, a clean alternative to regular petroleum-based fuels. The seeds per se are also important for consumption or can be processed for different products. Although of less economic importance, sunflower hybrids are also highly appreciated by the general population for their ornamental attributes (Seiler & Gulya, 2016).
To fulfil all the requirements for such a high diversity of utilization and also to gain resistance to several biotic and abiotic stressors who jeopardise the crops, sunflower was the subject of a comprehensive genetic improvement during the time, mainly through conventional breeding (Seiler & Gulya, 2016).
However, the lack of genetic resources diminishes the chances for obtaining varieties with high resistance to diseases and pests, drought tolerance and salty soils, or to improve the oil quality (Dagustu, 2018). New technologies are needed to increase the genetic variability of sunflower. The biotechnologies involving tissues culture and genetic engineering could be a useful approach for creating genetic variation. Reliable *in vitro* morphogenetic techniques for improving sunflower qualities are necessary in order to fully exploit the information provided by the newly available genome assembly for this species combined with the new genome-editing techniques (Lewi et al., 2006).
Although a plethora of methods was established for sunflower *in vitro* culture, it continues to be considered a species with high recalcitrance to morphogenesis (Dagustu, 2018; Radonic et al., 2015). The morphogenetic potential is highly dependent on intrinsic factors like genotype, explant type and age or extrinsic factors such are culture media components, light and temperature (Deglene et al., 1997; Espinasse & Lay, 1989).
The only explants allowing reproducible results in a genotype-independent manner for sunflower are those resulting from immature

zygotic embryo although the technique requires considerable time and effort (Finer, 1987; Hewezi et al., 2003; Power, 1987; Sujatha & Prabakaran, 2001). Applying different methods, it was demonstrated that the explants resulted from germinated seeds or from plantlets lose their regeneration ability compared with those resulted from embryos (Finer, 1987; Power, 1987; Shin et al., 2000). The conclusion is that the morphogenetic capacity declines rapidly by increasing the age of the explants (Knittel et al., 1991).

The aim of our study was to establish a fast, simple and reliable method for *in vitro* regeneration of sunflower starting from meristematic tissue originating from ungerminated mature embryos. The role of the amount of nitrogen supplied in the culture media upon sunflower *in vitro* morphogenesis and growing was briefly tested.

MATERIALS AND METHODS

Sunflower seeds belonging to the hybrid Florina, produced by the National Agricultural Research and Development Institute - Fundulea, were randomly selected. After the hulls removal, the seeds were sterilized first, in 70% ethanol for one minute followed by 7% Domestos treatment for 20 minutes under agitation. Subsequently were rinsed for several times with sterile distilled water to completely get rid of the detergent. To facilitate the removal of the transparent and thin teguments they were kept for two hours in sterile, distilled water, in the dark.

The explants, having about 200-300 µm consist of apical meristem and leaf primordia, together (referring from now on as M-LP). They were carefully sectioned from the mature seeds, under the stereomicroscope, and placed on the culture media.

The culture media were based on Murashige and Skoog basal medium (1962, MS), supplemented with organics (Table 1). The pH was adjusted to 5.6.

For testing the role of nitrogen, two variants of medium were prepared, one containing the normal amount of ammonium nitrate of MS - 1.65 g l^{-1} (RJM-MS) and the other, containing a reduced amount - 1 g l^{-1} (RJM).

The cultures were kept at 27°C, in the dark during induction step and subsequently were transferred in light to a photoperiod of 16 h for stimulating the shoot growth.

Table 1. The constituents added to MS basal culture medium

Constituents	Amount (mg l^{-1})
Vitamins	
Myo-inozitol	200
Nicotinic acid	0.5
Pyridoxine HCl	0.5
Thiamine HCl	0.1
Growth regulators	
Indole-3-acetic acid (IAA)	0.5
Zeatin	1
6-Benzyladenine (BA)	0.5
GibberellinA3 (GA3)	0.2
Others	
Sucrose	10000
Sorbitol	15000
Agar	7000

For inducing rhizogenesis, the well-developed shoots, of approximately 5 mm in length (Figure 1), were placed on rooting media - MS salts and vitamins supplemented with 0.1 mg l^{-1} indole-3-butyric acid (IBA).

Observations were performed weekly using a stereomicroscope for assessing the time necessary for buds induction and for estimating the regeneration efficiency and development of the shoots.

RESULTS AND DISCUSSIONS

The regeneration potential of the hybrid Florina was tested previously using the method established by Paterson and Everett (1985) but did not produce the expected results (data not published). As a consequence, a preliminary study was started to assess the role of the type of explants for *in vitro* regeneration of sunflower (Aurori, 2012, doctoral thesis). This study revealed that mature ungerminated embryo represents the best source of explants in term of morphogenetic potential. Here we present a new method of plant regeneration in sunflower starting from the apical meristem connected with leaf primordia, originating from mature seed.

The culture consists in two steps (Figure 2). In the first one, involving a media which contain a cocktail of growth regulators (Table 1), the shoot induction takes place, via callus. The same medium sustains the development of the shoots until they are suitable to be transferred, in the second step of culture, on medium containing 0.1 mg l^{-1} IBA, for induction and development of roots.

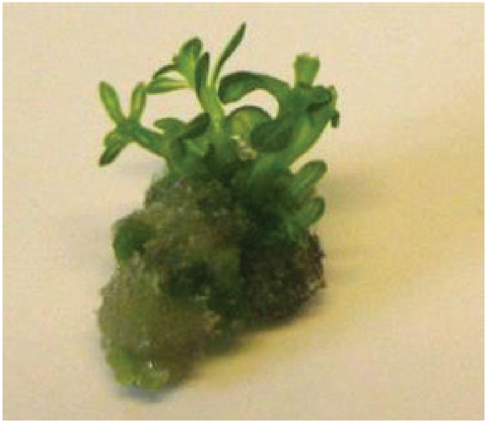

Figure 1. Plantlets regenerated on RJM-MS after 4 weeks of culture

After three weeks from initiation of the cultures all the explants started to develop callus on both induction media - RJM-MS and RJM, respectively. The callus has a vitrified appearance being white or translucent, with a hard consistency. At this stage of culture, the first signs of caulogenesis were observed but were restricted to the meristematic area. The foliar primordia did not regenerate buds.

Table 2. Plant regeneration on culture media - RJM and RJM-MS, respectively

Culture medium	Explants regenerating shoots (%)	Average no. of shoots/ explant	Explants regenerating roots (%)
RJM	100	2.1	82
RJM-MS	95	3.9	80

The source of nitrogen exerts an effect on enzyme activity, free amino acid composition and growth of sunflower (Weissman, 1972). We test here if the amount of ammonium nitrate affects the morphogenesis and efficiency of regeneration. Comparing the two culture media - RJM-MS and RJM - it was not found any significant difference in the morphogenetic potential in relation to the amount of ammonium nitrate (Table 2). During the induction phase, which takes place in the dark, the buds emerged on the 95% and 100% of the explants on RJM-MS and RJM, respectively. After the cultures were transferred to light the situation was reversed so the higher number of plantlets was harvested from RJM-MS. The average number of shoots per explant was of 2.1 and 3.9 on RJM and RJM-MS, respectively (Table 2). Although the plantlets exhibited mild vitrification (Figure 1), they had a normal morphology during growing. All the regenerated plants were transferred on rooting media. The percentage of plants that rooted did not differ significantly between the two culture media used in the previous step, being approximately 80%.

Particularly interesting and very useful in practice for *in vitro* culture of sunflower is the fact that these plants have a juvenile appearance - the flower bud has not been developed during culture as it happens so often for sunflower (Alibert et al., 1994; Baker et al., 1999; Power, 1987).

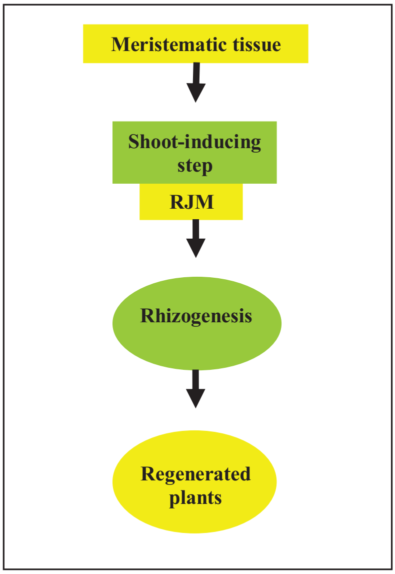

Figure 2. Schematic representation of the method for *in vitro* culture of the meristematic sunflower explants

CONCLUSIONS

For sunflower, as for other plants with poor *in vitro* response, the mature embryo proved to be a reliable source of explants with high morphogenetic potential. It also has the advantage of being available all year round.

Particularly the apical meristem connected with the leaf primordia, resulted from ungerminated embryo, retains the entire capacity of regenerating shoots.

The regeneration occurred indirectly, from newly developed meristems (neomeristems).

The method is fast - it does not require intermediate steps - induction of the buds and plantlet growth takes place on the same culture medium. Rooted plants can be obtained in 6 weeks.

A reduced amount of ammonium nitrate, although not critical for induction, can decrease the number of shoots developed per explant.

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EFFICACY OF HERBICIDES AND THEIR TANK MIXTURES AT SUNFLOWER (*Helianthus annuus* L.)

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Abstract

The research was conducted during 2012-2014. Under investigation were 4 sunflower hybrids (Helianthus annuus L.): hybrid Bacardy (an imitolerant hybrid by ClearField plus technology), hybrid Estiva (an imitolerant hybrid by ClearField technology), hybrid Sumico (a tribenuron-methyl tolerant hybrid by ExpessSun technology) and hybrid Arizona (a hybrid by conventional technology). Factor A included the years of investigation. Factor B, herbicides and tank mixtures, included 20 rates. It includes 3 variants by ClearField plus technology, 5 variants by ClearField technology, 5 variants by ExpessSun technology and 7 variants by conventional technology. Herbicide Pulsar plus by ClearField plus technology and herbicide Listego by ClearField technology, destroy completely all annual and perennial graminaceous and broadleaved weeds in sunflower crops, including Orobanche cumana Wall. Herbicide Express by ExpressSun technology, controls all perennial and annual broadleaved weeds. Tank mixture of Express with antigraminaceous herbicide Select super controlled successfully and all annual and perennial weeds. The highest seed yield is obtained at herbicide tank mixture Pulsar plus + Stomp aqua by ClearField plus technology. Tank mixture Listego + Dash + Sharpen by ClearField technology and Express + Trend + Select super by ExpressSun technology also lead to obtaining of high seed yields. Tank mixtures of herbicides Smerch, Pendigan, Wing, Raft, Pledge and Modown with Amalgerol premium by conventional technology have lower yields due to insufficient control of weeds as Xanthium strumarium L., Cirsium arvense Scop., Convolvulus arvensis L. in sunflower crops.

Key words: *oil-bearing sunflower, herbicides, tank mixtures, efficacy, selectivity, seed yield.*

INTRODUCTION

A large part of oil-bearing sunflower in the world is grown by ClearField and ExpressSun technologies. There are significant areas in Bulgaria where sunflower still is grown by conventional technology. There are many unsolved problems in this technology about controlling of weeds such *Xanthium strumarium* L., *Cirsium arvense* Scop., *Convolvulus arvensis* L., *Orobanche cumana* Wall., which necessitated the introduction of new ExpressSun and ClearField technologies for growing of oil-bearing sunflower (Simić et al., 2012; Brighenti et al., 2012).

During creating situation of increasingly louder and more frequent drought occur serious problems that must be solved (Zand et al., 2009; Suresh & Reddy, 2010; Saskevich et al., 2011). One of these problems is for the efficacy and selectivity, i.e. the behavior of foliar-applied and soil-applied herbicides under these conditions.

It should to consider a number of factors that determine the effective application of these complex organic compounds. Herbicides will remain in future agriculture efficient tool for control of weeds as part of an integrated weed control in sunflower, which is why there is need for research for optimization of their use (Mitric & Vuckovic, 2008; Jocić et al., 2011; Knežević et al., 2011; Delchev, 2018).

The purpose of this investigation was to establish the efficacy and selectivity of some herbicides, adjuvants, foliar fertilizer Lactofol B, growth regulator Amalgerol premium and their tank mixtures on the oil-bearing sunflower by influence of different meteorological conditions.

MATERIALS AND METHODS

The research was conducted during 2012-2014 on pellic vertisol soil type. Under investigation were 4 sunflower hybrids (*Helianthus annuus* L.): hybrid Bacardy (an imitolerant hybrid by ClearField plus technology), hybrid Estiva (an imitolerant hybrid by ClearField technology), hybrid Sumico (a tribenuron-methyl tolerant hybrid by ExpessSun technology) and hybrid

Arizona (a hybrid by conventional technology). Two factors experiment was conducted under the block method, in 4 repetitions, the size of the crop plot was 15 m^2. Factor A included the years of investigation. Factor B, herbicides and tank mixtures, included 20 rates. It includes 3 variants by ClearField plus technology, 5 variants by ClearField technology, 5 variants by ExpessSun technology and 7 variants by conventional technology.

Table 1. Investigated variants

№	Variants	Active substance	Doses
	ClearField plus technology - hybrid Bacardy		
1	Check	-	-
2	Pulsar plus	imazamox	1.2 l/ha
3	Pulsar plus + Stomp aqua	imazamox pendimethalin	1.2 l/ha + 2.3 l/ha
	ClearField technology - hybrid Estiva		
4	Check	-	-
5	Listego 40	imazamox	1.2 l/ha
6	Listego 40 + Dash HC	imazamox *	1.2 l/ha + 500 ml/ha
7	Listego 40 + Sharpen 33 EC	imazamox pendimethalin	1.2 l/ha + 2.3 l/ha
8	Listego 40 + Dash HC + Sharpen 33 EC	imazamox * pendimethalin	1.2 l/ha + 500 ml/ha + 2.3 l/ha
	ExpressSun technology - hybrid Sumico		
9	Check	-	-
10	Express 50 SX + Trend 90	tribenuron-methyl **	40 g/ha + 0.1 %
11	Express 50 SX + Lactofol B	tribenuron-methyl ***	40 g/ha + 8 l/ha
12	Express 50 SX + Trend 90 + Select super 120 EC	tribenuron-methyl ** clethodim	40 g/ha + 0.1 % + 1.6 l/ha
13	Express 50 SX + Lactofol B + Select super 120 EC	tribenuron-methyl *** clethodim	40 g/ha + 8 l/ha + 1.6 l/ha
	Conventional technology - hybrid Arizona		
14	Check	-	-
15	Smerch 24 EC + Amalgerol premium	oxifluorfen ****	800 ml/ha + 5 l/ha
16	Pendigan 330 EC + Amalgerol premium	pendimethalin ****	4 l/ha + 5 l/ha
17	Raft 400 SC + Amalgerol premium	oxidiargil ****	800 ml/ha + 5 l/ha
18	Wing P + Amalgerol premium	pendimethalin + dimethenamid ****	4 l/ha + 5 l/ha
19	Pledge 50 WP + Amalgerol premium	flumioxazin ****	80 g/ha + 5 l/ha
20	Modown 4 F + Amalgerol premium	bifenox ****	1.5 l/ha + 5 l/ha

All of variants are treated on herbicide Gardoprim plus gold 500 SC (S-metolachlor + terbuthylazine) - 3.5 l/ha, which is applied after sowing before emergence of the sunflower.

***Lactofol B - nitrogen in amide, ammonium and nitrate forms, easily absorbable phosphorus and potassium, trace elements, amino acids, physiologically active substances, complex agent - lactic acid.

****Amalgerol premium - extract of sea algae, mineral oils, plant extracts, essential oils, macro- and micronutrients.

Active substances of preparations and their doses are shown in Table 1. All of them were treated during 3-4 pair leaves stage of the sunflower.
All of variants are on herbicide Gardoprim plus gold 500 SC (S-metolachlor + terbuthylazine) - 3.5 l/ha, which treated after sowing before emergence of the sunflower. All of herbicides and herbicide tank mixtures were applied in a working solution of 200 l/ha.
It was investigated efficacy and selectivity of herbicides and their tank mixtures. It was established their influence on seed yield. Efficacy of herbicides against weeds was appointed according to 100% scale of EWRS (European Weed Research Society). Selectivity of herbicides to sunflower plants was followed according to the 9-rate scale of EWRS (rating 1 - without damages, rating 9 - crop is completely destroyed). The mathematical processing is done with analysis of variance method.

RESULTS AND DISCUSSIONS

Dominant weeds that determine secondary weeding in the experiment field are annual broadleaved species *Xanthium strumarium* L., *Amaranthus retroflexus* L., *Amaranthus albus* L., *Chenopodium album* L., *Solanum nigrum* L., *Datura stramonium* L., *Abutilon teophrasti* Medic., *Polygonum aviculare* L., a lesser amount *Amaranthus blifoides* W., *Portulaca oleracea* L., *Hibiscum trionum* L., *Tribulus terrestris* L.
Annual grassy weeds are represented by *Echinochloa crus-galli* L., *Panicum sanguinale* L., *Setaria viridis* Beauv., *Setaria glauca* Beauv. In a lesser amount are *Avena fatua* L., *Echinochloa coarctata* Vas., *Setaria verticilata* Beauv.
Perennial species in experiment are broadleaved weeds *Cirsium arvense* Scop. and *Convolvulus arvensis* L. and graminaceous weed *Sorghum halepense* Pers. mainly by seeds.
Herbicides Pulsar plus and Listego destroy completely *Setaria viridis* Beauv., *Setaria glauca* Beauv., *Setaria verticilata* Beauv., *Echinochloa crus-galli* L., *Panicum sanguinale* L., *Amaranthus retroflexus* L., *Amaranthus albus* L., *Amaranthus blifoides* W., *Chenopodium album* L., *Sinapis arvense* L., *Solanum nigrum* L., *Datura stramonium* L., *Abutilon teophrasti* Medic., *Polygonum aviculare* L., *Portulaca oleracea* L., *Hibiscum trionum* L., *Tribulus terrestris* L. et al. (Table 2). Pulsar plus and Listego fully destroyed and *Xanthium strumarium* L. These herbicides control successfully and perennial weeds - *Sorghum halepense* Pers. from seeds and rhizomes *Cirsium arvense* Scop. and *Convolvulus arvensis* L. (Table 3).
To the herbicide Listego is necessary to add adjuvant Dash for better control of weeds with wax coating leaves, as *Chenopodium album* L. or of weeds with pappus leaves, as *Polygonum aviculare* L. Herbicide Pulsar Plus does not require adjuvants for the effective control of these weeds. Tank mixtures Pulsar plus + Stomp aqua and Listego + Sharpen ensuring effective control of secondary emerged annual weeds.
Pulsar plus and Listego fully control and *Orobanche cumana* Wall. This weed grows with the sunflower hybrids Bacardy (by ClearField plus technology) and Estiva (by ClearField technology), and then destroyed by herbicides. By one side Pulsar plus and Listego have completed control against this parasitic weed and by other side the herbicides decrease its seed reserve in the soil.
By conventional and ExpressSun technologies fight agains *Orobanche cumana* Wall. is conducted by using resistant hybrids. Hybrids Sumico (by ExpressSun technology) and Arizona (by conventional technology) which are included in the experience are resistant to all its races.
Herbicide Express controls of 100% all perennial and annual broadleaved weeds - *Cirsium arvense* Scop., *Convolvulus arvensis* L., *Amaranthus retroflexus* L., *Chenopodium album* L., *Solanum nigrum* L., *Datura stramonium* L., *Abutilon teophrasti* Medic., *Portulaca oleracea* L., *Sinapis arvense* L., *Polygonum aviculare* L., *Hibiscum trionum* L., *Papaver rhoes* L., *Capsella bursa-pastoris* L., *Tribulus terrestris* L. et al. To the herbicide Express is absolutely necessary adding adjuvant Trend for better control of weeds with wax coating leaves, as *Chenopodium album* L. or of weeds with pappus leaves, as *Polygonum aviculare* L.

Table 2. Efficacy of some vegetation-applied herbicides and tank mixtures against annual broadleaved weeds at sunflower according to the 100% visual scale of EWRS (mean 2012-2014)

	Variants	*Xanthium strumarium*	*Amaranthus retroflexus*	*Chenopodium album*	*Solanum nigrum*	*Datura stramonium*	*Abutilon theophrasti*	*Polygonum aviculare*	*Sinapis arvense*
Gardoprim plus gold - 3.5 l/ha	**ClearField plus technology - hybrid Bacardy**								
	Check	0	0	0	0	0	0	0	0
	Pulsar plus - 1.2 l/ha	100	100	100	100	100	100	100	100
	Pulsar plus - 1.2 l/ha + Stomp aqua - 2.3 l/ha	100	100	100	100	100	100	100	100
	ClearField technology - hybrid Estiva								
	Check	0	0	0	0	0	0	0	0
	Listego 40 - 1.2 l/ha	100	100	85	100	100	100	87	100
	Listego 40 - 1.2 l/ha + Dash HC - 500 ml/ha	100	100	100	100	100	100	100	100
	Listego 40 - 1.2 l/ha + Sharpen 33 EC - 2.3 l/ha	100	100	88	100	100	100	92	100
	Listego 40 - 1.2 l/ha + Dash HC - 500 ml/ha + Sharpen 33 EC - 2.3 l/ha	100	100	100	100	100	100	100	100
	ExpressSun technology - hybrid Sumico								
	Check	0	0	0	0	0	0	0	0
	Express 50 SX - 40 g/ha + Trend 90 - 0.1 %	100	100	100	100	100	100	100	100
	Express 50 SX - 40 g/ha + Lactofol B - 8 l/ha	96	100	90	100	100	100	93	100
	Express 50 SX - 40 g/ha + Trend 90 - 0.1 % + Select super 120 EC - 1.6 l/ha	100	100	100	100	100	100	100	100
	Express 50 SX - 40 g/ha + Lactofol B - 8 l/ha + Select super 120 EC - 1.6 l/ha	96	100	90	100	100	100	93	100
	Conventional technology - hybrid Arizona								
	Check	0	0	0	0	0	0	0	0
	Smerch 24 EC - 800 ml/ha + Amalgerol premium - 5 l/ha	96	100	100	100	100	100	100	100
	Pendigan 330 EC- 4 l/ha + Amalgerol premium - 5 l/ha	0	100	100	100	95	96	100	98
	Raft 400 SC - 800 ml/ha + Amalgerol premium - 5 l/ha	90	100	100	100	98	100	100	100
	Wing P - 4 l/ha + Amalgerol premium - 5 l/ha	0	100	93	100	80	90	95	92
	Pledge 50 WP - 80 g/ha + Amalgerol premium - 5 l/ha	90	100	100	100	100	95	100	100
	Modown 4 F - 1.5 l/ha + Amalgerol premium - 5 l/ha	0	100	100	100	100	100	100	100

Herbicide Express controls of 100 % all perennial and annual broadleaved weeds - *Cirsium arvense* Scop., *Convolvulus arvensis* L., *Amaranthus retroflexus* L., *Chenopodium album* L., *Solanum nigrum* L., *Datura stramonium* L., *Abutilon teophrasti* Medic., *Portulaca oleracea* L., *Sinapis arvense* L., *Polygonum aviculare* L., *Hibiscum trionum* L, L., *Papaver rhoes* L., *Capsella bursa-pastoris* L., *Tribulus terrestris* L. et al.

Table 3. Efficacy of some vegetation-applied herbicides and tank mixtures against perennial broadleaved, annual and perennial graminaceous weeds at sunflower according to the 100% visual scale of EWRS and selectivity according to the 9-rate scale of EWRS (mean 2012-2014)

	Variants	Weeds							Selectivity
		Cirsium arvense	*Convolvulus arvensis*	*Echinochloa crus-gali*	*Setaria viridis*	*Setaria glauca*	*Digitaria sangvinale*	*Sorgum helepense*	
Gardoprim plus gold - 3.5 l/ha	ClearField plus technology - hybrid Bacardy								
	Check	0	0	0	0	0	0	0	1
	Pulsar plus - 1.2 l/ha	100	100	100	100	100	100	100	1
	Pulsar plus - 1.2 l/ha + Stomp aqua - 2.3 l/ha	100	100	100	100	100	100	100	1
	ClearField technology - hybrid Estiva								
	Check	0	0	0	0	0	0	0	1
	Listego 40 - 1.2 l/ha	100	100	100	100	100	100	90	2
	Listego 40 - 1.2 l/ha + Dash HC - 500 ml/ha	100	100	100	100	100	100	100	2.5
	Listego 40 - 1.2 l/ha + Sharpen 33 EC - 2.3 l/ha	100	100	100	100	100	100	90	2
	Listego 40 - 1.2 l/ha + Dash HC - 500 ml/ha + Sharpen 33 EC - 2.3 l/ha	100	100	100	100	100	100	100	2.5
	ExpressSun technology - hybrid Sumico								
	Check	0	0	0	0	0	0	0	1
	Express 50 SX - 40 g/ha + Trend 90 - 0.1 %	100	100	0	0	0	0	0	1
	Express 50 SX - 40 g/ha + Lactofol B - 8 l/ha	94	95	0	0	0	0	0	1
	Express 50 SX - 40 g/ha + Trend 90 - 0.1 % + Select super 120 EC - 1.6 l/ha	100	100	100	100	100	100	100	1.5
	Express 50 SX - 40 g/ha + Lactofol B - 8 l/ha + Select super 120 EC - 1.6 l/ha	94	95	100	100	100	100	100	1
	Conventional technology - hybrid Arizona								
	Check	0	0	0	0	0	0	0	1
	Smerch 24 EC - 800 ml/ha + Amalgerol premium - 5 l/ha	95	100	85	80	0	0	0	4
	Pendigan 330 EC- 4 l/ha + Amalgerol premium - 5 l/ha	0	0	97	98	98	95	50*	3
	Raft 400 SC - 800 ml/ha + Amalgerol premium - 5 l/ha	90	98	100	100	100	100	50*	3
	Wing P - 4 l/ha + Amalgerol premium - 5 l/ha	0	0	100	100	100	100	50*	3
	Pledge 50 WP - 80 g/ha + Amalgerol premium - 5 l/ha	90	95	90	90	90	90	0	3.5
	Modown 4 F - 1.5 l/ha + Amalgerol premium - 5 l/ha	0	0	0	0	0	0	0	3

*- only against *Sorghum helepense* Pers. by seeds

To the herbicide Express is absolutely necessary to add adjuvant Trend for better control of weeds with wax coating leaves, as *Chenopodium album* L. or of weeds with pappus leaves, as *Polygonum aviculare* L.

Express is a typical antibroadleaved herbicide. It does not have antigraminaceous effect. At presence of graminaceous weeds it is necessary to combine with antigraminaceous herbicide. Tank mixture Express + Select super controls successfully also and all annual and perennial graminaceous weeds, including *Cynodon dactylon* Pers., *Agropyrum repens* L. and *Sorghum halepense* Pers. from rhizomes. The replacement of adjuvant Trend with complex foliar fertilizer Lactofol B in mixture Express + Select super increase selectivity of this tank herbicide mixture, but decrease its efficacy against some annual broadleaved weeds as *Xanthium strumarium* L., *Chenopodium album* L. and *Polygonum aviculare* L.

Herbicides Smerch, Raft and Pledge applied as tank mixtures with growth regulator Amalgerol premium have efficacy from 90 to 100% against annual broadleaved weeds *Xanthium strumarium* L., *Amaranthus retroflexus* L., *Chenopodium album* L., *Solanum nigrum* L., *Datura stramonium* L., *Abutilon teophrasti* Medic., *Portulaca oleracea* L., *Sinapis arvense* L. Partial recovery is observed only single (often passed optimal stage of treatment) weeds of *Xanthium strumarium* L. Herbicide Smerch has stronger effect on *Cirsium arvense* Scop. from perennial weeds and depress more their development compared with *Convolvulus arvensis* L. Raft and Pledge are efficacy against *Convolvulus arvensis* L. compared with *Cirsium arvense* Scop. The effect of these three herbicides on *Xanthium strumarium* L., *Cirsium arvense* Scop. and *Convolvulus arvensis* L. is totally in the early stages of their development - from cotyledons stage to the emergence of the first true leaf at *Xanthium strumarium* L. and to 2-3 leaves stage at *Cirsium arvense* Scop. and *Convolvulus arvensis* L. At later treatment is achieved only a retardation of development of these three weeds, but sunflower developing faster, overcomes competition and overshadows weeds. At the other cases foliar treatment with Smerch, Raft or Pledge, combined with soil-applied of Gardoprim plus gold has good control of broadleaved weeds at conventional herbicide Arizona.

Herbicides Smerch, Raft and Pledge have also antigraminaceous affect. Raft in combination with Gardoprim plus gold has very good efficacy against annual graminaceous weeds *Echinochloa crus-galli* L., *Setaria viridis* Beauv., *Setaria glauca* Beauv., *Panicum sanguinale* L., *Avena fatua* L. Combination Pledge + Gardoprim plus gold is inefficacy against *Avena fatua* L., but is efficacy at 90% against *Echinochloa crus-galli* L., *Setaria viridis* Beauv., *Setaria glauca* Beauv. and *Panicum sanguinale* L. Smerch is efficacy at 80-90% against *Setaria viridis* Beauv., and *Echinochloa crus-galli* L., but is inefficacy against *Setaria glauca* Beauv., *Panicum sanguinale* L. and *Avena fatua* L.

Combinations of herbicides Pendigan and Wing applied as tank mixtures with growth regulator Amalgerol premium, after soil-applied of Gardoprim plus gold are inefficacy against *Xanthium strumarium* L., *Cirsium arvense* Scop. and *Convolvulus arvensis* L. Pendigan and Wing have very good antigraminaceous effect, including *Sorghum helepense* Pers. from rhizomes. They should be used at mixed weed infestation with annual graminaceous weeds and some broadleaved weeds, but in the absence of *Xanthium strumarium* L., *Cirsium arvense* Scop. and *Convolvulus arvensis* L.

Combination of herbicide Modown applied as tank mixture with growth regulator Amalgerol premium, after soil-applied of Gardoprim plus gold is inefficacy against *Xanthium strumarium* L., *Cirsium arvense* Scop. and *Convolvulus arvensis* L. This combination has inefficacy against annual graminaceous weeds *Echinochloa crus-galli* L., *Setaria viridis* Beauv., *Setaria glauca* Beauv., *Panicum sanguinale* L., *Avena fatua* L. This combination should be used at weed infestation mainly with annual broadleaved weeds, on which it exhibits efficacy from 95 to 100%.

After treatment with herbicides Pulsar plus, Listego and Express are visible weak phytotoxic effect in sunflower 2-3 days after treatment. At Listego they initially are stronger (rate 2-2.5 according to the scale of EWRS) than Pulsar plus and Express (rate 1 according to the scale of EWRS), and overcome more slowly. This is due to the addition of adjuvant Dash to Listego so as to increase the efficiency of the herbicide against weeds with wax coating leaves, as *Chenopodium album* L. or of weeds with pappus leaves, as *Polygonum aviculare* L. The signs of phytotoxicity disappeared 8-10 days after treatment. Thereafter do not have any signs of phytotoxicity during vegetation influenced by herbicide Listego. Weak phytotoxic events in sunflower plants by technology ClearField plus and ExpressSun overcomes faster than those ones by the technology ClearField.

Foliar use of herbicides Smerch, Pendigan Raft, Wing, Pledge and Modown during 3-4 leaf pair stage causes high phytotoxicity by sunflower hybrid Arena - yellow and white spots on the leaves that the herbicides fell. Phytotoxicity is the highest by Smerch, followed by Pledge. After vegetative treatment for 10 days the damage rating reaches to 4 by Goal, and to 3.5 by Pledge, 9-rate according to the scale of EWRS. At herbicides Pendigan, Raft, Wing and Modown phytotoxicity is weaker - rate 3 according to the scale of EWRS. Signs of phytotoxicity appear early by Smerch and Pledge - at the second day after treatment, followed by Pendigan - at the third day. At Raft, Wing and Modown phytotoxicity appears later. Use of growth stimulator Amalgerol premium with herbicides Smerch, Pendigan, Raft, Wing, Pledge and Modown as tank mixtures increases the selectivity of herbicides. Amalgerol premium assists also for faster overcoming the phytotoxic events of these six herbicides. At Smerch and Pledge although phytotoxicity is strongest, under influence of Amalgerol premium it overcomes equally with that one of Pendigan, Raft, Wing and Modown.

These six herbicides did not show systemic action and damage to sunflower consists of contact necrosis on the leaves where vegetation tip is remained. Duration of full recovery of damaged plants ranged from 15 to 20 or 30 days and it is directly dependent by agro-meteorological conditions. The damages are stronger and lengthy in conditions of extreme drought during the period after herbicide treatment - in 2013, and weaker - in cool and wet weather during this period - in 2014.

Data about the influence of the investigated herbicides, adjuvants, foliar fertilizers, stimulators and their tank mixtures on sunflower seed yields (Table 4) show that the lowest yields were obtained by the checks by fourth technologies for sunflower growing, treated with soil-applied herbicide Gardoprim plus gold.

The biggest increase in seed yields in ClearField plus technology is obtained by herbicide tank mixture Pulsar plus + Stomp aqua - 129.4% over untreated check. The alone use of herbicide Pulsar plus leads to lower yields as a result of secondary weed infestation, especially in the more humid years. Differences between the two variants are small and have not been mathematically proven.

The highest yield at ClearField technology is obtained by tank mixture Listego + Dash + Sharpen - 129.3% over the check. The use of the herbicide Listego with adjuvant Dash, but without herbicide Sharpen, leads to lower yields due to the lack of control of the secondary emerged weeds, especially during more humid years. Herbicide tank mixture Listego + Sharpen, but without adjuvant Dash, leads even lower yields. The main reason for this is insufficient control during the all vegetation period of weeds with wax coating leaves, as *Chenopodium album* L. or of weeds with pappus leaves, as *Polygonum aviculare* L.

The lowest yield at ClearField technology is obtained by alone use of herbicide Listego without adjuvant and without partner soil-applied herbicide.

The highest yield at ExpressSun technology is obtained by tank mixture Express + Trend + Select super - 128.9% over the check. Substituting of adjuvant Trend with complex foliar fertilizer Lactofol B in herbicide mixture Express + Select super leads to poor and mathematically unproven yield decrease. Bigger yield decrease is obtained by combinations Express + Trend and Express + Lactofol B. Herbicide Express is a typical antibroadleaved herbicide and cannot control annual and perennial graminaceous weeds in the absence of antigraminaceous herbicide.

It was studied six herbicides with foliar and soil action at conventional technology for sunflower growing. They are applied as tank mixtures with growth stimulator Amalgerol premium to decrease their phytotoxicity.

The highest yields are obtained by combinations Smerch + Amalgerol premium, Wing + Amalgerol premium and Raft + Amalgerol premium, followed by combinations Pledge + Amalgerol premium and Modown + Amalgerol premium. The worst result is obtained by combining of herbicide Pendigan with Amalgerol premium. Growth stimulator in this tank mixture does not decrease the herbicide phytotoxicity. At all variants by conventional technology seed yields are lower than those of technologies ClearField plus, ClearField and ExpressSun. The main reason for this is the impossibility in conventional technology to control weeds as *Xanthium strumarium* L., *Cirsium arvense* Scop. and *Convolvulus arvensis* L.

Table 4. Influence of some vegetation-applied herbicide and tank mixtures on sunflower seed yield (2012-2014)

	Variants	2012		2013		2014		Mean	
		kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%
Gardoprim plus gold - 3.5 l/ha	**ClearField plus technology - hybrid Bacardy**								
	Check	1976	100	1845	100	2142	100	1991	100
	Pulsar plus - 1.2 l/ha	2450	124.0	2334	126.5	2872	134.1	2552	128.2
	Pulsar plus - 1.2 l/ha + Stomp aqua - 2.3 l/ha	2474	125.2	2354	127.6	2898	135.3	2576	129.4
	ClearField technology - hybrid Estiva								
	Check	1965	100	1825	100	2120	100	1970	100
	Listego 40 - 1.2 l/ha	2384	121.3	2241	122.8	2820	133.0	2476	125.7
	Listego 40 - 1.2 l/ha + Dash HC - 500 ml/ha	2417	123.0	2283	125.1	2864	135.1	2516	127.7
	Listego 40 - 1.2 l/ha + Sharpen 33 EC - 2.3 l/ha	2401	122.2	2268	124.3	2845	134.2	2500	126.9
	Listego 40 - 1.2 l/ha + Dash HC - 500 ml/ha + Sharpen 33 EC - 2.3 l/ha	2439	124.1	2312	126.7	2894	136.5	2548	129.3
	ExpressSun technology - hybrid Sumico								
	Check	1952	100	1856	100	2180	100	1996	100
	Express 50 SX - 40 g/ha + Trend 90 - 0.1 %	2376	121.7	2285	123.1	2921	134.0	2521	126.3
	Express 50 SX - 40 g/ha + Lactofol B - 8 l/ha	2346	120.2	2264	122.0	2886	132.8	2495	125.0
	Express 50 SX - 40 g/ha + Trend 90 - 0.1 % + Select super 120 EC - 1.6 l/ha	2409	123.4	2355	126.9	2956	135.6	2573	128.9
	Express 50 SX - 40 g/ha + Lactofol B - 8 l/ha + Select super 120 EC - 1.6 l/ha	2385	122.2	2327	125.4	2906	133.3	2535	127.0
	Conventional technology - hybrid Arizona								
	Check	1979	100	1889	100	2222	100	2030	100
	Smerch 24 EC - 800 ml/ha + Amalgerol premium - 5 l/ha	2333	117.9	2286	121.0	2620	117.9	2442	120.3
	Pendigan 330 EC- 4 l/ha + Amalgerol premium - 5 l/ha	2308	116.6	2221	117.6	2591	116.6	2355	116.0
	Raft 400 SC - 800 ml/ha + Amalgerol premium - 5 l/ha	2351	118.8	2257	119.5	2640	118.8	2436	120.0
	Wing P - 4 l/ha + Amalgerol premium - 5 l/ha	2343	118.4	2272	120.3	2631	118.4	2438	120.1
	Pledge 50 WP - 80 g/ha + Amalgerol premium - 5 l/ha	2327	117.6	2263	119.8	2613	117.6	2420	119.2
	Modown 4 F - 1.5 l/ha + Amalgerol premium - 5 l/ha	2311	116.8	2221	117.6	2595	116.8	2395	118.0
	LSD 5 %	121		110		123			
	LSD 1 %	136		125		140			
	LSD 0.1 %	148		139		157			

CONCLUSIONS

Herbicide Pulsar plus by Clearfield plus technology and herbicide Listego by Clearfield technology, destroy completely all annual and perennial graminaceous and broadleaved weeds in sunflower crops, including *Orobanche cumana* Wall.

Herbicide Express by ExpressSun technology, controls all perennial and annual broadleaved weeds. Tank mixture of Express with antigraminaceous herbicide Select super controlled successfully and all annual and perennial weeds.

The highest seed yield is obtained at herbicide tank mixture Pulsar plus + Stomp aqua by Clearfield plus technology.

Tank mixture Listego + Dash + Sharpen by Clearfield technology and Express + Trend + Select super by ExpressSun technology also lead to obtaining of high seed yields.

Tank mixtures of herbicides Smerch, Pendigan, Wing, Raft, Pledge and Modown with Amalgerol premium by conventional technology have lower yields due to insufficient control of weeds as *Xanthium strumarium* L., *Cirsium arvense* Scop., *Convolvulus arvensis* L. in sunflower crops.

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INVESTIGATION OF THE PRODUCTION POSSIBILITY OF EARLY MAIZE HYBRIDS, CULTIVATED FOR GRAIN UNDER NON-IRRIGATION IN NORTH-EAST BULGARIA

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Abstract

The field experiment was held in the experimental of the selected area in Tulenovo village in region Shabla (North-East Bulgaria) during the period 2015-2017. The test was performed by means of a block method with four repetitions; experimental field area - 25 m² after winter triticale predecessor. The following hybrids of Syngenta Company were tested; Ambishas, Cansas, Cobalt, Ulises and Iridium. The aim of the study was to establish the elements of productivity and the yield of early maize hybrids, cultivated for grain under non-irrigation in North-East Bulgaria. All the stages of the established technology for maize growing were followed. The grain yield is determined with standard grain moisture of 13%. The indices; length of the cob (cm), number of the row per cob, number of the grains per row, mass of the cob, mass of the grains per cob (g) thousand kernel weight (g), test weight (kg), and grain yield (kg/ha) were determined. The analysis of the results showed that the production possibility of hybrids maize is determined to a great degree by the meteorological conditions of the year mostly by the precipitation quantity. The highest values of elements of productivity were reported with the hybrid Iridium and the lowest - with the Cansas hybrid. On average during the period of the study (2015-2017), the highest grain yield was obtained from Iridium - 8007 kg/ha, followed by Ulises - 7690 kg/ha and the lowest - from hybrid Cansas - 6893 kg/ha. The highest weight of thousand kernel (grain) and test weight of maize grain was reported for Iridium hybrid (367 g and 76.9 kg). Out of the studied maize hybrids grown in the region of North-Eastern Bulgaria, it is recommended to cultivate hybrid Iridium, as it proved to be more productive than hybrids Ambishas, Cansas, Cobalt and Ulises in climatically different years.

Key words*: maize, hybrids, elements of productivity, yield of grain, thousand kernel (grain), test weight.*

INTRODUCTION

The need to diversify and enrich the genetic reserve in the selection practice requires a continuous study of new and world-wide maize hybrids (Chen et al., 2013; Dong et al.,2016; Ilchovska, 2017; Kandil, 2013; Liu, et al., 2012; Popova et al., 2015; Yankov et al., 2014).
This is the subject of thorough and purposeful research on which doesn't cease to work. On the basis of the studies in the proceedings new maize hybrids are included with high genetic potential.
Cultivated in different agro-environmental regions of the country, they are of great interest and have a definite significance of scientific and practical significance. (Delibaltova, 2014; Dimitrova et al., 2013; Niaz et al., 2014; Popova et al., 2012; Zivkov & Matev, 2005). Proper choice of hybrid selection is decisive for the yield value and quality of the harvest product. This requires the continued introduction of better and stronger hybrids that are most appropriate and effective for individual micro-regions of the country.
A number of scientists (Delibaltova, 2018; Kirchev, 2016; Tsankova et al., 2006) are working on studying the productivity of maize hybrids, recommending the most suitable for growing in the different regions of the country.
The aim of the study was to establish the elements of productivity and the yield of early maize hybrids, cultivated for grain under non - irrigation in North-East Bulgaria.

MATERIALS AND METHODS

The field experiment was held in the experimental of the selected area in Tulenovo village in region Shabla (North-East Bulgaria) during the period 2015-2017. The test was performed by means of a block method with four repetitions; experimental field area - 25 m² after winter triticale predecessor. The following

hybrids of Syngenta Company were tested; Ambishas, Cansas, Cobalt, Ulises and Iridium.
The basic of soil treatment includes a reversal of stubble in August at a depth of 10-12 cm and a deeper plow at 28-30 cm in October. Annually, before sowing treatment include of double spring cultivation with harrowing in March and April. Autumn saving fertilization before deep plowing with 25 kg active substance phosphorus (50 kg triple super-phosphate) and before seeded 10.2 kg active substance nitrogen (30 kg ammonium nitrate).
Annually sowing is carried out in the second 10 days of April. The seeds were pre-treated against diseases by the manufacturer Syngenta. Immediately after sowing done rolling the crop. Pesticides were used to control the weeds, diseases and insects. During the vegetation of the corn, two inter-row treatments were carried out. The indices; length of the cob (cm), number of the row per cob, number of the grains per row, mass of the cob, mass of the grains per cob (g) thousand kernel weight (g), test weight (kg), and grain yield (kg/ha) were determined.
For the purpose of determining the quantity dependence between the studied indicators, the experimental data were processed according to the Anova Method of dispersion analysis, and the differences between the variants were determined by means of the Dunkan's Multiple Range Test.

RESULTS AND DISCUSSIONS

The main climatic factors determining growth and yield of maize are temperature and rainfall as it is combining and distributed during the vegetation period. The analysis of these factors shows that in the three years of the study (2015-2017), average monthly temperatures have similar values and meet fully the requirements the maize of heat from sowing to harvesting, while the amount and distribution of rainfall varies during in the different years.
In 2016, rainfall in the April-September period was 244.3 mm, i.e. values lower (by 42.6 mm) than the multi-year period (287.0 mm) and too unevenly distributed.
In the period April-June the amount of rainfall was significantly - 193.5 mm, which gave hopes for a year with high yields in maize - yields to offset favourable purchase prices. But at the end of June almost everywhere drought began, drought exceeded two months, as from June temperatures reached 28-29°C and in July even 40°C. During the growth phases, rainfall was almost lacking, and the temperature was over 35°C, which adversely affected the growth processes and yields of corn plants. In 2015, the amount of rainfall during the maize growing season was 337.7 mm at 319.6 mm for the multi-year period or 26 mm more than 2016. The last year of the survey (2017) is characterized by a higher sum of rainfall than the previous one - 368.7 mm.
Of the three years of study, the most favourable for maize in 2017, follows in 2015 and less favourable in 2016. The resulting averages for the structural elements of the extraction is presented in Table 1. The results show that these indicators change under the influence of meteorological factors during the survey years.
The highest values of the main structural elements of the yield were reported in 2017, followed in 2015, and the lowest in 2016. From the studied hybrids Iridium is distinguished from the others with longer cobs, with more rows and grains in the cob, as well as with a larger mass of cobs and grains.
The highest values of the main structural elements of the yield were reported in 2017, followed in 2015, and the lowest in 2016. From the studied hybrids Iridium is distinguished from the others with longer cobs, with more rows and grains in the cob, as well with a larger mass of cobs and grains. Average for the period of study length of the cob in hybrid Iridium is 18.0 cm and superior hybrids Ulises and Cobalt 5.3%, Ambishas with 14.6% and 20.0% in Cansas. In favourable for the growth and development of plants were recorded at 2017 - high values of number of grains in a row they range from 28.0 pcs. with hybrid Cansas up to 42.0 at - Iridium. Hybrid Ulises superior hybrids Cobalt and Ambishas by 11.8 and 26.7%, and hybrid Kansas 35.7% but inferior to Iridium 10.5%. In 2016, the maize hybrids tested produced a smaller number of grains in a row compared to the previous one. This indicator ranges from 24.0 to 32.0, i.e. from 16.7% to 31.2% lower. In the first year of the study maize hybrids formed from 26.0 to 38.0 grains per line and exceeded 8.3 to 18.7%

obtained in 2016 but declined from 10.5 to 16.5% of those in 2017. On average over the test period, a large number of grains in a row realized the Hybrid Iridium - 37.3 pcs followed by Ulises- 34.0 pcs and the lowest value was recorded in the Cansas hybrid - 26.0 pcs. The indicator table on the ear in the test hybrid is amended during the years, ranging from 160 g to 200 g in 2015, from 140 to 240 in 2016 and from 170 to 270 g in 2017 The values of this parameter are highest in hybrid Iridium, and the lowest at Cansas.

Table 1. Structural elements of the yield

		Length of the cob, cm	Number of the row per cob	Number of the grains per row	Mass of the cob	Mass of the grains per cob, g
Years (A)	2015	16.6^{b}	15.8^{b}	32.6^{b}	194.0^{b}	167.0^{b}
	2016	15.4^{a}	13.8^{a}	27.2^{a}	180.4^{a}	147.0^{a}
	2017	17.8^{c}	16.3^{c}	34.4^{c}	210.2^{c}	176.0^{c}
Hybrid (B)	Ambishas	15,7	14.5	28,7	173.0	140.0
	Canzas	15,0	13.4	26,0	157.0	128.0
	Cobalt	17,0	15.2	31,0	183.0	148.0
	Ulises	17,3	16.0	34,0	204.0	177.0
	Iriduun	18,0	17.3	37,3	257.0	225.0
2015	Ambishas	15,5^{a}	15,0^{ab}	30,0^{b}	170^{b}	140^{a}
	Canzas	15,0^{a}	14,0^{a}	26,0^{a}	160^{a}	135^{a}
	Cobalt	17,0^{b}	15,5^{b}	33,0^{c}	180^{c}	150^{b}
	Ulises	17,5^{bc}	16,5^{b}	36,0^{d}	200^{d}	180^{c}
	Iriduun	18,0^{c}	18,0^{c}	38,0^{d}	260^{e}	230^{d}
2016	Ambishas	14,5^{b}	13,0^{b}	26,0^{b}	160^{b}	130^{b}
	Canzas	14,0^{a}	12,0^{a}	24,0^{a}	140^{a}	110^{a}
	Cobalt	16,0^{c}	14,0^{c}	26,0^{b}	170^{c}	135^{b}
	Ulises	16,0^{c}	14,0^{c}	28,0^{c}	192^{d}	160^{c}
	Iriduun	16,5^{d}	16,0^{d}	32,0^{d}	240^{e}	200^{d}
2017	Ambishas	17,0^{b}	15,5^{a}	30,0^{b}	190^{b}	150^{b}
	Canzas	16,0^{a}	14,3^{ab}	28,0^{a}	170^{a}	140^{a}
	Cobalt	18,0^{c}	16,0^{ab}	34,0^{c}	200^{c}	160^{c}
	Ulises	18,5^{cd}	17,5^{bc}	38,0^{d}	220^{d}	190^{d}
	Iriduun	19,5^{d}	18,0^{c}	42,0^{e}	270^{e}	244^{e}
Anova	A	*	*	**	**	**
	B	*	*	**	**	**
	AB	n.s	n.s	*	n.s	n.s

*Means within columns followed by different lowercase letters are significantly different (P<0.05) according to the LSD test
* F-test significant at P<0.05; ** F-test significant at P<0.01;
ns - non-significant

On average, for the period 2014-2016, the mass of the cat in the hybrids studied ranges from 157 to 257 g. Hybrid Iridium exceed 48 g, 77 g, 85 g and 97 g in the values of this parameter hybrids Ulises, Cobalt, Ambishas and Cansas. Differences in climatic conditions during the years of the experiment are one of the reasons for the formation of grains of different mass. In the second year of study (2016), due to insufficient moisture in maize growing, the grain mass in the hull varies from 110 g in the Cansas hybrid to 200 g at Iridium. In the first experimental year, which is favourable for the growth and development of corn plants, this indicator ranges from 135 g to 230 g in the hybrids under study, or 15% to 23% more than in 2016. The third experimental year, the most corn-friendly corn, the grain mass in the cob ranges from 140 g in the Cansas hybrid to 244 g at - Iridium.

Intermediate for the experimental period, the Iridium hybrid formed with 48 g, 77 g, 85 g, and 97 g greater grain mass in the coke compared to Ulises, Cobalt, Ambishas and Cansas respectively.

The results obtained for the grain yield of the maize hybrids tested show that both the productivity components and the values of this indicator vary depending on the weather conditions during the experiment years (Table 2). Falling vegetation rainfall, their good distribution and combined with monthly average temperatures favour higher grain yields in 2017 compared to 2015 and 2016.

During the last experimental year, this indicator is 9.7% and 4.0% higher than the second and first business year.

In 2017, the highest yield was statistically proven from the Iridium hybrid - 8160 kg/ha, followed by Ulises (8040 kg/ha) and Cobalt (7990 kg/ha), and the lowest - from Cansas (7170 kg/ha).

Table 2. Grain yield, kg/ha

Hybrid	Years of study			Average for the period kg/ha
	2015 kg/ha	2016 kg/ha	2017 kg/ha	
Ambishas	7320^{b}	6750^{b}	7710^{b}	7260
Canzas	7010^{a}	6500^{a}	7170^{a}	6893
Cobalt	7460^{c}	7260^{c}	7990^{c}	7570
Ulises	7680^{d}	7350^{d}	8040^{d}	7690
Iriduun	8100^{e}	7760^{e}	8160^{e}	8007
Mean values for Years	7514	7124	7814	7484

* Means within columns followed by different lowercase letters are significantly different (P<0.05) according to the LSD test

The uneven distribution of rainfall during the 2016 vegetation and especially its shortage during the collapse and harvesting of corn are the reason for the reported lower grain yields compared to the others included in the experiment. In test hybrids, they range from 6500 to 7760 kg/ha. This year's hybrid, Ulises, has proven to outperform Ambishas and Cobalt by 8.9 and 2.1%, but yields to Iridium by 5.6%. It is mathematically proven that the Iridium hybrid was obtained on average 11.4% higher than the others. The lowest grain yield was obtained from the Cansas hybrid.

In the first year of experience (2015), grain yields are in the range of 7010 to 8100 kg/ha, i.e. up to 390 kg/ha more than in 2016. The highest yield is realized by hybrid Iridium and proven superior to 420, 640, 780 and 1090 kg/ha hybrids Ulises, Cobalt, Ambishas and Cansas, respectively.

Average for the period of examination of the tested hybrids at - high yield is Iridium and realized grain yield to 8007 kg/ha he is superior to 4.1, 5.8 and about 10.3% hybrids Ulises, Cobalt and Ambishas, and the - or low-yield is Cansas (6893 kg/ha). This hybrid is statistically proven by the hybrids - Iridium with 16.2%, Ulises with 11.6%, Cobalt with 9.8 and Ambishas with 5.3%. The grain yield dispersion analysis showed a strongly statistically proven influence of both the genetic hybrids of the hybrids and the years with their specific climatic conditions (Table 3). There is also a well-proven interaction between Hybrid and Year.

Table 3. Analysis of variance ANOVA

Source of Variation	Sum of Square	df	Mean Square	F	P-value	F crit
Years**	4908790	2	2454395	246,6591	0,000	3,204317
Hybrid**	9104407	4	2276102	228,7412	0,000	2,578739
Interactions**	481443,3	8	60180,42	6,047945	0,000	2,152133
Within	447775	45	9950,556			

* F-test significant at P<0.05; ** F-test significant at P<0.01; ns - non-significant

Table 4 presents the mass data per 1000 grains and the specific mass over the years of testing and averaged over the period. The results show that these indicators are influenced by both the genetic hybrids and the climatic conditions of the year. Not so favourable for the development of corn in 2016, created the preconditions mass of 1000 grains range from 240 g in hybrid Ambishas to 350 g at - Iridium, while in 2015 the values of this indicator are on average 5.8% higher. The highest mass of 1000 grains tested hybrids in 2017 from 260 to 380 g.

Table 4. Physical properties of the grain

Hybrid	Thousand kernel (grain) weight, g				Test weight, kg			
	Years of study			Average	Years of study			Average
	2015	2016	2017		2015	2016	2017	
Ambishas	254^{a}	240^{a}	260^{a}	251	71,4^{a}	61,8^{a}	73,8^{b}	69,9
Canzas	300^{b}	280^{b}	315^{b}	298	71,7^{a}	57,2^{a}	72,0^{a}	67,0
Cobalt	335^{c}	320^{c}	340^{c}	332	75,4^{b}	68,2^{b}	76,0^{c}	73,2
Ulises	350^{c}	340^{d}	355^{d}	348	74,7^{b}	66,0^{b}	75,2^{c}	72,0
Iriduun	370^{d}	350^{e}	380^{e}	367	77,0^{c}	75,4^{c}	78,3^{d}	76,9
Mean values for Years	322	306	330	319	74.0	65.7	75.1	71.6

*Means within columns followed by different lowercase letters are significantly different
(P<0.05) according to the LSD test

During the period of the 2015-2017 experience with the wholesale grain features hybrid Iridium (367 g), followed hybrids Ulises (348 g), Cobalt (332 g) and Cansas (298 g). The smallest grains formed hybrid Ambishas.

The results of the ANOVA for the effects of the factors and their interaction on the physical characteristics of the grain are shown in Table 5. For the indicator "mass of 1000 grains" are accounted for reliable variance factors - year and hybrid reliability of $p \leq 0.01$ and the interaction between the two.

Table 5. Analysis of variance ANOVA

	Source of Variation	Sum of Square	df	Mean Square	F	P-value	F crit
Thousand kernel (grain) weight, g	Years**	5878,63	2	2939,32	13,4526	0,000	3,20432
	Hybrid**	100134	4	25033,5	114,573	0,000	2,57874
	Interactions n.s	511,2	8	63,9	0,29246	0,965	2,15213
	Within	9832,25	45	218,494			
Test weight, kg	Years**	1028,272	2	514,136	703,4928	0,000	3,204317
	Hybrid**	704,465	4	176,116	240,98	0,000	2,578739
	Interactions *	214,228	8	26,7785	36,64105	0,000	2,152133
	Within	32,8875	45	0,730833		0,000	3,204317

* F-test significant at P<0.05; ** F-test significant at P<0.01; ns - non-significant

The results of the analyses of the data on the hectolitre mass show that the most significant influence on the variation of the trait was the hybrid and the conditions of the year. The interaction of the two factors is less pronounced, $p \leq 0.05$

CONCLUSIONS

The highest values of elements of productivity (length of the cob, number of the row per cob, number of the grains per row, mass of the cob and mass of the grains per cob) were reported with the hybrid Iridium and the lowest - with the Cansas hybrid.

On average during the period of the study (2015-2017), the highest grain yield was obtained from Iridium - 8007 kg/ha, followed by Ulises - 7690 kg/ha and the lowest - from hybrid Cansas - 6893 kg/ha.

The highest weight of thousand kernel (grain) and test weight of maize grain was reported for Iridium hybrid (367 g and 76.9 kg).

Out of the studied maize hybrids grown in the region of North-Eastern Bulgaria, it is recommended to cultivate hybrid Iridium, as it proved to be more productive than hybrids Ambishas, Cansas, Cobalt and Ulises in climatically different years.

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EFFECT OF PLANTING DENSITY OF DIFFERENT MAIZE HYBRIDS ON CROP GROWTH AND YIELD

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Abstract

Three hybrids of maize of Pioneer Company (P9241, P9900 and P0023) grown at different plant densities (40000, 46000, 56000, 69000 number per ha) were studied in the experimental field of Agricultural University of Plovdiv in 2015 and 2016. The purpose of this study was to trace the influence of sowing density of maize hybrids on growth and yield. The experiments were carried out by split-plots method.
The experimental areas were fertilized with a nitrogen fertilizer rate of 240 kg/ha - ½ $CO(NH_2)_2$, applied in the 5-6 leaf stage of the plant and ½ NH_4NO_3, applied into the 10th leaf stage.
A hybrid P9900 has the highest plants at the end of vegetation. There was no significant difference between variants with plant densities - from 279.4 cm (40000 plants/ha) to 284.4 cm (56000 plants/ha). Height of plants of hybrid P9241 was the smallest - 260.5 cm at a sowing density of 40000 plants/ha.
The highest yield between 3 hybrids was obtained at a sowing density of 69000 plants per ha. Hybrid P9241 showed yield of 13800 kg/ha, while hybrid P9900 - 14257 kg/ha.

Key words: *maize, planting density, growth, yield.*

INTRODUCTION

Maize is one of the most important food and feed crops in the world. Over the last few years, there has been a steady tendency to an increase of the planted areas in Bulgaria, expanding from 328 000 ha in 2010 to 400 000 ha in 2017 (Agricultural Reports 2010-2018, website of the Ministry of Agriculture and Food in the Republic of Bulgaria). Crop density is one of the major factors determining the yield. It depends on the hybrid, the application of innovative approaches in the cultivation technology, a differentiated approach to pest control, etc. (Delibaltova et al., 2009; Delibaltova, 2018; Dimitrova et al., 2013; Dimitrova et al., 2018). The aim of the present study was to follow out the effect of maize planting density on crop growth and yield.

MATERIALS AND METHODS

In 2015 and 2016 in the Training-and-Experimental Fields of the Agricultural University in Plovdiv, precise field trials were carried out with 3 maize hybrids - **P9241, P9900** and **P0023**, grown at different planting densities (**40000, 46000, 56000** and **69000** plants per hectare). The experiments were set by the split-plot design method with a perpendicular location of the factors. Drip irrigation was provided in the experimental field during the two years of the study.
The soil in the experimental field of the Agricultural University - Plovdiv has been determined as alluvium, which based on the international classification of FAO belongs to the category of Mollic Fluvisols. It is characterized by average sandy-clay mechanical composition, not high humus content of 1.01-1.32%, a weak alkaline reaction of the soil (pH 7.6-7.9) (Popova et al., 2012).

Plant Material
Seeds of three maize hybrids for forage production of Pioneer Company were used.
According to the length of their vegetation period, the hybrids refer to the following groups, following the classification of FAO:

1. **Hybrid P0023 - 450 according to FAO**
A new hybrid, its grain releases moisture at the highest rate after reaching physiological maturity compared to the other hybrids in the

group. It is tolerant to high temperatures during flowering and grain filling, which characterizes the hybrid as drought-resistant.

2. Hybrid P9900 - 420 FAO
It is characterized by early flowering and excellent moisture release ability. Tolerant to drought. The hybrid prefers and tolerates high temperatures during flowering.

3. Hybrid P9241 - 370 according to FAO
It resists high temperatures from the intensive growth stage to the end of the grain filling stage. Due to its rapid early start, P9241 is suitable for early sowing. It is characterized by rapid release of moisture during ripening and stress resistance at emergence (www.pioneer.com).

Agro-technical practices
The experimental field was fertilized with a nitrogen fertilizer at the rate of 240 kg/ha ½ CO $(NH_2)_2$, applied at the stage of 5th-6th leaf of the crop and ½ $NH4NO_3$, applied at the stage of 10th leaf.
Weed control was carried out with the herbicide Stomp New 330 EC at a rate of 4000 ml/ha, applied after sowing before the emergence of weeds. During the vegetation, treatment was carried out at the 4th-6th leaf stage of the crop with the herbicide Principal Plus 66.5 WG - 440 g/ha + Trend 0.1%. Selectivity of the herbicide preparations to the crop was reported following EWRS (European Weed Research Society) scale: from score 1 - no damage to the crop plants, to score 9 - the crop is completely destroyed.
Soil and leaf herbicides were applied by a back-sack sprayer, the spray solution being 300 l/ha.
The agrotechnical measures were carried out according to the generally accepted technology for maize growing (soil cultivation, fertilization, sowing, rolling).

RESULTS AND DISCUSSIONS

In both experimental years, the growing season was warm, with temperatures around and above average over a long period of time. A significant difference with respect to the average monthly temperatures was established only in the initial period of crop development, i.e. in April, May and June (Figure 1).

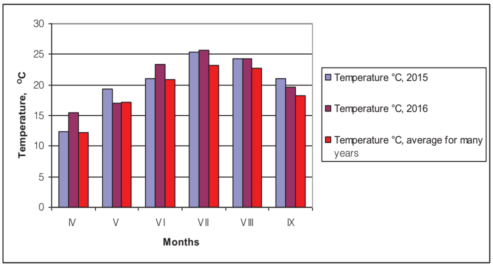

Figure 1. Temperature during the test period, °C

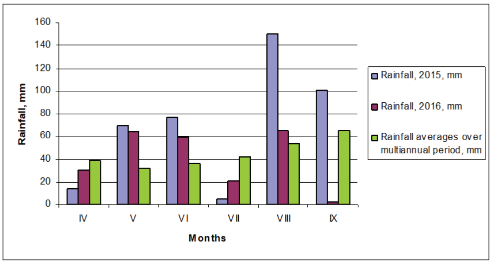

Figure 2. Rainfall during the test period, mm

The amount of rainfall during the experimental period is shown in Figure 2. In April and July 2015, a severe drought was reported, which was compensated by the large amount of rainfall during the rest period of the crop vegetation. Precipitation exceeded the average amount for a long period of time by 143 mm. In 2016, the rainfall was more evenly distributed, with a slight drought in July and September. The amount of rainfall for the vegetation period was 243.3 mm and it was close to the average for a long period of time (268 mm).
In the period 2015-2016, the experimental areas were heavily infested by weeds from the group of the annual late-spring species. Major representatives of that group were: *Amaranthus retroflexus* L., *Solanum nigrum* L., *Chenopodium album* L., *Portulaca oleraceae* L., *Datura stramonium* L., *Setaria* spp., *Echinochloa grus-galli* L. etc. The perennial weed species found are: *Sorghum halepense* Scop. and *Convolvulus arvensis* L. Those weed species are typical for the maize crop in the region (Dimitrova et al., 2013; Zhelyazkov, 2007; Tonev et al., 2007). That combination provided a good control of the weeds found in the experimental site. It was fully selective to

the 3 maize hybrids - **P9241, P9900** and **0023** (score 1, EWRS scale).

Effect of maize crop density on plant height

The height of the maize plants at the end of the vegetation season is presented in Table 1 and Figure 3, on average for the two experimental years. It should be noted that each hybrid showed different development, depending on crop density. According to the length of the vegetation season, each of the 3 hybrids belongs to a different FAO group. The highest plants were reported in hybrid **P9900**, regardless of the crop density, i.e. crop density did not have a significant influence on the studied characteristic. Plant height ranged from 279.4 cm (at 40000 plants per ha) to 284.4 cm (at 56000 plants per ha).

Hybrid **P0023** formed lower plants and the increase of plant density from 46000 to 69000 plants per hectare resulted in 13.3 cm plant height reduction.

Hybrid **P9241** belongs to 370 FAO group. That is one of the leading hybrids in this group and at the same time it does not fall behind the hybrids of the higher group in yields obtained (www.pioneer.com). At a crop density of 40 000 plants/ha, the plant height at the end of vegetation was smaller (260.5 cm) compared to the other two hybrids (Figure 3). The increase of crop density up to 56000 and to 69000 plants per hectare resulted in an increase of plant height by 19.2 cm (7.4%) and 14.2 cm (5.4%), respectively.

Table 1. Height of plants at the end of vegetation, cm

Number of harvested plants per 1 ha	Maize Hybrids		
	P9241	**P9900**	**P0023**
40000	260.5	279.9	268.5
46000	269.4	281.4	269.9
56000	279.7^{+}	284.4	259.0
69000	274.7	283.8	255.2

LSDp5%=18.45 LSDp1%=23.90 LSDp0.1%=29.45

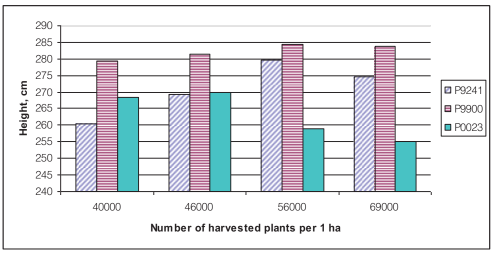

Figure 3. Height of plants at the end of vegetation, cm

Effect of maize crop density on grain yield

The grain yield of maize plants is presented in Table 2 and Figure 4, on average for the two years of the study. The highest yield of all the 3 hybrids was reported at a plant density of 69000 plants per hectare, the grain obtained ranging from 13800 kg/ha (**hybrid P9241**) to 14257 (**hybrid P9900**) kg/ha. The yield was harvested at 12% grain moisture content.

Table 2. Grain yield of maize, kg/ha

Number of harvested plants per 1 ha	Maize Hybrids		
	P9241	**P9900**	**P0023**
40000	10786	12071	12557
46000	12143	12757	12950
56000	13200^{+}	13328	13471
69000	13800^{++}	14257^{+}	14072

LSDp5%=2169 LSDp1%=2845 LSDp0.1%=3620

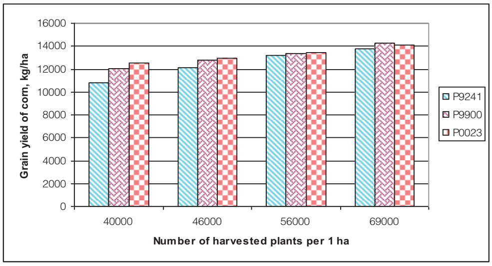

Figure 4. Grain yield of maize, kg/ha

At a planting density of 40000 plants per hectare, the lowest grain yield was established in hybrid **P9241** - 10786 kg/ha and the highest - in hybrid **P0023** - 12557 kg/ha. Similar results were established at a crop density of 46000 and 56000 plants/ha, but the difference of the values between the separate hybrids was less significant.

In hybrid **P9241**, it can be clearly seen that with the increase of the number of harvested plants from 40000 to 69000 plants per hectare, the yield also increased. The largest increase in yield was reported at the increase of the harvested plants per hectare from 40000 to 46000. The yield increase reported with the increase of plant density from 56000 to 69000 plants per hectare was less, but significant compared to the yield obtained from 40000 harvested plants per hectare.

A gradual yield increase with the increase in the number of harvested plants was also established in hybrid **P9900**. The yield increased from 12071 kg/ha at a density of 40000 plants/ha to 14257 kg/ha at 69000 plants per hectare and the difference was statistically significant.

The highest average yield, irrespective of the planting density, was established in hybrid **P0023** (13262 kg/ha), followed by the yield obtained from hybrid **P9900** (13103 kg/ha).

The yield of hybrid **P0023** gradually increased with the increase in the number of harvested plants per hectare, although in that case the increase was insignificant (Table 2).

CONCLUSIONS

The largest plant height at the end of the vegetation season was reported in hybrid **P9900**, no significant difference being established between the variants of different planting densities. Plant height ranged from 279.4 cm (at 40000 plants/ha) to 284.4 cm (at 56000 plants/ha). Hybrid **P0023** formed lower plants and the increase of planting density from 46000 to 69000 plants/ha resulted in a reduction in plant height by 13.3 cm (5%).

At a planting density of 40000 plants/ha, the plant height in hybrid **P9241** was the smallest - 260.5 cm. The increase of planting density to 56000 and 69000 plants/hectare led to an increase of plant height by 19.2 cm (7.4%) and 14.2 cm (5.4%), respectively, in contrast to hybrids **P9900** and **P0023**.

The highest yield from all the 3 studied hybrids was obtained at a planting density of 69000 plants per hectare, ranging from 13800 kg/ha (hybrid **P9241**) to 14 257 kg/ha (hybrid **P9900**), respectively.

At a planting density of 40000 plants per hectare, the lowest grain yield was obtained from hybrid **P9241** - 10786 kg/ha and the highest - from hybrid **P0023** - 12557 kg/ha. Similar results were established in the variants with a density of 46000 and 56000 plants/ha, but the difference between the hybrids was less significant.

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STUDY REGARDING THE YIELD COMPONENTS AND THE YIELD QUALITY AT SOME WHEAT VARIETIES

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Abstract

Wheat is of particular interest for the Romanian growers because it has high ecological plasticity and ensures relative constant yields. Having into account that the wheat growers are interested in varieties that produce the highest yields with good milling and bakery value, the purpose of this paper is to highlight the yield, yield components and yield quality of nine winter wheat varieties in the conditions of the reddish preluvosoil from the Romanian Plain. In this respect, under the specific climatic conditions of the 2018-2019 agricultural year, nine Romanian and foreign wheat varieties were tested under rainfed conditions on reddish preluvosoil within a field experiment in the Crop Production Didactic Field belonging to the Faculty of Agriculture, University of Agronomic Sciences and Veterinary Medicine of Bucharest.
The following determinations were performed: number of ears per m^2; number of grains per ear; weight of grains per ear; thousand grain weight – TGW (g); grain yield (kg/ha) reported at 14% moisture content; grain test weight (kg/100 l); protein content (%); wet gluten content (%).
The yielding capacity of a given wheat variety, which is determined by the values of the yield component, as well as the yield quality which is determined by several indicators are important traits in making growers to choose the variety to be cultivated.

Key words: *wheat, yield, yield components, yield quality.*

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important crop species in the world, being cultivated according to FAO database on an area which varied after 2010 year from 215.4 to 223.8 million hectares. It is grown all over the world for its wider adaptability and high nutritive value (Patel et al., 2018).
Wheat is of particular interest for the Romanian growers because it has high ecological plasticity and ensures relative constant yields. In Romania, wheat is grown on an average area of about 2 million hectares annually, with an annual variation after 2010 year from 1.95 to 2.15 million hectares. The total wheat production in the last years in Romania exceeded 10 million tons.
The wheat yield in Romania varied annually after 2010 year from 2,659 to 4,888 kg/ha under the influence of genetics used by growers (variety or hybrid), pedoclimatic conditions (soil, climatic factors, climatic accidents) and technological factors (mainly crop rotation, fertilization strategy, soil tillage, seed quality and sowing conditions, control of weeds, diseases and pests, harvesting conditions).
According to the data published by the Association of Romanian Maize Growers (2019), which tested 36 Romanian and foreign wheat varieties in five different soil and climatic conditions from Romania in the 2018-2019 agricultural year, the yield varied from 3,479 to 10,393 kg/ha.
Among all wheat traits, yield is one of the most complex and economically important character (Yousif et al., 2015).
The yield of the wheat varieties occurs due to the interaction between the varieties, which are defined by specific genetic characteristics, and the soil and climatic conditions, as well as the crop technology which is aimed at mitigating the effect of the limiting factors on yield components and yield quality (Dumbravă, 2004).
The environmental conditions have a considerable influence on yield components in relation to varieties (Mustățea et al., 2008). The

environmental impacts have a significant effect on grain yield, as well as on quality traits (Egesel et al., 2012).

Along with genetic factors, technological factors and above all, mineral fertilization is an important way to increase and stabilize the yield of winter wheat production (Dragomir, 2019).

The considerable plasticity of wheat in reaching final yield is dynamically determined by three yield components: ear number per square meter, grain number per ear, and 1000-grain weight (TGW) (Yang et al., 2018). The number of ears per unit ground area (ear density) is one of the main agronomic yield components in determining grain yield in wheat (Fernandez-Gallego et al., 2018). The grain number per ear mainly contribute to a better grain yield with some contribution by spike length as well (Mohsin et al., 2009). Among the three important components of yield in wheat, TGW is probably most influenced by the environment conditions (Kumar et al., 2019).

The quality of wheat for milling and bakery is influenced by the interaction between varieties, the environmental conditions, the applied crop technology and the effect of some climatic accidents (Dumbravă et al., 2012).

The wheat growers are interested in varieties that produce the highest yields with good milling and bakery value. Having into account this, the purpose of this paper is to highlight the yield, yield components and yield quality of nine winter wheat varieties in the conditions of the reddish preluvosoil from the Romanian Plain.

MATERIALS AND METHODS

Researches were conducted in 2018/2019 agricultural year within a field experiment in the Crop Production Didactic Field belonging to the Faculty of Agriculture, University of Agronomic Sciences and Veterinary Medicine of Bucharest. A number of nine winter wheat varieties were studied, respectively Izvor, Glosa, Otilia, Pajura, Miranda, Anapurna, Avenue, Sorrial, Rubisko, under rainfed conditions on reddish preluvosoil. Micro plots of 10 m^2 were used for each variety in three replications.

From a climatic point of view, the agricultural year 2018-2019 in the area the field experiment was performed is characterised as being warmer than normal years and more dryer in the cold season and beginning of spring, but with rainfalls in the second part of spring and beginning of summer.

Crop management. The preceding crop was peas and the soil tillage practices were the classic ones.

The sowing density was of 500 grains/m^2. The grains were treated with Yunta Quattro 373.4 FS product based on clothianidin (166.7 g/l) + imidacloprid (166.7 g/l) + prothioconazole (33.3 g/l) + tebuconazole (6.7 g/l).

Fertilization was performed as follows:

- 18:46:0 fertilizer applied upon sowing, in a rate of 100 kg/ha;
- 26:13:13 fertilizer applied in early spring, in a rate of 100 kg/ha;
- NH_4NO_3 fertilizer applied at the stem elongation stage, in a rate of 100 kg/ha;
- Folimax Gold fertilizer applied upon occurrence of the last leaf, in a rate of 3 l/ha.

Weed control was carried out in the first decade of April using Rival Super Star 75 GD (37.5% chlorsulfuron + 37.5% tribenuron-methyl) herbicide in a rate of 20 g/ha.

Two fungicide products were used for controlling the diseases, respectively: Falcon Pro 425 EC (53 g/l prothioconazole + 224 g/l spiroxamine + 148 g/l tebuconazole), applied in a rate of 0.6 l/ha in April, and Prosaro 250 EC (125 g/l prothioconazole + 125 g/l tebuconazole), applied in a rate of 0.75 l/ha, at the boot stage.

Pest control was carried out by using Karate Zeon (50 g/l lambda-cyhalothrin) insecticide, which was applied in a rate of 0.15 l/ha, first application at the stem elongation stage and the second one upon occurrence of the ear.

Crop irrigation was carried out in 2 stages: after sowing, using 250 m^3/ha of water and at the stem elongation stage, using 500 m^3/ha of water.

Determinations. The following yield components were analysed upon harvesting: number of ears/m^2; number of grains/ear; weight of grains/ear; thousand grain weight (TGW).

Grain yield was calculated and expressed in kg/ha, this being reported at 14% moisture content of the grains.

Grain samples of 1 kg per each variety were taken and analysed in laboratory in order to determine the grain test weight, the protein content and the wet gluten content. These indicators are taken into consideration upon wheat selling and reflect the commercial and technological value for milling and bakery. The Inframatic Grain Analyzer equipment from Perten Instruments was used to determine these indicators.

The obtained data were statistically processed using the analysis of variance (ANOVA).

RESULTS AND DISCUSSIONS

The number of ears per m^2

The analysis of yield components indicates that the number of ears per m^2 for the studied varieties was on average of 511, with large variations between the varieties (Figure 1).

Anapurna variety with 551 ears/m^2 registered a difference distinct significant compared to average value of the studied varieties, this being followed by Avenue variety, with 545 ears/m^2, and Glosa variety, with 541 ears/m^2.

The lowest ear densities were registered for Pajura (462 ears/m^2) and Miranda (478 ears/m^2) varieties, which registered a difference negative distinct significant respectively negative significant compared to average value of the studied varieties.

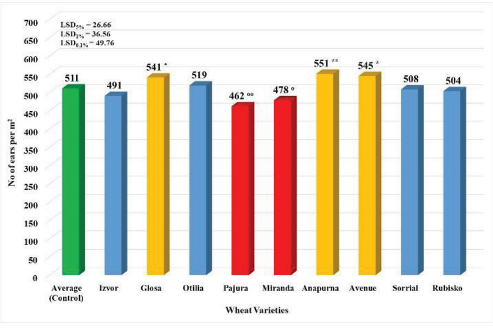

Figure 1. The number of ears per m^2 at the analysed wheat varieties

The number of grains per ear

The number of grains per ear is influenced by the number of ears/m^2, the growing conditions from the vegetation period, especially the climatic ones, and the crop technology.

The average number of grains per ear for the studied varieties was 32 (Figure 2). The Anapurna variety with 38 grains/ear registered a significant difference compared to average value of the studied varieties. This was followed by Sorrial variety with 34 grains/ear and Pajura with 33 grains/ear, but without significant differences compared to average value of the studied varieties.

Most varieties registered 31 grains/ear.

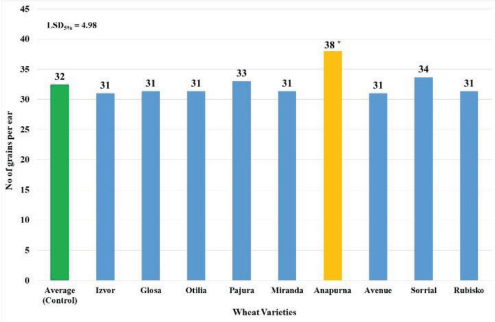

Figure 2. The number of grains per ear at the analysed wheat varieties

The weight of grains per ear

The weight of grains per ear is influenced by the number of ears/m^2 and by the certain limiting factors, such as deficiencies in nitrogen nutrition, the water stress, the excessive temperatures, the temperature differences between day and night during the grain formation and filling period, the foliar and ear diseases and the attack of certain pests.

The average weight of grains per ear for the studied varieties was of 1.29 g, with a large variation between varieties (Figure 3).

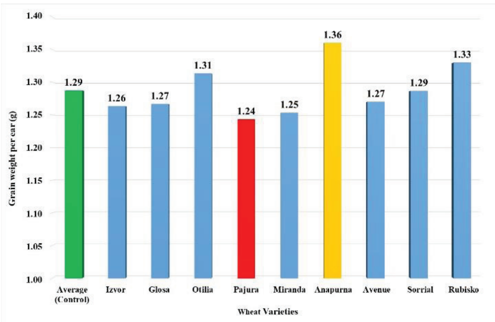

Figure 3. The weight of grains per ear at the analysed wheat varieties

The Anapurna variety with 1.36 g/ear registered the highest value of the weight of grains per ear, but without a significant difference

compared to average value of the studied varieties. High values of the weight of grains per ear have registered also the varieties Rubisko (1.33 g/ear) and Otilia (1.31 g/ear).
The lowest values of the weight of grains per ear were registered at the varieties Pajura (1.24 g/ear) and Miranda (1.25 g/ear).

Thousand grain weight (TGW)
The TGW is a genetic characteristic of the variety, but it is influenced by the ear density per m^2, the number of grains per ear, the weight of grains per ear and the effect of certain limiting factors during the grain formation and filling period, such as the presence of the foliar and ear diseases, the attack of certain pests, the thermal and water stress, the nutrition deficiencies.
For the studied varieties, the TGW registered an average value of 40.5 g, with obvious variations between varieties (Figure 4).
The Anapurna variety with a TGW of 43.94 g registered a significant difference compared to average value of the studied varieties, this being followed by the varieties Otilia with 42 g, Sorrial with 41.18 g, and Izvor with 41.15 g, but without significant differences compared to average value of the studied varieties.
The lowest values of TGW were registered at the varieties Avenue (37.67 g) and Rubisko (38.17 g).

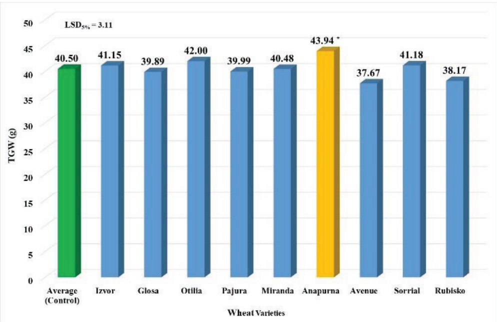

Figure 4. Thousand grain weight (TGW) at the analysed wheat varieties

Yield
The grain yield of a given variety is considerably influenced by the soil and climatic conditions specific to the area and the year of cultivation, the fertilisation strategy, the photosynthetically active leaf area, the preceding crop, the vegetation conditions in autumn, in early spring and until harvesting, the lack of some climatic accidents and the harvesting conditions.
The grain yield is the most synthetic indicator of variety agronomical value assessment.
The average yield of the studied varieties was of 6,618 kg/ha (Figure 5).
The highest yield was registered at the Anapurna variety, with 7,498 kg/ha and with a very significant difference compared to average value of the studied varieties. A significant difference compared to average value of the studied varieties was registered at the Sorrial variety, with 7,035 kg/ha. High yields were registered also at the varieties Glosa (6,862 kg/ha), Avenue (6,839 kg/ha) and Otilia (6,751 kg/ha), but without significant differences compared to average value of the studied varieties.
The lowest yields were registered at the varieties Izvor (6,202 kg/ha), Miranda (6,002 kg/ha), and Pajura (5,806 kg/ha), with negative significant difference compared to average value of the studied varieties for Izvor variety, respectivelly with negative very significant difference for Miranda and Pajura varieties.

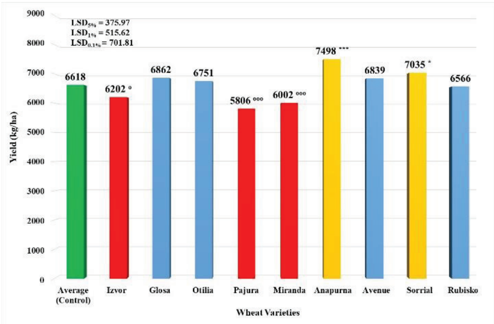

Figure 5. Yield at the analysed wheat varieties

Yield quality
The grain test weight (kg/100 l) reflects the commercial and technological value of wheat and it is taken into consideration for the payment calculation, wheat gradation, storehouse partitioning and baking value establishment.
The grain test weight of a given variety is influenced by the specific soil and climatic conditions of the cultivation area, the crop technology, the presence of foliar diseases, the pest attack, the grain chemical composition and the state of the grains upon harvesting (impurity content, the percentage of broken grains).

The average grain test weight for the studied varieties was of 76.1 kg/100 l, with variations between the varieties (Figure 6).
The highest values of the grain test weight were registered at the varieties Glosa (77.5 kg/100 l) and Avenue (77.1 kg/100 l). Good values of the grain test weight were registered also at the varieties Anapurna (76.3 kg/100 l), Izvor (76.2 kg/100 l), and Miranda (76.1 kg/100 l).
The lowest values of the grain test weight were registered at the varieties Rubisko (74.9 kg/100 l) and Pajura (75.5 kg/100 l).

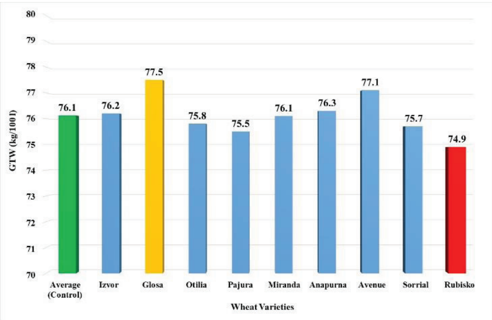

Figure 6. Grain test weight (GTW) at the analysed wheat varieties

The protein content reflects the wheat bakery quality and is taken into consideration in wheat gradation, in partitioning and in the establishment of the yield destination.
Protein is the main quantitative factor determining the quality of wheat grains; in this connection, factors that affect protein levels are of particular importance (Stoyanova et al., 2019). But, it has to be taken into account that along with protein concentration, protein quality is an important factor to determine the end use of the wheat (Egesel et al., 2012).
The protein content of a given variety is influenced by the specific soil and climatic conditions, the fertilisation strategy, the presence of diseases and pests, the climatic conditions and climatic accidents, as well as the harvesting conditions.
The protein content of the studied varieties was on average of 12.8%, with small variations between the varieties (Figure 7).
Glosa variety with a protein content of 13.3% registered the highest value, this being followed by varieties Miranda with 13.2%, Pajura with 13.1%, and Otilia with 13.0%.
The smallest values of the protein content were registered at the varieties Rubisko and Avenue, with 12.3%, and Sorrial variety, with 12.5%.

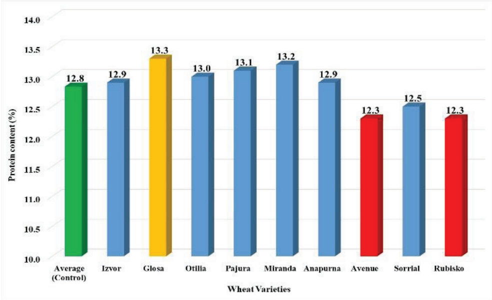

Figure 7. The protein content at the analysed wheat varieties

The wet gluten content reflects the bakery value and the quality of gluten influences the dough rheological characteristics and the commercial look of the bread (Figure 8). The gluten content of wheat is a critical factor in bread making and high gluten content of wheat is associated with good bread making characteristics (Delibaltova & Dallev, 2018).
The wet gluten content of the studied varieties was on average of 24.3% (Figure 7).
Glosa variety with a wet gluten content of 26% registered the highest value, this being followed by varieties Izvor, Otilia, Pajura, and Anapurna, all with a wet gluten content of 25%.
The smallest values of the wet gluten content were registered at the varieties Rubisko (22%) and Sorrial (23%).

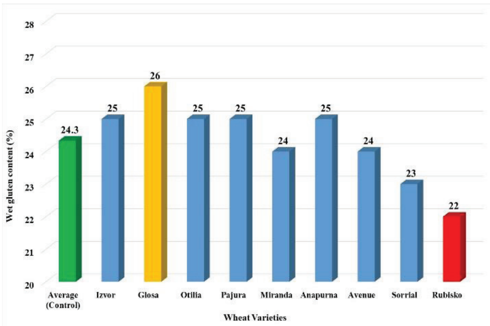

Figure 8. The wet gluten content at the analysed wheat varieties

Based on the quality indices analysed, the varieties Glosa, Pajura, Otilia, and Anapurna can be characterised as being very good for milling and bakery, while the other tested varieties can be characterised as being good for milling and bakery.

CONCLUSIONS

The yielding capacity of a given wheat variety, which is determined by the values of the yield component, as well as the yield quality which is determined by several indicators are important traits in making the growers to choose which variety to cultivate.

Because of the successive formation of the yield components (number of plants/m^2, number of tillers/m^2, number of ears/m^2, number of spikelets/ear, number of grains/ear and thousand grain weight - TGW), the yielding capacity of the varieties has to be assessed throughout the vegetation phases, from the crop settlement in the field to the grain filling stage.

The number of ears/m^2 is a result of the tillering process and the competition in the plant population for water, light, nutrients, diseases and pests during the stem elongation stage.

The number of grains/ear is formed from the beginning of stem elongation and ends upon flowering and correlates with the dry matter accumulated in the ear and the competition with other organs of the plant. The optimal conditions for the formation of a large number of grains/ear are: the reduced competition in the plant population upon stem elongation, flowering and grain formation; the absence of thermic stress; the absence of the water deficit; the non-limiting global radiation.

The thousand grain weight (TGW) is influenced by the water stress upon grain formation stage, the number of ears/m^2, the nitrogen nutrition, and the photosynthetically active leaf area.

The grain test weight is influenced by the grain size and uniformity, the impurity content and the nature of impurities, the grain chemical composition and it is a commercial indicator.

The protein content is influenced by the environmental conditions, the fertilisation strategy, and foliar diseases.

The wet gluten content is influenced by the protein content, the plant nutrition, and the environmental conditions. This quality trait has a considerable influence on the wheat bakery value.

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RELATIONSHIP BETWEEN YIELD AND GRAIN QUALITY IN PERSPECTIVE WINTER OAT LINES

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Abstract

This research was conducted within the period 2011-2013 in the Department of Plant-growing experimental facility at the Agricultural University of Plovdiv (Bulgaria). The method of fractional plots in three repetitions over an area of 10.5 m^2 was used. The object of this research are eight winter oat genotypes (Avena sativa L.) - № 1, 07/Z 1, Dunav 1, 08/Z 2, M-K, Kt 651, Ressor 1 and line Kt 718. The aim of the study is to establish the correlations between the studied genotype grain yield and some of its quality indicators.
A genotype specificity of the correlative interconnections has been determined. For Dunav 1 and line 07/Z 1 those between yield and 1000-grain weight are medium to strongly positive. Line 08/Z2 is with small grain but high quantity of beta-glucans (4.6%). The correlative interconnections of this indicator for yield and 1000-grain weight are positive.
Line Kt 718 has also got potential in terms of grain weight (1000-grain weight - 28.7 g) and beta-glucan content (3.75%). The correlation between them is positive.

***Key words**: Avena sativa L., winter oat, correlation, yield, 1000-grain weight, hectolitre weight, β-glucans.*

INTRODUCTION

Oat has demonstrated unquestionable advantages of grain compared with other cereal commodities. The high content of proteins and their nutritional indispensability make it a preferred diet both for adolescents and people with specific nutrition needs.
For the last decades, beta-glucans have been provoking particular interest as they are mandatorily included in the healthy diet.
Oat has the highest content of beta-glucans among other cereal commodities (Wood, 1994; Lee et al., 1997). According to Aman and Graham (1987), and Welch and Lloyd (1989), oat contains between 25 and 66 g/kg β-glucans.
Beta-glucans correlation with other quantitative and qualitative grain characteristics, were examined in the process of testing various cultivars. Aman and Graham (1987), for example, has not found a proven correlation with 1000-grain weight for 121 tested cultivars. Peterson (1991) confirms the same interconnection. The correlation with grain weight is also negative and unproven, according to Holthaus et al. (1996). Whereas the correlation between β-glucan content and husked grain percentage is positive (Peterson, 1995).
Beta-glucan content is not always in one-way correlation with grain yield (Kibite & Edney, 1998). Holthaus et al. (1996) published data for low positive phenotype correlation, and Saastamoinen et al. (1992) reported a strong positive correlation with the yield. Contrary to that, Kibite and Edney (1998), established low negative phenotype correlation, while Peterson et al. (1995) reported both - low positive and negative correlation with grain yield. According to Brunner and Freed (1994), phenotype correlation between beta-glucans and yield can also vary from positive to negative, depending on the growing conditions. All this has provoked our scientific interest towards a profound analysis of correlative interconnections between basic quantitative and qualitative indicators in perspective Bulgarian lines of winter oats.

MATERIALS AND METHODS

This research was conducted within the period 2011-2013 in the experimental facility of the Department of Plant-growing at the Agricultural University of Plovdiv, on Mollic fulvisols (FAO). A field trial was executed with two selected and well-established winter cultivars (Dunav 1 and Ressor 1) and line №1, 07/Z1, 08/Z2, M-K (Agricultural University of Plovdiv, Bulgaria), Kt 651, Kt 718 (Institute of Agriculture of Karnobat, Bulgaria). Sunflower was used as predecessor. Three repetitions with size of the reporting plot of 10.5 m^2 were used. Statistical data processing was performed using the SPSS program for Microsoft Windows 9.4 (SAS Institute Inc., 1999). In order to establish the relationships between yield and quality, a correlation analysis was applied.

RESULTS AND DISCUSSIONS

Table 1 shows the results of realized grain productive capacity in kg/da for the tested 8 genotypes, 1000-grain weight, hectolitre weight and ß-glucan content in grain. On the average, the highest yield for the three-year period was observed with Dunav 1 cultivar (427.89 kg/da) - which is the yield standard for Bulgaria, followed by the new line 07/Z1. The lowest yield was detected for lines 08/Z2 (selection of the Agricultural University) and Kt 718 - selection of the Institute of Agriculture of Karnobat). The way indicators for 1000-grain weight and hectoliter weight are reported, is extremely important, related to the use of oats for human consumption in the form of whole grains or flour. They define the yield rate of the final product and are directly related to the processing industry.

Table 1. Yield, 1000-grain weight, hectolitre weight and β-glucan content (average for the period 2011-2013)

Variant	Yield* (kg/da)	1000-grain weight* (g)	Hectolitre weight* (kg)	β-glucans* (%)
№1	370.12b	26.67bc	50.47b	3.03 c
07/Z1	421.89a	32.12a	51.62ab	2.52 d
Dunav1	427.26a	26.58bc	50.33b	3.04 c
08/Z2	332.90b	23.97c	46.38c	4.06 a
M-K	402.64ab	28.78b	51.56ab	3,15 c
Kt 651	393.82ab	27.47bc	48.26c	3.44 b
Resor 1	355.43b	27.40bc	51.02ab	2.39 d
Kt 718	332.55b	28.57b	53.23a	3.75 b

**Data in the same column and heading followed by the same letter are not statistically different (P≤0,05%) by Dunkan's multiple range test*

The results presented in Table 1 show that line 07/Z1 definitely distinguishes for largest seeds. These findings are a good reason for relating the line to genotypes utilized for oat flakes production. Line 08/Z2 shows the lowest value for the same indicator.

Line Kt 718 displays highest hectolitre weight. This fact is partially explained with the comparatively low share of grain husk (Zorovski et al., 2013).

Despite all other grain qualities, the beta-glucan content has recently aroused people's sound interest in healthy food consumption. Line 08/Z2 - 4.06% has displayed outstanding values within our experiment, followed by two lines selected at the Institute of Agriculture, Karnobat - Kt 718 -3.75% and Kt 651 - 3.44%.

The succeeding tables (from Table 2 to Table 9) show the calculated correlative interconnections between the studied quantitative and qualitative grain indicators per variant. The obtained results demonstrate genotype specificity which has to be considered in accordance with the particular selection objective or production sphere.

Table 2 makes it clear that (as it is with many genotypes) yield is in strong negative correlative interconnection with 1000-grain weight, whereas with hectolitre weight it is positive. Beta-glucans are in positive interconnection with 1000-grain weight.

Table 2. Correlative interconnections between yield and grain quality for line № 1

Indicator	Yield (kg/da)	1000-grain weight (g)	Hecto-litre weight (kg)	β-glucans (%)
Yield, kg/da	1,000	-0.940	0.721	-0.397
1000-grain weight, g		1,000	-0.914	0.686
Hectolitre weight, kg			1,000	-0.922
β-glucans, %				1,000

Table 3 shows the interconnections for 07/Z1 - one of the highly productive genotypes.

The most valuable asset for this new line is the fact that, yield is in positive correlative interconnection with: the 1000-grain weight, hectoliter weight and beta-glucans. This allows this line to be rated as particularly perspective both in terms of yield and tested qualitative indicators for 1000-grain weight and hectolitre weight.

Table 3. Correlative interconnections between yield and grain quality for line 07/Z1

Indicator	Yield (kg/da)	1000-grain weight (g)	Hectolite weight (kg)	β-glucans (%)
Yield, kg/da	1,000	0.344	0.803	0.491
1000-grain weight, g		1,000	-0.284	-0.650
Hectolitre weight, kg			1,000	0.913
β-glucans, %				1,000

Dunav 1 is the standard for winter oats yielding in Bulgaria. It behaves as leader among the tested cultivars in terms of yield but gives way to the best lines for 1000-grain weight, hectoliter weight and beta-glucans. On the other hand, the calculated correlative interconnections (Table 4) between yield and studied qualitative indicators show high positive values, thus explaining the permanent users' interest in this cultivar.

Table 4. Correlative interconnections between yield and grain quality for Dunav 1 cultivar

Indicator	Yield (kg/da)	1000-grain weight (g)	Hectolitre weight (kg)	β-glucans (%)
Yield, kg/da	1,000	0.711	0.884	0.626
1000-grain weight, g		1,000	0.299	0.993
Hectolitre weight, kg			1,000	0.188
β-glucans, %				1,000

Line 08/Z2 is distinguished for highest β-glucan content - over 4%. It is not competitive in terms of yield and grain size, but β-glucans are in medium positive correlative interconnection with yield and in very strong - with 1000-grain weight (Table 5).

Therefore, this line allows simultaneous activities directed to achieving both better yield and quality, motivated by the high β-glucan content.

Table 5. Correlative interconnections between yield and grain quality for line 08/Z2

Indicator	Yield, (kg/da)	1000-grain weight (g)	Hectolitre weight (kg)	β-glucans (%)
Yield, kg/da	1,000	0.413	-0.965	0.399
1000-grain weight, g		1,000	-0.161	0.998
Hectolitre Weight, kg			1,000	-0.146
β-glucans, %				1,000

M-K is a new line selected by the Agricultural University of Plovdiv. It is one of the most productive new lines tested in the experiment (Table 1). Its grain is comparatively large, with positive correlation between weight and yield (Table 6), which allows simultaneous exploration for higher yield and larger grain size. The beta-glucan content is over 3%, nevertheless, the strong negative correlative interconnection between the latter and yield must be taken into consideration in the course of selection.

Table 6. Correlative interconnections between yield and grain quality for line M-K

Indicator	Yield (kg/da)	1000-grain weight (g)	Hectolitre weight (kg)	β-glucans (%)
Yield, kg/da	1,000	0.720	-0.243	-0.778
1000-grain weight, g		1,000	-0.848	-0.123
Hectolitre weight, kg			1,000	-0.421
β-glucans, %				1,000

Line Kt 651 yield is slightly lower than the standard Dunav 1, but with larger grain size and higher beta-glucan content (Table 1). Besides, the 1000-grain weight is in positive correlation with β-glucans (Table 7), thus raising the interest in the cultivar for using in food production. Kt 651 is among the three tested genotypes with highest β-glucan content - 3.44%.

Table 7. Correlative interconnections between yield and gain quality for line Kt 651

Indicator	Yield (kg/da)	1000-grain weight (g)	Hectolitre weight (kg)	β-glucans (%)
Yield, kg/da	1,000	-0.999	0.624	-0.589
1000-grain weight, g		1,000	-0.584	0.547
Hectolitre Weight, kg			1,000	-0.999
β-glucans, %				1,000

The Bulgarian Ressor 1 cultivar is used as quality standard in Bulgaria. However, it gives way on grain size and, particularly, on β-glucan content (Table 1).

Table 8. Correlative interconnections between yield and grain quality for Ressor 1 cultivar

Indicator	Yield (kg/da)	1000-grain weight (g)	Hectolitre weight (kg)	β-glucans (%)
Yield, kg/da	1,000	-0.892	-0.512	0.912
1000-grain weight		1,000	0.846	-0.999
Hectolitre Weight, kg			1,000	-0.819
β-glucans, %				1,000

On the other hand, a very strong negative interconnection of -0.999 between 1000-grain weight (g) and β-glucan content (%) has been determined (Table 8). This fact defines the cultivar as non-preferred, whenever both grain quality characteristics are required at the same time.

Table 9. Correlative interconnections between yield and grain quality for line Kt 718

Indicator	Yield (kg/da)	1000-grain weight (g)	Hectolitre weight (kg)	β-glucans (%)
Yield, kg/da	1,000	-0.839	-0.335	0.166
1000-grain weight		1,000	-0.232	0.397
Hectolitre weight, kg			1,000	-0.985
β-glucans, %				1,000

Line Kt 718 shows a very well balanced indicator values for yield, 1000-grain weight, hectolitre weight and especially beta-glucans (Table 1).

The established correlative interconnections show contradiction between yield and 1000-grain weight, while between yield and beta-glucans, 1000-grain weight and beta-glucans a positive correlation is observed (Table 9)

CONCLUSIONS

The present study shows best performance of genotype Dunav 1, lines 07/Z1 and M-K in terms of yield (over 400 kg/da).

For the first two, the correlative interconnections between yield and 1000-grain weight are medium to strongly positive which defines them as perspective for yield and large-size grain. Line 08/Z2 has small grain but high beta-glucan content (4.06%).

The correlative interconnections between yield and 1000-grain mass, as well as between yield and beta-glucans, on the one hand, and between 1000-grain weight and beta-glucans, on the other, are positive.

This is a good precondition for evaluating this line as particularly perspective in terms of high yield and quality selection.

Line Kt 718 is also considered perspective from point of view of grain size (1000-grain weight - 28.57g) and beta-glucan content (3.75%). The correlation between both indicators is positive.

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EFFECT OF LEAF TREATMENT PRODUCTS ON SOME STRUCTURAL COMPONENTS IN THE YIELD OF COMMON WHEAT

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Abstract

In a field experiment conducted at the Training Experimental and Implementation Base of the Agricultural University of Plovdiv in 2015-2017, the effect of leaf treatment products on some structural components in the yield of common wheat varieties: Enola, Annapurna, Ginra and Biliana was studied. The following products have been tested: alone - Plantafol (mineral leaf fertilizer) at a dose of 250 g/da and Bombardier (organic biostimulator) at a dose of 400 ml/da, as well as a combination of the two products. The treatment was carried out in the wheat tillering phase (22-25 on the Zadoks scale). The experiment has been set by the fractional parcel method in 4 repetitions with crop plot size of 15 m^2.
It has been found that the independent and combined application of the tested products had a positive effect on the values of the structural components in the yield (spike length, spikelet number, grain number and grain mass in the spike of common wheat).

***Key words**: foliar treatment products, structural components of yield, common wheat.*

INTRODUCTION

In recent years the use of foliar treatment products has been increasing when growing common wheat. They help to solve the issues related to accelerating the growth and development of plants (Delchev et al., 2004; Delchev et al., 2007; Delchev, 2009), their resistance to stress factors (Fujita et al., 2006), as well as enhancing the productivity and quality of the grain obtained from the wheat (Gallie, 2013). According to the research of a number of authors, treatment of plants with foliar treatment products during the vegetation of common wheat contributes to increasing the number of grains and their mass, resulting in increased productivity (Sevov & Delibaltova, 2013; Wasternack & Hause, 2013; Delchev et al., 2015).
The objective of the conducted research is to establish the effect of foliar treatment products on some structural components of yield in common wheat varieties Enola, Annapurna, Ginra and Biliana.

MATERIALS AND METHODS

The experiment was cconducted at the Training Experimental Field of the Department of Plant Production at the Agricultural University of Plovdiv in the period 2016-2018. The field experiment was laid out in a block method in four replications and crop plot size of 15 m^2 on carbonate alluvial meadow Mollic Fluvisols (FAO - UNESCO, 1990) soil characterized by medium sand-clayey mechanical composition, 1-2% humus content, pH 7.7, presence of carbonates up to 7.4% and lack of salts. In the soil layer 0-20 cm the content of the main nutrients was as follows: N - 20.8 mg/1000 g, P_2O_5 - 7.01 mg/100 g, K_2O - 32.8 mg/100 g.
The following products were tested: separately - Plantafol (mineral foliar fertilizer) at a dose of 250 g/da and Bombardier (organic biostimulator) at a dose of 400 ml/da, as well as a combination of both products. Treatment was carried out in the wheat tillering phase (22-25 on the Zadoks scale). The tested wheat varieties were grown by the approved technology after predecessor sunflower. Sowing was made within the optimum time (01-20.XI). The experiment was fertilized with N_{16} P_{14}, and the entire amount of phosphorous fertilizer was introduced prior to the main cultivation, whereas the nitrogen 1/3 before sowing and 2/3 in early spring as supplemental nutrition.
The following biometric measurements were taken: spikelet number per spike, grain number per spike, grain weight per spike (g) and grain yield (t/ha).

The amount of precipitation during the vegetation period of common wheat (X-VI) was as follows: 2016/2017 - 264.2 mm and in 2017/2018 - 457.2 mm at 419.6 mm over a multiannual time period (Figure 1).

RESULTS AND DISCUSSIONS

A favourable year for the growth and development of common wheat with a relatively good distribution of precipitation was 2016-2017 and then the values of the structural components of yield were higher for the tested varieties. Unfavourable for plant development was the 2017-2018 harvest year due to a significant amount of precipitation that prevented harvesting, which had negative effect on common wheat productivity (Figure 2).

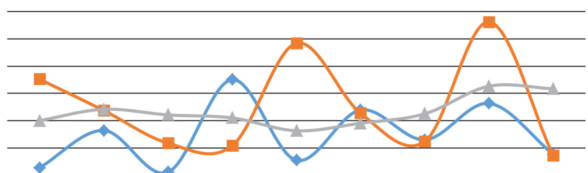
The data from the biometric measurements of the variants with the tested foliar treatment products are presented in Table 1.

The number of spikelets and the favourable conditions during flowering and fertilization are a guarantee of the formation of well-grained spikes.

The extremely favourable meteorological conditions at that time were a good prerequisite for the formation of a great number of spikelets in the different varieties with the greatest numberproduced by the Enola variety.

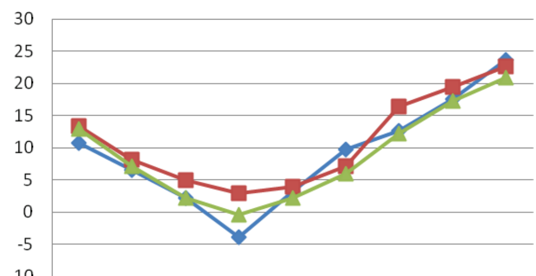
During the study period it was found out that the foliar treatment products had stronger effect on the spike length in the Enola variety, which increased by 2.4 cm (29.8%) with individual treatment with Bombardier, and with Plantafol by 2.2 cm (18.3%), and in the Plantafol + Bombardier variant 2.36 cm (29.3%).

When using the foliar treatment products for Annapurna wheat variety, the greatest number of spikelets per spike are formed 21.6 pcs. (14.0%) with individual treatment with Plantafol, followed by treatment with Bombardier 20.8 pcs. (11.8%), followed by Biliana and Enola varieties, and the lowest number of spikelets were observed in the Ginra variety.



	X	XI	XII	I	II	III	IV	V	VI
2016-2017	5,6	32,9	2,4	70,1	11,1	47,9	26,1	52,7	15,4
2017-2018	70,4	47,6	23,7	21,7	96,7	45,5	24,9	112,3	14,4
Climatic norm	40,1	48,4	44,3	42,1	32,7	38,2	45,1	65,3	63,4

Figure 1. Precipitation by months (sum mm/m^2)



	X	XI	XII	I	II	III	IV	V	VI
2016-2017	10,8	6,6	2,2	-3,9	3,2	9,7	12,7	17,6	23,7
2017-2018	13,3	8,2	4,9	2,9	3,9	7,1	16,4	19,4	22,6
Climatic norm	12,9	7,2	2,2	-0,4	2,2	6	12,2	17,2	20,9

Figure 2. Monthly temperatures (average)

Number of germinate plant

The germinate plants in Annapurna variety is higher from 398.4 counts (79%) to 409.9 counts (81.9%), Biliana variety is following from 369.2 counts (73.8%) to 387.9 counts (77.6%), next is Enola variety from 354.2 counts (70.8%) to 367.3 counts (73.5%) and the last is Ginra variety from 342.5 counts (68.5%) to 358.2 counts (71.6%) (Table 1).

Number of surviving plants the winter/cold temperatures plants Into the technological development one of the most important componens is the winter surviving plants quality the the variety. According the characteristic of the varieties coming from their inventors, the minimum healthy plants surviving the winter period should be 80%

One of the reason of lower yield is a destroyed plants after the winter period. The varieties should have a cold resisting element. Otherwise there is a possibilities cold temperature to stress the plants, or even to destroy them. In our case the surviving winter plants were less than the emerged ones.

The survaiving winter plants were satisfied. It vary in Biliana variety from 80.9% to 84.6%, Ginra variety from 88.1% to 90.3%, Annapurna variety from 94.9% to 96.6% and Enola variety from 95.9% to 96.3% (Table 1).

Tillering plants

The tillering vary in Enola variety from 60.08% to 63.11%, in Annapurna variety from 65.08% to 68.62%, Ginra from 60.02% to 61.17%, and Biliana from 64.67% to 66.28% (Table 2).

On average for the study period treatment of plants in wheat varieties with the tested products resulted in an increase in the grain weight per spike, being the highest in treatment of plants from the Biliana variety in the combination of Plantafol + Bombardier 2.99 g (15.0%) and individual treatment with Bombardier 2.89 g (11.1%) (Table 3).

The number of grains per spike as a result of the effect of the studied foliar treatment products varies in the Annapurna variety from 59.7 pcs. in the Bombardier variant (12.0%) and with Plantafol 58.3 pcs. (9.4%), whereas in treatment with Plantafol + Bombardier 58.9 pcs. (10.5%). In the Biliana Enola and Ginra wheat varieties fewer number of grains per spike were reported.

Variety Annapurna follows treated with Plantafol + Bombardier 2.79 g (18.7%), individual treatment with Plantafol 2.71 g (15.3%), with Bombardier 2.68 g (14.0%) more than the untreated control (Table 3).

Table 1. Number of germinated and wintering plants (average 2016-2018)

Variety	Foliar treatment products	Number of germinated plants	% relative to the sowing rate	Number of wintering plants	% of emerging plants
A_1 - Enola	B_0 Control - not fertilized	354.2	70.8	340.5	96.1
	B_1 Plantafol	359.1	71.8	345.7	96.3
	B_2 Bombardier	361.3	72.3	347.5	96.2
	B_3 Plantafol + Bombardier	357.4	71.5	342.8	95.9
A_2- Annapurna	B_0 Control - not fertilized	398.4	79.7	379.6	95.3
	B_1 Plantafol	406.7	81.3	389.1	94.9
	B_2 Bombardier	403.2	80.6	387.7	96.1
	B_3 Plantafol + Bombardier	405.4	81.1	384.8	94.9
A_3 - Ginra	B_0 Control - not fertilized	342.5	68.5	301.8	88.1
	B_1 Plantafol	345.7	69.1	312.1	90.3
	B_2 Bombardier	348.4	69.7	308.7	88.6
	B_3 Plantafol + Bombardier	344.6	68.9	304.2	88.2
A_3 - Biliana	B_0 Control - not fertilized	369.2	73.8	300.5	81.3
	B_1 Plantafol	379.2	75.8	317.2	81.8
	B_2 Bombardier	384.6	76.9	311.7	81.0
	B_3 Plantafol + Bombardier	381.5	76.3	309.0	80.9

Table 2. Common tillering and yield tillers plants (average 2016-2018)

Variety	Foliar treatment products	Number of brothers/m^2	Number of classical stems/m^2	Common tillering, %
A_1 - Enola	B_0 Control - not fertilized	544.8	331.2	60.08
	B_1 Plantafol	553.1	339.3	61.34
	B_2 Bombardier	556.0	340.2	61.18
	B_3 Plantafol + Bombardier	548.5	346.2	63.11
A_2 - Annapurna	B_0 Control - not fertilized	607.4	395.3	65.08
	B_1 Plantafol	622.6	424.2	68.13
	B_2 Bombardier	620.3	429.3	69.21
	B_3 Plantafol + Bombardier	615.7	422.5	68.62
A_3 - Ginra	B_0 Control – not fertilized	482.9	290.9	60.02
	B_1 Plantafol	499.4	308.4	61.18
	B_2 Bombardier	492.9	303.8	61.16
	B_3 Plantafol + Bombardier	486.7	300.5	61.17
A_3 - Biliana	B_0 Control – not fertilized	480.8	312.3	64.67
	B_1 Plantafol	507.5	335.3	66.07
	B_2 Bombardier	498.7	330.4	66.25
	B_3 Plantafol + Bombardier	494.4	327.7	66.28

Table 3. Biometrics data (average 2016-2018)

Variety	Foliar treatment products	Length of spike, cm	Number of spikelets per spike	Number of grains per spike	Weight of grains per spike, g
A_1 - Enola	B_0 Control - not fertilized	8.05	17.3	44.8	2.00
	B_1 Plantafol	10.25	18.9	51.9	2.39
	B_2 Bombardier	10.45	19.8	50.5	2.26
	B_3 Plantafol + Bombardier	10.41	19.7	52.6	2.34
A_2-Annapurna	B_0 Control - not fertilized	8.45	18.6	53.3	2.35
	B_1 Plantafol	9.45	21.2	58.3	2.71
	B_2 Bombardier	9.73	20.8	59.7	2.68
	B_3 Plantafol + Bombardier	9.56	20.5	58.9	2.79
A_3 - Ginra	B_0 Control – not fertilized	7.65	17.1	36.5	2.00
	B_1 Plantafol	9.05	18.9	44.7	2.38
	B_2 Bombardier	9.17	19.4	43.9	2.41
	B_3 Plantafol + Bombardier	9.23	19.1	45.1	2.49
A_3 - Biliana	B_0 Control – not fertilized	9.70	19.0	52.2	2.60
	B_1 Plantafol	9.92	19.7	55.5	2.72
	B_2 Bombardier	9.89	19.9	55.2	2.89
	B_3 Plantafol + Bombardier	9.98	20.2	55.9	2.99
	GD 5%	0.47	1.35	4.85	0.34

Photo 1. Photos from the field January mount

CONCLUSIONS

The values of the structural components of yield in common wheat varieties Enola, Annapurna, Ginra and Biliana, when treated with the tested foliar treatment products exceed those of the non-treated controls.

Spike length in the Enola variety increases in individual treatment with Bombardier and in the Plantafol + Bombardier variant, and is the weakest with Plantafol.

When using the foliar treatment products for the Annapurna wheat variety, the greatest number of spikelets per spike are formed in individual treatment with Plantafol, followed by treatment with Bombardier, followed by Biliana and Enola varieties, and the smallest number of spikelets was observed in the Ginra variety.

Treating plants from wheat varieties with the tested products results in an increase in the grain weight per spike, it being the highest in treatment of plants from the Biliana variety in the combination Plantafol + Bombardier combination and the individual treatment with Bombardier. Annapurna variety follows treated by Plantafol + Bombardier and individual treatment with Plantafol or Bombardier.

Photo 2. Ripening period – June

Photo 3. Tillering stage of development

Photo 4. Photos from mount June. Ear comparison. Ripening period - June

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FERTILIZATION OF SWEET SORGHUM WITH COMPOST FROM WASTE WOOL

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Abstract

In Romania, wool waste from the felt industry would be suitable for the fertilization with compost sorghum saccharatum. This hypothesis was tested in an experiment at USAMV Bucharest. The experience consists in the fertilization treatments of reddish preluvosol with both the lemon straw directly into the soil and a compost consisting of a mixture of waste wool, bovine and wheat. Experience includes untreated control variant (Mt), compost variant (C) and variant of wool debris embedded directly into soil (L). Experience results showed that variant (L) generated the largest biomass, followed insignificantly by variant (C).

Key words*: waste wool, biomass, compost, sweet sorghum, chlorophyll.*

INTRODUCTION

Agricultural farmers face many problems, one of which is control over the use of organic fertilizers. The result of these problems is the lack of fertilizer with nitrogen easily accessible to crop plants. Organic fertilizers contain organic nitrogen, but they are not assimilated sufficiently quickly to meet the needs of plants during critical periods (Vončina A. et al., 2013; Pang X. N. et al., 2000).

In Romania, it is not known when this plant was brought and cultivated, but the literature mentions that in 1936 "a ha was cultivated in four kinds of land and in all it succeeded" (Popescu I., 1943, quoted by Antohe I., 1991).

Sugar is an agricultural crop that supplies strains to produce syrup, sugar, fuel, litter (for cattle), food ethyl alcohol, starch, building material, agglomerated sheets, paper pulp. Starch can be used as additives, for clotting in the textile industry or alcohol can be produced by fermentation.

Sugar sorghum biomass can be used to feed animals in the form of silo or green cow dairy cows. Cultivated as a fodder plant is produced as a green table with several sews. Sugar beans have uses like corn grains.

The plant is tolerant to soil and climate. Moisture resistance -1/3 to sugar cane and 1/2 to maize, as well as a high CO_2 absorption power of 45 tons of CO_2/ha over the entire vegetation period.

With regard to environmental protection, it can reduce the population's limit: one ha of sugar sorghum can absorb annually from the atmosphere up to 50-55 t of CO_2, compared to deciduous trees that absorb 16 t/ha/year CO_2 (Roman G.V. et al., 2016).

Secondary products, such as wool waste from the felt mill, are mostly deposited in landfills. An alternative to such wastes is their use as organic fertilizers. Scientific literature of specialists mentions that these by-products are richer in organic nitrogen (over 5%) and carbon (30-50%) than manure (Vončina A. et al., 2013; Baker R.A., 1991). The hydrolysed sheep wool improves the growth conditions by the large amount of nitrogen, carbon and phosphorus that it emits during the plant growth process in the soil (Vončina A. et al., 2013; Govi R.S. et al., 1998).

The applied wool has also improved the appearance and growth of plants (Vončina et al., 2013; Nustorova M. et al., 2005).

MATERIALS AND METHODS

The experiment took place in the spring of 2018 on the field of the University of Agronomic Sciences and Veterinary Medicine of Bucharest. Comparing the effects of fertilizers on growth and development of sorghum (*Sorghum saccharatum*) were made on red preluvosol soil. The cut was made at a depth of 0-20 cm. The placement of the experimental field was made on the principle of randomized variants (Figures 1, 2), with three repetitions. The land was relatively homogeneous. In each variation, the lots were fertilized with either compost (C) or sheep wool waste (L), and having non-fertilized soil (Mt) as a control.

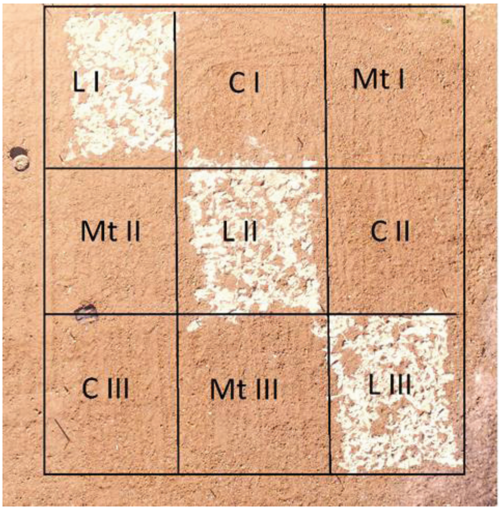

Figure 1. Experimental field placement within the experience

Each variant measured 12 m^2 (3 m x 4 m). Fertilization was performed on May 2, 2018 (Table 1). The wool waste distribution was done manually and uniformly on the test version, and covered with hoeing in the first 10 cm of plowed soil, so as not to be swept by the wind. The compost was spread evenly, using the fork.

In field experiments, research has shown that parcels close to one another on the ground tend to produce more similar to each other than the distant ones.

The square placement was recommended to find out the very small differences between the few variants. Also, the Latin square is very suitable for experiences where there are variations in temperature, brightness, air current and uniformity of watering.

The statistical analysis allows to eliminate both the differences between the blocks and the columns, making it possible to control the influence of soil unevenness as well as other influences, thus achieving a double control.

Figure 2. Experimental ground framing vs. other experiences

Table 1. Experimental treatments, application rates for fertilizers

Treatment	Fertilization	Rate of application (kg)
(M_t)	Unfertilized soil	-
(C)	Compost	15
(L)	Waste wool	10

After fertilization, the soil was processed with a rotary harrow only for the (C) and (Mt) treatments, since variant (L) does not allow mixing with the rotary harrow. Prior to the beginning of the sowing of the sorghum grains, the rows were drawn at a distance of 50 cm on the 3 m side of the parcel. During the year, the prevention and growth of weeds between rows of sucrose sorghum was done manually. Sowing was applied after sowing.

In order to make evident the influence of the experimental factors, the chlophyll concentration of the sorghum leaves was quantitatively determined. Determination was performed on 9 samples (in 3 repetitions) of sorghum (*Sorghum saccharatum*).

Green chlorophyll pigments (chlorophyll a and b) and yellow or carotenoid pigments (carotenes and xanthophylls) are photosynthetic pigments or assimilators.

All organs or tissues of a plant, if green, that is to say if they have chlorophyll, make photosynthesis, but adapted and at the same time specialized to fulfill this function are the leaves.

Chlorophyll a and b are the two main pigments involved in photosynthesis. Chlorophyll a is the primary pigment of photosynthesis, capture of luminous energy and the emission of high energy electrons in the two photosensitive systems. Chlorophyll b is the auxiliary pigment, passing the energy captured in chlorophyll a. Thus, the main difference between chlorophyll a and b is their function in photosynthesis.

The identification and quantification of total carotenoid content was made according to a method adapted from Lichtenthaler and Wellburn (1983).

Thus, 1.0 g of the sample was mixed in the presence of quartz sand. The mojarate was washed several times with 100% acetone, filtered in vacuo and passed quantitatively into a 50 ml volumetric flask containing 10 ml of distilled water.

The obtained acetone extract was spectrophotometrically compared to a 80% acetone blanc at wavelength λ = 470 nm (carotenoids), 646 nm (chlorophyll b), 663 nm (chlorophyll a).

The results wer calculated based on the formulas developed by Lichtenthaler and Wellburn (1983):

Chlorophyll a (μg/ml) = [(12.21 x DO663) - (2.81 x DO646)]

Chlorophyll b (μg/ml) = [(20.13 x DO646) - (5.03 x DO663)]

Carotenes and xanthophylls (μg/ml) $= \frac{(1000 \text{ x DO470}) - (3,27\, x\, Ca - 104\, x\, Cb)}{229}$

RESULTS AND DISCUSSIONS

Experience shows that between variants (L) and (C) was used on the basis of the amount of green mass expressed in t/ha (Table 2).

Table 2. Green sweet sorghum (*Sorghum saccharatum*) t/ha

Variants	Product	Meaning
Waste wool (L)	21.9	a
Compost from wool waste (C)	18.8	a
Control (M_t)	11.6	b

Dl 5% = 7.01 t/ha

The greenhouse weight values of the sorghum recorded differences of 21.9 t/ha and 18.8 t/ha compared to the control variant (Mt) (Figures 3 and 4). The variations obtained under the influence of the fertilization mode were statistically assured in all fertilization variants.

Figure 3. Variation of biomass production

Figure 4. Production variation on 20 August 2018

The green biomass obtained from the wool waste variant (L) did not differ as the production of the wool waste compost (C), both of which were marked with the letter a. The green weight difference (Mt) was significantly lower with the letter b, than variants (L) and (C) (Table 3).

Table 3. Influence of compostable (C) and non-compostable wool (L) waste on biomass of sorghum leaf (*Sorghum saccharatum*) on chromic luvisol

Variants	Product	Meaning
(L)	28.83	a
(C)	28.59	a
(M_t)	26.93	b

Dl 5% = 4.75 t/ha

Wool waste is a rich source of nutrients, being composed of keratin proteins that contain abundant nitrogen, carbon and sulfur, playing an essential role in plant nutrition. It has been argued that the use of sheep's wool on the soil has produced beneficial effects on the productivity of several plant species (Górecki R.S., 2010; Zheljazkov V.D. et al., 2008; Zheljazkov V.D., 2005).

Table 4. Influence of treatments applied to sugar sorghum on chlorophyll a content

Variants	Chlorophyll a content (µg/ml)	The difference (µg/ml)	Semnification
Witness	12.47	Mt	-
Waste compost wool	15.59	3.12	-
Wool waste	18.39	5.92	***

$Dl_{5\%}$ = 3.15 µg/ml; $Dl_{1\%}$ = 4.34 µg/ml; $Dl_{0,1\%}$ = 5.98 µg/ml

Tables 4 and 5 present the results of the chlorophyll a analyzes. We note that for the variant treated with wool waste and compost from the wool debris, the chlorophyll does not differ significantly between them (receiving letters a 18.39 and 15.59). This means that the reddish chromic luvisol has been subjected to a more intense phosphorus ion release activity, by statistical differentiation. This differentiation is due to the fertilization conditions and the amount of nutrients (nitrogen, phosphorus).

Table 5. Influence of treatments applied to sugar sorghum culture

Variants	Chlorophyll a content (µg/ml)	Semnification
Witness	18.39	a
Waste compost wool	15.59	a
Wool waste	12.47	b

$Dl_{5\%}$ = 4.46 µg/ml; $Dl_{1\%}$ = 4.67 µg/ml

Table 6. Influence of treatments applied to sugar sorghum on chlorophyll b content

Variants	Chlorophyll b content (µg/ml)	The difference (µg/ml)	Semnification
Witness	3.88	Mt	-
Waste compost wool	6.04	2.16	-
Wool waste	6.83	2.95	***

$Dl_{5\%}$ = 2.21 µg/ml; $Dl_{1\%}$ = 3.04 µg/ml; $Dl_{0,1\%}$ = 4.19 µg/ml

Table 7. Influence of treatments applied to sugar sorghum

Variants	Chlorophyll b content (µg/ml)	Semnification
Witness	6.83	a
Waste compost wool	6.04	a
Wool waste	3.88	b

$Dl_{5\%}$ = 3.12 µg/ml; $Dl_{1\%}$ = 3.27 µg/ml

Tables 6 and 7 present the results of the chlorophyll b analyzes. We find that for the variant treated with wool waste and wool waste compost, chlorophyll b does not differ significantly between each other (receiving letters a 6.83 and 6.04). This means that the soil in reddish chromic luvisol has undergone a more intense phosphorus ion release activity, by statistical differentiation.

Table 8. Influence of applied treatments on carotene and xanthophyll content in sugar sorghum plants

Variants	Content carotenes and xanthophylls (µg/ml)	The difference (µg/ml)	Semnification
Witness	2.95	Mt	-
Waste compost wool	3.06	0,11	-
Wool waste	3.58	0,63	***

$Dl_{5\%}$ = 0.70 µg/ml; $Dl_{1\%}$ = 0.96 µg/ml; $Dl_{0,1\%}$ = 1.33 µg/ml

Table 9. Influence of treatments applied to sugar sorghum culture

Variants	Content carotenes and xanthophylls (µg/ml)	Semnification
Witness	3.58	a
Waste compost wool	3.06	a
Wool waste	2.95	b

$Dl_{5\%}$ = 0.99 µg/ml; $Dl_{1\%}$ = 1.04 µg/ml

Tables 8 and 9 present the results of analyzes of carotene and xanthophyll content. We note that for the wool waste and wort waste compost variants, carotenes and xanthophylls do not differ significantly (by the letter a 3.58 and a 3.06). This means that in the soil the reddish-uptake was carried out a more intense nutrient release activity, marked by the statistical differentiation and the more intense color of the sorghum leaves.

CONCLUSIONS

Sheep's wool is a rich source of nutrients. Lana is composed of protein (keratin) that contains abundant nitrogen, carbon and sulfur, which play an essential role in plant nutrition. It has been argued that the fertilization of soil with sheep's wool caused beneficial effects on the productivity of several plant species (Zheljazkov V.D. et al., 2008; Zheljazkov V.D., 2005).

The results of fertilization research for variants (L) and (C) allow the formulation of a set of conclusions on green biomass and separat (*Sorghum saccharatum*).

The results of this study suggest that with the onset of degradation and degradation of debris, they can provide sufficient nutrients for plants. However, it takes time for wool waste to begin to degrade and release nutrients.

In the agricultural year 2018 from the point of view of the green biomass, the variants (L) and (C) are noted. Following the analysis of the influence of fertilization on the sorghum leaves, the variants (L) and (C) are also compared with the control variant (Mt).

The compost obtained can also be used as a bio-stimulator of soil microbianity and as a plant growth stimulant for trace elements (Fe, Cu, Zn) as a valid alternative to the use of other synthesis substances.

Due to fertilization, the percentage of green meal did not vary significantly between fertilized fertilizer with wool waste and fertilized fertilizer with compost from wool waste, wheat straw and cattle manure.

After harvesting the sugar sorghum plants, wool waste has not completely decomposed into the soil, making the next crop come with a nutrient input.

Sweet sorghum plants for which fertilizer was used with wool waste can see the color of leaves of a darker green, most likely due to the nitrogen that wool waste put at the disposal of plants, resulting in an increase in the content in carotenes and xanthophylls.

It can be concluded that wool waste is a valuable fertilizer in the production of many plant species over several years. Both wool waste and wool waste compost can be valuable as organic fertilizers for sustainable agriculture. Overall, the amount of wool waste used as a fertilizer for sugar sorghum plants was reduced after harvesting plants, indicating a possibility for a new harvest. Further mineralization of wool wastes is expected, which could provide phyto-available nutrients for further harvesting.

Further research is needed to release nutrients from the collection of wool waste to crop requirements and to determine optimal rates of application of wool waste to different crops. Since wool waste may contain pathogens or chemicals, further research is needed to address the possible concerns of consumers and the general public about the use of waste wool waste as a source of nutrients for crops.

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AGROCHEMICAL STUDY ON MAIZE (*Zea mays* L.) GROWN UNDER DIFFERENT VARIANTS OF NITROGEN FERTILIZATION

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Abstract

Basic agrochemical characteristics were studied in maize grown under different variants of nitrogen fertilization. The maize hybrid P0216 of Pioneer Company was studied, grown under irrigation conditions, following the conventional adopted technology in our country. The hybrid is characterized by high productivity and drought resistance. The trial was set by the block-plot method with a plot size of 21 m^2. Nitrogen (2.4 kg N/ha) was applied in the following variants: 1. Untreated control; 2. NH_4NO_3 - pre-sowing application of the whole rate; 3. NH_4NO_3 - split application: ½ pre-sowing and ½ at 5th leaf; 4. NH_4NO_3 - 1/3 pre-sowing application, 1/3 - at 5th leaf and 1/3 - at tasseling stage; 5. NH_4NO_3 - ¼ pre-sowing application, ¼ - at 5th leaf, ¼ - at 12th leaf and ¼ - at tasseling stage; 6. $CO(NH_2)_2$ - pre-sowing application of the whole rate; 7. $CO(NH_2)_2$ - ½ pre-sowing and ½ at 10th leaf; 8. $CO(NH_2)_2$ - ½ pre-sowing and NH_4NO_3 - ½ at 10th leaf; 9. $CO(NH_2)_2$ - ½ pre-sowing and NH_4NO_3 - ½ at tasseling stage. Export of nutrients and their use efficiency per production unit are important agrochemical indicators for maize. Their values vary according to the genotype, soil and climatic conditions, the predecessor and fertilization. Nitrogen export varies greatly depending on the fertilization rate and phosphorus and potassium export - depending on the genotype and climatic conditions during the year.

Key words: *maize, nitrogen fertilization, climatic conditions.*

INTRODUCTION

Maize is a crop highly responsive to nitrogen fertilizer, as its productivity after treatment increases proportionally. The importance of the nitrogen absorbed before flowering is extremely important and it promotes the development of the cob, affecting the number and size of the grains. Nitrogen can influence the leaf area development and maintenance, as well as photosynthetic efficiency (Arduini et al., 2006) and dry matter partitioning to the reproductive organs (Prystupa et al., 2004; Vouillot & Devienne-Barret, 1999). Grain is the most active acceptor of carbon and nitrogen assimilates at post-anthesis stage. Detailed studies in the recent years showed that the nitrogen needed for grain filling, originates from both remobilized nitrogen from leaves, stems and ears and continued nitrogen uptake from soil (Burzaco et al., 2013; DeBruin et al., 2013; Duffy, 2014; Haegele et al., 2013). In addition, phosphorus affects the number of grains and the grain yield and diminishes biomass accumulation in a different fashion than N (Batten, 1992; Prystupa et al., 2004). Prevailing scientific opinion is that nitrogen uptake occurs predominantly prior to anthesis and it is the major determinant of 75-90% of the final N content in the grain (Cox et al., 1985a; 1985b). The degree of nitrogen accumulation is determined by the relationship between plant capacity to absorb and remobilize nitrogen (Fageria & Baligar, 2005).

Phosphorus uptake occurs throughout the life cycle of the plants and unlike nitrogen uptake, it continues until physiological maturity (Batten, 1992). Remobilization of phosphorus depends on the genotype, mobile phosphates in soil, growing conditions (drought, high temperatures, salinization) and crop density. Scarce studies have been conducted in the world on donor-acceptor processes related to phosphorus, especially under field conditions (Masoni et al., 2007; Prystupa et al., 2004).

MATERIALS AND METHODS

The study was carried out during the period 2015-2016 at the Department of Farming and Weed Science at the Agricultural University of Plovdiv, on Molic fluvisoil soil type. The trial was set by the block-plot method in 4 replications, with a plot size of 21 m^2. The following nitrogen fertilization variants were studied: 1. Untreated control; 2. NH_4NO_3 - pre-sowing application of the whole rate; 3. NH_4NO_3 - split application: ½ pre-sowing and ½ at 5th leaf; 4. NH_4NO_3 - 1/3 pre-sowing application, 1/3 - at 5th leaf and 1/3 - at tasseling stage; 5. NH_4NO_3 - ¼ pre-sowing application, ¼ - at 5th leaf, ¼ - at 12th leaf and ¼ - at tasseling stage; 6. $CO(NH_2)_2$ - pre-sowing application of the whole rate; 7. $CO(NH_2)_2$ - ½ pre-sowing and ½ at 10th leaf; 8. $CO(NH_2)_2$ - ½ pre-sowing and NH_4NO_3 - ½ at 10th leaf; 9. $CO(NH_2)_2$ - ½ pre-sowing and NH_4NO_3 - ½ at tasseling stage. The agrotechnical activities were carried out following the adopted maize cultivation technology.

Soil analyses

Mineral nitrogen (ammonium nitrate) in extraction with 1% KCl;

Mobile phosphates by Egner-Reim method;

Digestible potassium in extraction with 2N HCl acid;

Soil reaction (pH) - potentiometrically in water extraction.

Plant analyses

Plant samples were taken from the above-ground part of the plants at milk maturity stage of the maize hybrid P0216. They were divided into grain and leaf-and-stem biomass, then dried, weighed, ground and analyzed for the content of major nutrients. An aliquot part of the dry plant samples was mineralized with concentrated H_2SO_4, with H_2O_2 catalyst, and the total nitrogen content was determined (distillation in Parnas-Wagner apparatus); total phosphorus content (colorimetrically, using Camspec M105 spectrophotometer) and total potassium content (using PFP-7 flame photometer).

Plant analyses include a study of:

- grain yield and leaf-and-stem yield (kg/ha);
- NPK export (kg/ha);
- NPK use efficiency (kg per 100 kg of grain).

Soil and climatic characteristics

The soil in the Training-and-Experimental Fields of the Agricultural University of Plovdiv is alluvial-meadow. Geographically the site is located in the Thracian-Strandja region. The alluvial-meadow soils are formed on sandy-loam and sandy-gravel quaternary deposits. According to the International Classification of FAO they refer to Mollic fluvisol.

They are formed on alluvial deposits, they have a well-formed humus-accumulative horizon, which gradually passes into C horizon and a gleization process is observed deeply down (below 100 cm) in the soil forming material - the A-C-G profile. The humus content is usually not high - no more than 1-2%.

The content of the mobile nutrient elements nitrogen, phosphorus and potassium before the beginning of the experiment and the soil reaction are presented in Table 1.

On the basis of the generally accepted limit values for the content of macroelements in soil, it was found that it is poorly supplied with nitrogen and very well-supplied with phosphorus and potassium.

Table 1. Soil reaction, mineral nitrogen content and mobile forms of phosphorus and potassium

Depth, cm	pH_{water}	NH_4-N mg/kg	NO_3-N mg/kg	Nmin mg/kg	P_2O_5 mg/100g	K_2O mg/100 g
0-30	8.09	9.8	11.2	21.0	32.0	46.2

The climate in the region of Plovdiv is transitional-continental.

The agrometeorological conditions during the experimental period did not show significant deviations from the norms for the region, which made it possible to compare the effect of the different fertilization variants.

The sum of the monthly precipitation provided a relatively good moisture content for the plants.

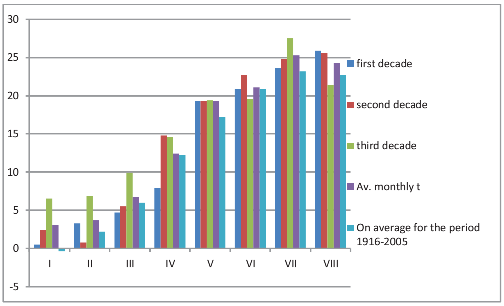

Figure 1. Average monthly temperatures during the study period

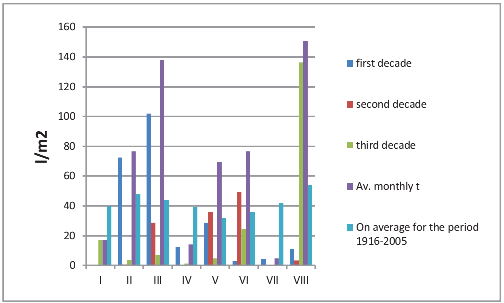

Figure 2. Amount of monthly precipitation during the study period

RESULTS AND DISCUSSIONS

Maize productivity in Bulgaria, depending on the mineral nutrition, was the subject of study by a number of authors (Petrov & Georgiev, 2009; Basitov & Gospodinov, 2007; Toncheva et al., 2006; Dimitrova & Borisova, 2001 etc.).

On average for the study period, grain yields from the maize hybrid P0216 (Table 2) varied between the separate fertilization variants from 3080 kg/ha in the control variant to 12450 kg/ha in Variant 4 (NH_4NO_3 1/3 pre-sowing, 1/3 at 5th leaf and 1/3 at tasseling stage). The three-fold application of nitrogen and the plant growth stage had the most significant effect on maize productivity. Relatively higher yields were reported in the second experimental year compared to the first. The highest maize productivity was reported in Variant 4 - 11640 kg/ha in 2015 and 13260 kg/ha in 2016, and, the lowest - in the control variant - 3910 kg/ha and 2250 kg/ha, respectively. The maize hybrid demonstrated a good productive capacity on average for the experimental period after fertilizing with urea, applied twice at the following rates: ½ of the fertilizer rate - pre-sowing and ½ at 10th leaf (Variant 7) - 11340 kg/ha. The increase in grain yield compared to the control ranged from 51.8 kg/ha to 93.7 kg/ha. Applying nitrogen fertilization (NH_4NO_3 - the whole rate pre-sowing) in the maize cultivation technology led to an increase in grain yield of 6793.5 kg/ha compared to the untreated control. The lowest values of the additional yield over the control were reported at pre-sowing urea application (Variant 6) - 5180 kg/ha.

The fertilization scheme had a lesser effect on the produced leaf-stem biomass (Table 3). On average for the experimental period, the results of that characteristic ranged from 3785 kg/ha in the untreated control variant to 12450 kg/ha in Variant 4. The maize hybrid accumulated significant amounts of net biomass at three-fold application of ammonium nitrate - 1/3 pre-sowing, 1/3 at 5th leaf and 1/3 at tasseling stage. In the other fertilization variants, the values of that characteristic were approximately the same. The additional straw yield over the control variant ranged from 5640 kg/ha to 8780 kg/ha. The application of the whole nitrogen rate as urea (Variant 6), compared to the untreated variant, resulted in the formation of the least leaf-stem biomass - 5640 kg/ha on average for the study period.

Table 2. Grain yield (kg/ha)

Variants	Study period		On average for the study period	Additional yield over the control
	2015	2016		
1	3910	2250	3080	-
2	9740	10007	9873,5	6793,5
3	10003	10000	10001,5	6921,5
4	**11640**	**13260**	**12450**	**9370**
5	10080	10250	10129	7049
6	8210	8310	8260	5180
7	10020	12660	11340	8260
8	10040	10510	10275	7195
9	10080	10380	10230	7150

Table 3. Leaf-stem biomass yield (kg/ha)

Variants	Study period		On average for the study period	Additional yield over the control
	2015	2016		
1	4250	3320	3785	-
2	11140	11260	11200	7415
3	11230	11190	11210	7425
4	**12050**	**13080**	**12565**	**8780**
5	11200	12004	11602	7817
6	9560	9290	9425	5640
7	11200	12140	11670	7885
8	11210	11630	11420	7635
9	11930	12020	11975	8190

Determining the optimal crop nutrition regime requires the estimation of the nutrient export with the harvest and their balance in the different soil types in the country, thus avoiding the negative effects of improper fertilization (Basitov, 1998). Nitrogen export during vegetation is a result that varies greatly depending on the concentration of nitrogen in plant biomass and the dry matter formed. On the other hand, the nitrogen content in the vegetative biomass and the accumulation of dry matter are influenced by the genetic type, development stage, climatic conditions over the years and nitrogen fertilization (Yordanova, 2012). Each kilogram of additionally imported nitrogen per decare leads to an increase of nitrogen export from 0.94 kg/da on average in Prelom cultivar to 1.62 kg/da in Sadovo 1 cultivar (Tomov et al., 2005).

During the experimental period, differences in the export of macroelements by the maize plants were established in the fertilization variants applied. Including nitrogen nutrition in the maize cultivation technology resulted in a significant increase in nutrient export and, therefore, to increased grain yields. In the first experimental year, nitrogen export ranged from 56 kg N/ha in the control variant to 232 kg N/ha in Variant 4; the phosphorus export ranged from 27 to 94 kg P/ha and the potassium export - from 89 to 291 kg K/ha, respectively. The lowest values of that characteristic were established in the control and the highest - after three-fold application of ammonium nitrate - 1/3 pre-sowing, 1/3 at 5th leaf and 1/3 - at tasseling stage. Similar results were also reported during the second year of study. On average for the study period, no significant differences were found between the tested fertilization variants with respect to the consumption of macroelements.

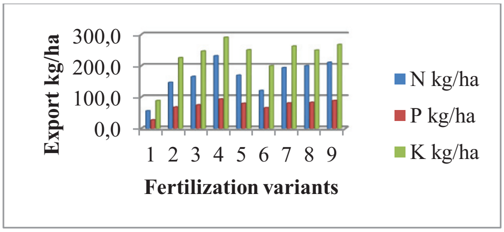

Figure 3. Export of NPK kg/ha (2015)

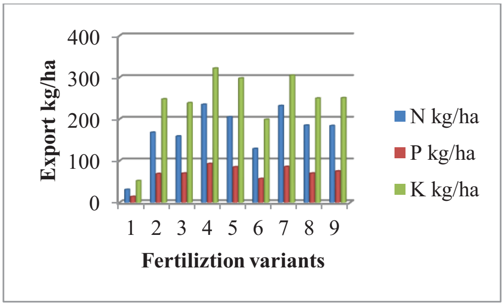

Figure 4. Export of NPK kg/ha (2016)

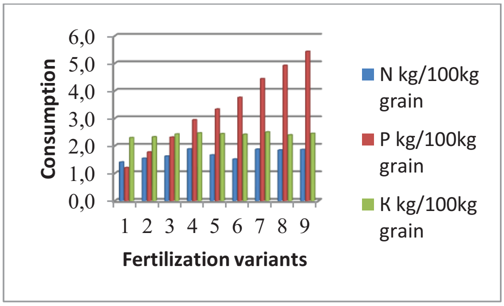

Figure 5. NPK efficiency - kg/100 kg grain on average for the study period

CONCLUSIONS

The results obtained showed that the three-fold nitrogen application as ammonium nitrate: 1/3 pre-sowing, 1/3 at 5th leaf and 1/3 at tasseling stage, has the most significant effect on the productivity of maize, hybrid PO216, the increase in grain yield compared to the control variant being 9370 kg/ha.

The studied crop demonstrated well its productive capacity after fertilizing with urea, split application at the following rates: ½ of the rate applied pre-sowing and ½ - at 10th leaf (Variant 7) - 11340 kg/ha.

The increase in grain yield compared to the control ranged from 5180 kg/ha to 9370 kg/ha. Including nitrogen fertilization (NH_4NO_3 - the whole rate pre-sowing) in the maize cultivation technology resulted in an increase in productivity by 6793.5 kg/ha compared to the control variant.

The export of nitrogen, phosphorus and potassium with the crop is significantly affected by the applied nitrogen nutrition.

The highest values of the characteristic were reported in Variant 4.

On average for the period, the export of nitrogen increased compared to the control variant from 81 kg/ha to 190 kg/ha, export of phosphorus from 41 to 73 kg/ha and potassium - from 129 to 236 kg/ha, respectively.

In contrast to export, the nitrogen fertilization scheme did not have a significant effect on the efficiency use of macroelements.

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THE USE OF GROWTH ANGLE OF SEMINAL ROOTS AS TRAIT TO IMPROVE THE DROUGHT TOLERANCE IN WINTER WHEAT (*Triticum aestivum* L.)

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Abstract

Root system characteristics are fundamental importance not only for the uptake of nutrients and water from soil but also for environmental stress tolerance. Root architectural traits determine the in situ space-filling properties of a root system or root architecture. The growth angle of root axes is a principal component of root system architecture that has been strongly associated with water efficiency in many crop species. The aims of this study were to examine the extent of genotypic variability for the growth angle of seminal roots in 100 Romanian haploid lines derived from a cross between two winter wheat cultivars (Triticum aestivum L.), different for osmotic adjustment and association between growth angle of seminal roots and cuticular transpiration. Also three simple sequence repeat (SSR) markers (WMC596, WMC603 and SCM9) were examined for polymorphism between Izvor and F000628 wheat genotypes and to quantify the effect of 1RS:1AL translocation (from Secale) on seminal root characteristics and association between growth angle of seminal roots and cuticular transpiration. The growth angle of seminal roots showed significant genotypic variation among the wheat genotypes with values ranging from 53 to 119°. The obtained results revealed that SSR markers studied (wmc 596 and wmc 603) and 1AL/1RS translocation (from Secale) were weakly associated with growth angle of seminal roots. The implications of genotypic variation in the seminal root characteristics are discussed with emphasis on the possible exploitation of root architectural traits in breeding for improved wheat cultivars for water-limited environments.

Key words: *winter wheat, angle of seminal roots, cuticular transpiration, SSR markers, drought resistance.*

INTRODUCTION

Roots play several essential roles in the plant life cycle both for the uptake of nutrients and water but also for hydric tolerance of some plants. Plants have several ways to modify their root system architecture in response to changes in the external environment (Osmont et al., 2007). Analyses of genetic factors contributing to root system architecture are still very limited, however, partly because is difficult to observe the distribution of roots in field conditions, and partly because of the complexity of the effects of environmental conditions on root system architecture.

Some study suggested that the seminal root growth angle is useful for predicting vertical root distribution. Manschadi et al. (2008) have also suggested that selection for seminal root traits might be useful in breeding to increase the drought tolerance of wheat varieties with deep root architecture. They conducted that selection for root growth angle and number of seminal roots may help to identify genotypes with root system architecture adapted to drought tolerance. Therefore, identification of the genetic factors controlling growth angles of roots at the seedling stage is an important key to predicting root system architecture in cereals.

Drought resistance can be improved by increasing the water use efficiency, and one way to achieve this is by selecting genotypes with low cuticular transpiration. Cuticular (or residual) transpiration represents the main way of water loss during night under optimal conditions and during noon under drought conditions, when stomata are closed. It was used as selection trait in wheat breeding for drought resistance (Clarke, 1991; Balota, 1995; Petcu, 2005).

The aims of this study were to examine the genotypic variability for the growth angle of seminal roots in 100 Romanian haploid lines derived from a cross between two winter wheat cultivars (*Triticum aestivum* L.), different for osmotic adjustment and association between growth angle of seminal roots and cuticular transpiration. This will help in establishing a strategy to improve the tolerance of winter wheat to water stress.

MATERIALS AND METHODS

The haploid lines derived from a cross between two winter wheat cultivars different for osmotic adjustment (Izvor with gene for osmotic adjustment, Or^+ and F00628 without osmotic adjustment gene, or^-) and lines with 1AL/1RS translocation (from Secale) were studied.

For determination the seminal root angle, we used 0.75L transparent pots. The transparent pots were filled with two types of soils mixture (70% turba and 30% chernozem soil). Seeds were sown at a depth of 2 cm every 2.5 cm along the pot wall. The seeds were carefully placed vertically, embryo downwards and facing the wall to facilitate root growth along the transparent wall. After sowing, the clear pots were wrapped in aluminum foil and placed in dark-colored paper bags to exclude light from the developing. The pots were watered after sowing and no additional water or nutrients were supplied thereafter.

The roots were photographed at 7 days after sowing, then foto images of each individual seedling were transferred in PC. The angle between the two most outer seminal roots was measured with ImageJ program.

Cuticular transpiration, according to Clarke (1991) method, was measured on second leaves (five for each replicate) from plants that were stresses 14 days (without water). Following the initial weight determination, the leaves were maintained in the darkness for stomata closure under ambient room conditions, weighed again after 5 h and then dried at 90°C. Water loss was expressed in grams of water lost per gram of leaf dry matter, using the formula: [(Gi-Su)-(G5-Su)]/Su; where Gi is initial fresh weight, G5 - fresh weight after 5 h and Su is the dry weight.

A total of three simple sequence repeat (SSR) markers were analysed for polymorphism between Izvor and F000628.

DNA isolation of materials used in this study was extracted from two seeds using the SDS3 method described by Cristina et al. (2017). The molecular analysis for SSR markers WMC596 and WMC603 located on 7A chromosome were conducted according to the method described by Ciucă et al. (2010) and for SSR markers SCM9 we used the protocol by Saal and Wricke (1999).

RESULTS AND DISCUSSIONS

The anlyses of variance of the seminal root angle indicated a significant effect of genotype at the 0.1% level of significance (Table 1).

Table 1. Analyses of variance for seminal root angle

Specification	Source of variance	DF	Sum of squares	Mean square	*F value and significance*
Genotypes Or^-	Variants	24	18146	756.11	128.91***
	Error	48	281	5.86	
Genotypes Or^+	Variants	25	15311	612.46	1526***
	Error	50	20.05	0.40	
Genotypes Or^- with 1AL/1RS translocation	Variants	25	13102	524.08	1366***
	Error	50	19.6	0.38	
Genotypes Or^+ with 1AL/1RS translocation	Variants	24	15886	661.02	1056***
	Error	48	30.07	0.62	

Izvor cultivar carry gene for osmoregulation (*or)* by Banica et al. (2008), Ciucă et al. (2010). F000628 line carry 1AL: 1RS translocation by Ciucă et al. (2015). The DH lines created by crossing between Izvor and F000628 were characterized regarding the presence/absence of gene for osmotic adjustment and for presence/absence of 1AL/1RS wheat-rye translocation using molecular markers. Based on molecular markers results the lines were split into four groups, according to Table 2.

Considerable variation was observed among these cultivars concerning seminal root angle. Within each genotype group there were variations in the seminal root angle from 53 to 119°, with the average between 86 and 94°, (Table 2).

The analyzed Western Europe cultivars had seminal roots angles between 84 and 88º, the Austrian and Russian cultivars had angles of 79 and 85º, respectively and some Romanian

varieties showed a variability from 74-115º, (David, 2018).
The value of angle of seminal roots for Izvor genotype (known as drought resistant by its osmotic adjustment capacity) was 82° as compared with genotype F00642 (115°), without adjustment capacity (Figure 1).

Figure 1. The seminal root angle of Izvor (left) and F00642 (right) genotypes

Not all genotypes with gene for osmotic adjustment had small angles of seminal roots such as control genotypes (Izvor). It is noted that there are a total of eight genotypes with Or^+ gene that have a seminal angle over 100°. Also in the group of genotypes withoth osmotic adjustment (or^-) are many genotypes that have shallower root systems (Table 2).
Oyanagi (1994) have found that wheat varieties bred for western Japan tend to have shallower root systems than varieties bred for eastern Japan, and explained this regional difference as an adaptation to the more abundant soil moisture in western Japan. Manschadi et al. (2008) have found that drought-tolerant varieties tend to have deeper root systems compared to susceptible varieties. These results illustrate the close relationship between root system architecture and soil environmental conditions.
Previous studies on seminal root angle reported lower values, which could be due to their measurement of the angle between primary seminal root and one of the first pair of seminal roots and also using entirely different genotypes than the ones used in your study (Richard et al., 2015). Manschadi et al. (2006) reported that a narrower seminal root angle was associated with higher grain yield in moisture limiting condition.
The rye translocation increased biomass of root and shoot in some cases, reduced plant height, and delayed maturity in some cases. The 1RS.1BL translocation produced the highest grain yield associated with the lowest root and shoot biomass under both well watered and water stressed conditions.
In our study the 1AL/1RS translocation increased a little bit the seminal root angle, the average of the two groups of genotypes possessing the rye translocation was 93 and 94°, respectively, compared to 86 and 91°, the values of the two groups without 1AL/1RS translocation (Table 2).

Table 2. The seminal root angle of studied genotypes

Genotypes without osmotic adjustment (or^-)		Genotypes with osmotic adjustment (Or^+)		Genotypes with 1AL/1RS translocation and or^-		Genotypes with 1AL/1RS translocation and Or^+	
AiI 65	53	BiII 18	54	AiII 55	60	AiI 1	89
BiII 13	61	BiII 71	68	Bi II 3	76	BiII-2	102
AiII232	62	BiII 107	74	AiII 271	76	BiI - 8	85
BiII 81	64	Bi II 87	78	AiI- 33	79	AiII -19	83
AiII 118	68	Bi II 141	80	Ai I - 76	81	BiII- 24	62
BiII 140	71	Ai I - 44	82	Ai I - 73	85	Ai I 24	99
BiII 96	73	**Izvor**	**82**	Ai II 115	88	Bi I 32	106
BiII 114	79	Bi II 78	84	Ai I - 65	88	Bi I 44	86
BiII 79	84	AiII- 130	85	AiII 141	89	Ai I 45	71
BiII 110	86	Ai II 253	87	Ai II 51	89	Ai II 66	106
BiII 86	86	AiII- 215	89	Bi II 147	91	Ai II 104	73
AiII 90	88	AiII- 238	89	Bi I 36	93	Bi II 109	110
AiII 230	88	Bi II 10	89	BiII 100	94	Bi II 129	82
AiII - 82	89	Ai II 251	90	Bi II 1	95	Ai II 137	80
AiII 204	89	Bi II 16	91	Ai II 248	96	Ai II 159	69
BiII 143	93	AiII- 233	93	Ai II 34	97	Ai II 163	106
AiII 241	94	Bi II 85	96	Ai II 225	99	AiII 172	101
AiII - 89	94	Bi I 23	97	Bi II 142	99	Ai II 175	100
AiII - 83	96	Bi II 25	102	AiI - 20	100	AI II 183	118
AiII 167	97	Bi II 95	103	BiII 72	101	AiII 184	111
BiII 137	100	Bi II 29	104	Ai II 14	101	Ai II 202	95
AiI - 62	105	Bi II 122	104	Ai II 20	104	Ai II 231	93
BiII 75	105	BiII 144	106	Ai II 86	108	Ai II 237	111
AiII 126	106	BiII 104	112	AiII 47	113	AiII 239	96
AiII - 54	114	Bi II 134	114	**F00628**	115	AiII 259	97
		Ai II 240	114	Ai II 45	119		
Average	**86**		**91**		**94**		**93**
LD 5%	*3.9*		*1.03*		*1.36*		*1.8*
LD 1%	*5.3*		*1.38*		*1.81*		*2.4*

Most of the wheat lines with osmotic adjustment capacity and 1AL/1RS translocation from rye exhibited a cuticular transpiration of between 0.6 and 0.9 g/g while those without osmotic adjustment had a cuticular transpiration over 1 g/g, with some exceptions (Figure 1).

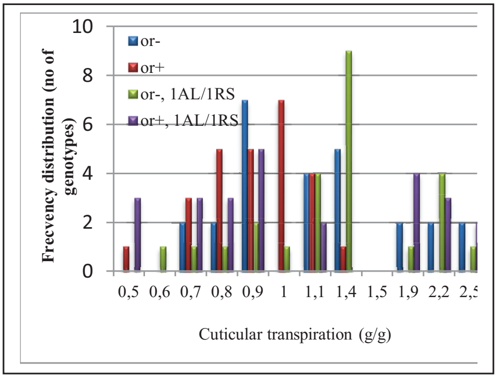

Figure 1. The frecvency distribution for cuticular transpiration

Correlation studies between characters are very important in plant breeding for indirect selection and have also been of great value in the determination of the most effective breeding procedures. In our study, regression analysis shows the existence of the correlation between seminal root angle and cuticular transpiration at the 0.1% level of significance for the genotypes without osmotic adjustment capacity and 1AL/1RS translocation and witout significance for the genotypes with Or^{+} gene. (Table 3). This results suggest that seminal root angle can be selected for wheat improvement as it showed association with cuticular transpiration.

Table 3. Coefficients of correlation between seminal root angle and cuticular transpiration respectively WTS of studied winter wheat genotypes

	Genotypes or^{-}	Genotypes Or^{+}	Genotypes or^{-} and 1AL/1RS	Genotypes Or^{+} and 1AL/1RS
Cuticular transpiration				
Seminal root angle	r = 0.60**	r = 0.36	r = 0.79***	r = 0.82***
The weight of thousand seeds				
Seminal root angle	r = 0.02	r = -0.15	r = 0.07	r = 0.12
Cuticular transpiration	r = - 0.39	r = -0.18	r = 0.2	r = 0.008

We conducted correlation analysis of seminal root angle with MMB and also between WTS and culticular transpiration and did not find significant correlation except the correlation between cuticular transpiration and WTS at the 0.5% level of significance for the genotypes without osmotic adjustment capacity (Table 3).

This results are in concordance with many studies but other reported a weak correlation of yield with the seminal root number or evidentiate that root growth angle (RGA) was negatively correlated with grain yield, positively with canopy temperature depression, negative correlations with SPAD in the managed drought and irrigated experiments Madhav Pandey et al. (2015).

Molecular analyzes have shown that molecular markers responsible for osmotic adjustment (WMC603 and WMC596) can explain part of the phenotypic variation of the seminal root angle because only 45.5% of the DH lines with Or+ gene had an electrophoretic profile similar to that of the variety Izvor. Xie et al. (2017) found a QTL associated with emergence angle of seminal root in wheat and this is located on 7D chromosome. In this respect, molecular analyses will be focused on chromosome 7D.

Similar studies of wheat, which compared the architecture of drought-adapted genotypes to that of standard genotypes, have the relevance that drought-adapted genotypes have a compact root system (the roots are laterally dispersed at a maximum of 45 cm from the main stem), the roots occupy a volume of soil uniformly and grow more in the depths of soil (3.8 times more than standard) (Manschadi et al., 2006). This type of root system allows the plant to access moisture in deeper layers. At the same time, large seminal root angle should be considered as they re-use water from superficial soil layers. This could be beneficial in capitalizing small amounts of precipitation during periods of drought. It will be necessary also to evaluate evolutions of rainfall from our zone in order to established what kind of seminal root angle is better to improve the drought resistance of wheat for the future.

CONCLUSIONS

Our results have confirmed the presence of significant genotypic differences in seminal root angle among our set of 100 genotypes. The genotypes with the narrow seminal root angle grow more in the depths of soil and this type of root system will allow the plant to access moisture in deeper layers. At the same time many varieties have the shallow seminal root angle, this might be an adaptation to the high moisture content of the soil and could be beneficial in capitalizing small amounts of precipitation during periods of drought/vegetation. The existence of positive correlations between the seminal angle and the cuticular transpiration, opens up new possibilities of amelioration of winter wheat.

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SOME BIOLOGICAL FEATURES AND BIOMASS QUALITY OF *Sorghum almum* UNDER THE CONDITIONS OF MOLDOVA

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Abstract

Taking into account the intensity and frequency of natural hazards, the expansion of areas with salinized and degraded soils in our region, it is necessary to mobilize, acclimatize and breed new crops that would ensure production in these severe conditions. The main objective of this research was to evaluate some biological features, the quality of green mass, the physical and mechanical characteristics of the dry biomass of the C_4 perennial grass species - Sorghum almum Parodi, under the conditions of the Republic of Moldova. We have found that, in the 3rd year, Sorghum almum resumed vegetation in the middle of April and, in the mid- June the plants were about 190-200 cm tall, being harvest for the first time. The green mass productivity was 28.3 t/ha at the first harvest, 17.2 t/ha at the second harvest and 15.3 t/ha at the third harvest, respectively. The annual feed productivity achieved 11183 nutritive units and 860 kg digestible protein. The calculated biochemical methane production potential of Sorghum almum substrate reached 279-316 l/kg organic matter. The specific density of the solid biofuel - briquettes was 788 kg/m^3, with 16.5 MJ/kg net calorific value. Sorghum almum can be used to obtain alternative green fodder for livestock, but also as multi-purpose feedstock for the production of renewable energy.

Key words: *biological features, fodder value of green mass, biochemical methane production potential, solid biofuel, Sorghum almum.*

INTRODUCTION

Taking into account the intensity and frequency of natural hazards, the expansion of areas with salinized and degraded soils in our region, it is necessary to mobilize, acclimatize and breed new crops that would ensure production in these severe conditions.

The genus *Sorghum* Moench, *Poaceae* family, includes 31 species, is native to Europe, Asia, North and South America, along with Australia. *Sorghum* species have recently gained popularity due to their numerous advantages, such as heat and drought tolerance, resistance to specific diseases and pests, being able to exploit the salty soils where the cultivation of cereals is more difficult. The adaptive nature of *Sorghum* species as C_4 plants and the better water use efficiency, their potential to produce higher tonnage of grains or green forage and their diverse uses make them a valued tool and one of the best choices for forage growers and dairy farmers demanding high quality feed stocks, also for food and other industrial uses, production of cellulose or renewable energy (Moraru, 2008; Roman et al., 2016; Wannasek et al., 2017; Ivanova et al., 2018).

Sorghum almum Parodi, native to Argentina, is an erect, robust, tussocky perennial grass with numerous tillers and thick short rhizomes which curve upwards to produce new shoots near the parental stool. The stem is solid and pithy, about 1 cm thick, sometimes reaching a height of 300 cm. The leaves are 1.3-3.8 cm wide and 45.7-81.3 cm long, generally glabrous except for the hairs near the ligule. The panicles are 15.2-61 cm long open, with branchlets mostly by four in whorls. It is predominantly cross-pollinated, but is also self-fertile. The caryopsis is brown to reddish-brown, 3-3.8 mm long, elliptic to obovate, dorsally compressed, the embryo - the length of the caryopsis, the hilum - round. Chromosome number is 2n = 40. *Sorghum almum* is a short-day plant, it propagates by seeds or by thick underground rhizomes, prefers soils from light loams to heavy clays, with a pH range from 5

to 8.5, tolerates drought and salinity but does not tolerate prolonged flooding. It is more tolerant to drought than maize, Sudan grass and Johnson grass, and can survive in areas receiving 200 mm of annual rainfall. Common names of this species, which can be found literature, are: Columbus grass, five-year sorghum, perennial sorghum - in English; sorgho d'Argentine - in French; Columbus grass - in German; sorgo almo - in Italian; sorgo negro, pasto colon - in Spanish; сорго щедрое, колумбова трава, сорго многолетнее - in Russian; сорго багаторічне, колумбова трава - in Ukrainian; iarba grasa, sorg peren, iarba lui Columb in Romanian (Popescu & Albu, 1970; Elizondo, 2004; Rakhmetov & Rakhmetova, 2009; Heuze et al., 2015; Ţîţei et al., 2015). In the former USSR, it has been researched since 1957, in the Central Asian republics, and then it became a popular research subject in Ukraine, from where it was introduced in Moldova, in the 70s of the past century. In the conditions of forest-steppe and in the Polissya region, Ukraine, the Columbus grass forms a bush of three to five productive stems of 230-300 cm in height, is characterized by high yields of biomass (75 t/ha fresh mass) and seeds (2.2 t/ha) and is moderately frost resistant (Rakhmetov & Rakhmetova, 2009). The green mass productivity of *Sorghum almum*, under irrigation conditions, in Uzbekistan, reached 211 t/ha (Avutkhonov et al., 2016).
The goal of this research was to evaluate some agro-biological features, the biochemical composition of the harvested green mass of perennial sorghum, *Sorghum almum*, as well as the biochemical methane potential of the green mass substrate, the physical and mechanical characteristics of dry biomass and briquettes.

MATERIALS AND METHODS

The cv. 'Argentina' of perennial sorghum, *Sorghum almum,* created in the National Botanical Garden (Institute) Chişinău, which was cultivated in the non-irrigated experimental plot of the Plant Resources Laboratory, N 46°58′25.7″ latitude and E 28°52′57.8″ longitude, served as subject of the research.
The green mass of three-year-old plants of *Sorghum almum* was cut manually for the first time in the middle of June, the second time - at the end of July and the third time - at the end of the September. The harvested green mass was weighed. The leaves/stems ratio was determined by separating leaves and panicles from the stem, weighing them separately and establishing the ratios for these quantities, samples of 1.0 kg harvested plants. For chemical analyses, the samples were dried at 65 ± 5°C. 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; calcium concentration - using the atomic absorption spectrometry method and phosphorus - using the spectrophotometric method; acid detergent fiber (ADF), neutral detergent fiber (NDF) and acid detergent lignin (ADL) have been determined by near infrared spectroscopy (NIRS) technique PERTEN DA 7200, the concentration of hemicelluloses (HC) was approximated from subtraction of the ADF from the NDF, while the concentration of cellulose (Cel) of each sample was estimated by subtracting the ADL from the ADF. The biochemical biogas potential (Yb) and the methane potential (Ym) were calculated according to the equations of Dandikas et al. (2014) based on the chemical compounds – acid detergent lignin (ADL) and hemicellulose (HC) values:

$$Yb = 727 + 0.25\,HC - 3.93\,ADL;$$

$$Ym = 371 + 0.13HC - 2.00ADL.$$

To produce solid fuel, the *Sorghum almum* plants were mowed at the end of the flowering stage (July) and were left to lie in swaths for drying directly in the field. The dry biomass was chopped and milled in a beater mill equipped with a sieve with diameter of openings of 10 mm. The following scientific research on biomass for the production of solid biofuel was carried out: the moisture content of the plant material was determined by CEN/TS 15414 in an automatic hot air oven MEMMERT100-800; automatic calorimeter LAGET MS-10A with accessories was used for the determination of the calorific value, according to CEN/TS 15400; the particle size distribution was determined using standard sieves; the cylindrical containers were used for the determination of the bulk density; the briquetting was carried out by using the special equipment; the mean compressed (specific) density of 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, under the conditions of the Republic of Moldova, in the third year of growth, the plants of *Sorghum almum* resumed growth in the middle of April; new shoots grew from the rhizomes formed in the underground part in the previous year. At the end of the first week after the resumption of growth, the plantlets were 3-5 cm tall and had 2-3 leaves. A more intensive growth and development rates of plants were observed in May. Thus, in the middle of May, the stems reached 60-65 cm in height and branching began. By the end of the month, the plants were already over 120 cm tall. In mid-June, the initiation of formation of the panicles was observed.

The results of our study concern the agro-biological features, the green mass yield and the leaves/stems ratio, depending on the harvesting period (cut) of the *Sorghum almum* plants (Table 1). It has been determined that, in the third year of growth, when the plants were cut for the first time in mid-June, they were 196 cm tall, with a moderate leaves/stems ratio, and the productivity reached 2.85 kg/m^2 of green mass or 0.67 kg/m^2 dry matter. Due to the favourable weather conditions in June-July 2018 y., with considerable amount of rainfall and moderate temperatures 22-25°C, the plants recovered well after the harvest. Thus, several new shoots developed and, at the end of July, the height of the plants was 160-165 cm and 1.72 kg/m^2 green mass were harvested, with reduced dry matter content (18.6%), but higher proportion of leaves (49%). After the second cut, the growth and the development of plants were slower in the August, but then they intensified and, until the end of September, the shoots reached a height of about 153 cm and 30% of the plants were in the stage of panicle development. The yield at the third cut was 1.53 kg/m^2 green mass or 0.41 kg/m^2 dry matter. The annual productivity from three harvests was 6.1 kg/m^2 green mass or 1.4 kg/m^2 dry matter, surpassing the productivity of maize by 35%.

Table 1. The yield and its structure depending on the harvest time of *Sorghum almum* plants

Harvest time	Plant height, cm	Stem, g		Leaf, g		Yield, kg/m^2	
		green mass	dry matter	green mass	dry matter	green mass	dry matter
First cut 13.06.2018	196	23.2	7.0	11.3	2.9	2.85	0.67
Second cut 27.07.2018	163	16.4	2.6	11.0	2.5	1.72	0.32
Third cut 24.09.2018	153	8.5	2.1	7.1	2.1	1.53	0.41

It is a well-known fact that the content of dry matter and its biochemical composition are important for the feed and energy value of natural fodder. The dry matter content in *Sorghum almum* green mass significantly differed in dependence of the harvest time; it was optimal in the green mass obtained after the first and third cuts and the lowest - after the second cut. It was determined that the biochemical composition of the dry matter also varied depending on the harvest time: crude protein varied from 51.0 to 141.9 g/kg, crude fats - from 19.6 to 34.5 g/kg, crude cellulose - from 336.8 to 396.3 g/kg, nitrogen free extract - from 348.0 to 442.7 g/kg, ash - from 76.7 to 138.8 g/kg (Table 2). The amounts of protein, fats and ash were high in the green mass obtained after the second cut and low – after the third cut. The concentration of carbohydrates: crude cellulose and nitrogen free extract, in the green mass obtained after the first and the third cuts was significantly higher in comparison with the green mass obtained after the second cut.

The content of nutrients and their digestiblity influence the feed and energy value of *Sorghum almum* plants. Therefore, 100 kg of green mass obtained at the first cut contained 19.3 nutritive units and 207 MJ metabolizable energy, at the second cut - 12.4 nutritive units and 131 MJ metabolizable energy and at the third cut - 23.2 nutritive units and 249 MJ metabolizable energy for cattle. The annual feed productivity achieved 11183 nutritive units and 860 kg digestible protein.

Table 2. The biochemical composition, the nutritive and the energy value of the *Sorghum almum* green mass

Indices	First cut	Second cut	Third cut
Crude protein, %	8.29	14.19	5.10
Crude fats, %	2.70	3.45	1.96
Crude cellulose, %	39.00	33.68	39.63
Nitrogen free extract, %	42.25	34.80	44.27
Ash,%	7.67	13.88	9.05
Nutritive units/kg fodder	0.19	0.12	0.23
Metaboliz. energy, MJ/kg fodder	2.07	1.31	2.49
Calcium, %	0.53	0.52	-
Phosphorus, %	0.18	0.32	-
Carotene, mg/kg fodder	45.59	30.34	24.00

Minerals and vitamins have a disproportionate effect on animal production relative to their low concentration in total diets. Calcium is closely associated with phosphorus in the animal body, they are vital for the skeleton and the function of nerve impulses, cellular energy transfer and lipid metabolism. The Ca/P ratio should be 2:1 since there is an antagonist relationship between the two minerals concerning uptake from the small intestine. It was determined that calcium content reached 5.2-5.3 g/kg dry matter, varying insignificantly depending on the harvest time, while the phosphorus content increased substantially from 1.8 g/kg dry matter, at the first cut, to 3.2 g/kg dry matter, at the second cut, the calcium/phosphorus ratios were acceptable for cattle diets.

Plant carotenoids are precursors of retinol - vitamin A, together with Vitamin E and polyphenols, are natural antioxidants in ruminant diets. Higher carotenoid concentrations in milk contribute to an improvement in the nutritional value of dairy products. It was found that, during the development of *Sorghum almum* plants, the amount of carotene decreased from 45.59 mg/kg fodder at the first cut to 24.00 mg/kg fodder at the third cut.

Several literature sources describe the nutritional performance of *Sorghum almum* plants. According to Heuze et al. (2015) the average feed value of fresh aerial part was: 17.5% dry matter, 10.0% protein, 2.5% fats, 33.6% raw cellulose, 68.8% NDF, 39.3% ADF, 5.2% lignin, 11.7% ash, 4.5 g/kg calcium and 4.1 g/kg phosphorus, 63.8% digestible organic matter, 10.8 MJ/kg digestible energy and 8.7 MJ/kg metabolizable energy. Amador and Boschini (2000) reported that the nutritional quality of whole plants during growth stages from 24 to 150 days after sprouting changed: 10.41-38.20% dry matter content, 25.97-7.7% protein, 13.40-7.46% ash, 50.58-75.05% NDF, 26.69-50.63% ADF, 26.49-43.25% cellulose, 20.89-28.70% hemicellulose and 2.82-7.51% lignin. The results obtained by Elizondo (2004) in Costa Rica, varied with advancing stage of regrowth from 56 to 84 days: 11.2-17.3% dry matter content, 15.02-12.47% protein and 67.67-69.56% NDF. Lanyansunya et al. (2006), studied the chemical composition of *Sorghum almum* in pure stand and intercropped with *Vicia villosa*, harvested at the age of 18 weeks, and found that pure *Sorghum almum* contained 8.7% crude protein, 6.7% ash, 70.0% NDF 38.1% ADF, 6.9% ADF, 31.2% cellulose and 31.9% hemicellulose, but in mixture with *Vicia sativa* - 9.6% crude protein, 6.9% ash, 69.7% NDF 32.2% ADF, 5.9% ADF, 26.4% cellulose and 37.4% hemicellulose. Alpizar et al. 2014 mentioned that harvested *Sorghum almum* plants contained 8.77% crude protein, 54.88% NDF, 35.08% ADF, 19.80% hemicellulose and 8.29 % ash, but the produced silage was characterized by pH 3.8, 7.92% protein, 60.70% NDF, 36.49% ADF, 24.21% hemicellulose and 9.01% ash.

Biomass is an important source for the production of multi-purpose renewable energy. Pytomass can be converted into biomethane using anaerobic digestion process. The stability and the productivity of biogas reactors are mostly influenced by biochemical composition, biodegradability and ratio of carbon and nitrogen of substrate. We would like to mention that the carbon and nitrogen ratio in the investigated substrates of *Sorghum almum* green mass ranged from 29.6 to 60.1, the C/H ratio was optimal in the green mass substrates from the first and the second cuts. It has been found that, depending on the harvest time, the plant cell wall content also varies and affects the methane potential (Table 3). The results show that the cellulose concentration ranged from 376 to 447 g/kg, hemicellulose - from 249 to 315 g/kg and lignin - from 45 to 62 g/kg, which are much larger amounts than in the green mass substrate obtained after the third cut. The calculated gas forming potential was 546-617 l/kg; the methane yield was 279-316 l/kg. The annual methane productivity achieved 4198 m^3/ha.

Mahmood et al. (2013) found that the specific methane yield of *Sorghum* substrate varied from 250 to 354 l/kg and the total methane yield - from 3924 to 6554 m^3/ha. Wannasek et al. (2018) determined that *Sorghum* biomass yield reached 20.67 t/ha and the methane yield was 6500 m^3/ha.

Table 3. The biochemical methane potential of the green mass substrate from *Sorghum almum*

Indices	First cut	Second cut	Third cut
Carbon/nitrogen	33.3	29.6	60.1
Lignin, g/kg	50	45	62
Cellulose, g/kg DM	390	376	447
Hemicellulose , g/kg DM	266	249	315
Biogas, l/kg ODM	597	617	546
Biomethane, l/kg ODM	306	316	279
Methane yield, m^3/ha	2035	1011	1152

Table 4. Some physical and mechanical properties of biomass and briquettes from *Sorghum almum*

Indices	*Triticum aestivum*	*Sorghum almum*
Particle size distribution		
<5mm	31.5	22.1
4-5mm	17.3	17.8
3-4 mm	15.2	18.4
2-3 mm	17.7	15.7
1-2 mm	12.4	17.5
1 mm	6.0	8.5
Biomass properties		
moisture content, %	11.6	9.9
ash content, %	4.93	4.96
gross calorific value, MJ/kg	17.4	18.3
bulk density 7-35 mm chaffs, kg/m^3	79	109
bulk density 10 mm chaffs, kg/m^3	90	121
Briquette properties		
specific density, kg/m^3	740	788
bulk density, kg/m^3	407	439
net calorific value, MJ/kg	15.5	16.5

Direct combustion of grass biomass is not practical and briquetting is the most common densification method used for solid fuel production. Our study showed that *Sorghum almum* milled chaffs had the lowest percentage of particles larger than 5 mm (22.1%) and the highest percentage of particles smaller than 2 mm (26.0%), in comparison with wheat straw, *Triticum aestivum* chaffs (Table 4), this fact had a favourable impact on bulk and specific density. We could mention that *Sorghum almum* biomass contained about the same amount of ash as wheat straw (4.96%). The bulk and specific density of briquettes from *Sorghum almum* was 439 kg/m^3 and 788 kg/m^3, but wheat straw 407 kg/m^3 and 740 kg/m^3, respectively. The net calorific value of *Sorghum almum* briquettes was 16.5 MJ/kg.

Under the conditions of Ukraine, Kurylo et al. (2018) mentioned that the yield of dry phytomass of *Sorghum almum* was 11–14 t/ha and the energy value was 3750-3810 kcal/kg. Plistil et al. (2005), reported that the density of briquettes of *Sorghum vulgare* was 800-870 kg/m^3, the same index was 600-840 kg/m^3 for *Phalaroides arundinacea* and 650-730 kg/m^3 for barley straw, the destruction force was 40-60 N/mm, 10–35 N/mm and 6-13 N/mm, respectively. The results obtained by Ivanova et al. (2018), for sweet sorghum briquettes, were as follows: 7.7% moisture, 3.9% ash, 70.8% volatile matter, gross calorific value 18.9 MJ/kg dry matter, net calorific value 17.7 MJ/kg dry matter, the specific density was 617.5 kg/m^3 and the mechanical durability was 90.5%.

CONCLUSIONS

1. *Sorghum almum* plants, in the third growing season, resumed vegetation in the middle of April and were characterized by intensive growth and development rate, high regenerative capacity after being cut, thus making it possible to mow them three times per season.
2. The green mass productivity reached 28.3 t/ha at the first harvest, 17.2 t/ha at the second harvest and 15.3 t/ha at the third harvest, respectively.
3. The harvested green mass contained 5.10-14.19% crude protein, 1.96-3.45% crude fats, 33.68-39.63% crude cellulose, 34.80-44.27% nitrogen free extract and 7.67-13.88% ash, the fodder value was 0.12-0.23 nutritive units/kg and 1.31-2.49 MJ/kg metabolizable energy for cattle.
4. The biochemical methane potential of *Sorghum almum* substrate reached 279-316 l/kg and the annual productivity 4198 m^3/ha.
5. The specific density of the briquettes from *Sorghum almum* was 788 kg/m^3, with net calorific value 16.5 MJ/kg.

We consider that *Sorghum almum* biomass may be used as alternative feed for livestock and as multi-purpose feedstock for the production of renewable energy.

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RESEARCHES REGARDING THE ENTOMOFAUNA OF SOME AGRICULTURAL CROPS FROM N-E MOLDAVIA

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Abstract

The purpose of these research is to identify the useful entomofauna from the agricultural crops which were taken for the study: maize and wheat. The researches were carried out in the Ezareni station, which belongs to "Ion Ionescu de la Brad" University of Applied Life Sciences and Environment of Iasi, Romania. The biological material was sampled by the mean of the Barber soil traps from April 30th of June until 7th of August 2018. The samples were carried out at the following dates: 30.04, 03.05, 07.05, 12.05, 15.05, 18.05, 22.05, 25.05, 05.06, 08.06, 13.06, 21.06, 05.07, 12.07, 18.07, 25.07, 01.08, 07.08. One with another, 18 samples were made for every crop. The traps were placed every six in a row. To prevent the maceration of insects, a conservative liquid was used (water+ washing powder) in proportion of 16%. After finishing the experiments, the insects were bringing to the laboratory of Entomology in order to be counted and determined. From the Coleoptera order, the most dominant species are:
-within the crop of maize: Carabus nemoralis (Carabidae) - 48 samples; Dermestes maculatus (Dermestidae) - 27 samples; Coccinella septempunctata (Coccinellidae) - 33 samples;
-within the crop of wheat: Pterostichus cupreus (Carabidae) - 52 samples; Dermestes maculatus (Dermestidae) - 21 samples; Coccinella septempunctata (Coccinellidae) - 30 samples.

Key words: *soil traps, Coccinellidae, Dermestidae, Carabidae.*

INTRODUCTION

Carabidae family includes ground beetles, with fast moving, which move to the surface of the soil, and only seldom walk on the trees. There are over 40,000 species known around the world, from which 2,700 are known in Europe. Almost all species of this family are predators for invertebrates, some of the being specialized for a certain type of food.
Coccinellidae family has species of round or oval species, almost hemispherical, with spots on the wings with color spots and contrasting patterns. The most species of *Coccinellidae* are benefical predators which prefer the aphids as main feed.
According to the author (Foltz, 2002), there are more than 5,000 species all around the world. The most representative species of the *Coccinellidae* family are: *Coccinella septempunctata*, *Adalia variegata*, *Chilocorus bipustulatus*, *Adalia bipunctata*.
Dermestidae family includes, in general, small insects, of cylindrical shape, with short legs and covered with fine hair. Their larva are very hairy. They feed with material animals, bodies, tendons.

MATERIALS AND METHODS

In order to carry out the researches, the insects were collected from one station: Ezareni from Iasi county, belonging to "Ion Ionescu de la Brad" University, by using the method of Barber soil traps. The experiments were made between April and August of 2018. The traps were placed within two crops: maize and wheat, each six in a row. As a conservative liquid, water and washing powder were used, in order to conserve the insects. There were 18 samples in total, the first one took place on 30th of April, and the last one on 7th of August.

RESULTS AND DISCUSSIONS

The samples of the biological material were carried out at the following dates: 30.04, 03.05, 07.05, 12.05, 15.05., 18.05., 22.05, 25.05, 05.06, 08.06, 13.06, 21.06, 05.07, 12.07, 18.07, 25.07, 01.08, 07.08.

Within the crop of maize (Table 1), the situation is as follows:

30.04: there were 2 samples identified, the both belonging to *Dermestes maculatus* (*Dermestidae* family);

03.05: there were 10 samples identified: all of them belonging to *Dermestes maculatus* (*Dermestidae* family);

07.05: there were 32 samples identified, all of them belonging to *Carabidae* family: *Carabus nemoralis* (10 samples); *Amara aenea* (10 samples); *Brachinus crepitans* (10 samples); *Amara communis* (2 samples);

12.05: there were 16 samples identified, all of them belonging to *Carabidae* family: *Carabus nemoralis* (3 samples); *Pterostichus melanarius* (10 samples): *Amara aenea* (1 sample); *Amara communis* (2 samples);

15.05: there were 15 samples identified, 13 of them belonging to *Carabidae* family: *Anisodactylus binotatus* (3 samples); *Anisodactylus signatus* (10 samples) and 2 belonging to *Dermestidae* family: *Dermestes maculatus*;

18.05: there were 21 samples identified, all of them belonging to *Carabidae* family: *Carabus nemoralis* (8 samples); *Amara communis* (2 samples); *Brachinus crepitans* (2 samples); *Anisodactylus signatus* (2 samples); *Pterostichus melanarius* (5 samples); *Anisodactylus poeciloides* (2 samples);

22.05: there were 19 samples identified, 16 belonging to *Carabidae* family: *Carabus nemoralis* (7 samples); *Anisodactylus poeciloides* (3 samples); *Carabus lineatus* (9 samples) and 3 belonging to *Dermestidae* family (*Dermestes maculatus*);

25.05: there were 7 samples identified, all of them belonging to *Carabidae* family: *Carabus nemoralis* (3 samples), *Brachinus crepitans* (2 samples); *Brachinus texanus* (2 samples);

05.06: there were 5 samples identified, all of them belonging to *Carabidae* family: *Carabus granulatus* (2 samples), *Brachinus texanus* (3 samples);

08.06: there were 12 samples identified, 2 belonging to *Carabidae* family: *Pterostichus cupreus* and 10 belonging to *Coccinellidae* family: *Harmonia axyridis*;

13.06: there were 6 samples identified, 4 belonging to *Carabidae* family: *Carabus nemoralis* and 2 to *Dermestidae* family: *Dermestes maculatus*;

21.06: there were 16 samples identified, one belonging to *Dermestidae* family: *Dermestes maculatus* and 15 to *Coccinellidae* family: *Coccinella septempunctata* (13 samples); *Harmonia axyridis* (2 samples);

05.07: there were 3 samples identified, all of them belonging to *Carabidae* family: *Carabus nemoralis* (1 sample); *Carabus serratus* (2 samples);

12.07: there were 30 samples identified, all of them belonging to *Carabidae* family: *Carabus nemoralis* (5 samples); *Pterostichus melanarius* (3 samples); *Brachinus texanus* (4 samples); *Cicindela germanica* (12 samples); *Calosoma inquisitor* (6 samples);

18.07: there were 4 samples identified, 3 belonging to *Carabidae* family: *Carabus nemoralis* and 1 belonging to *Dermestidae* family: *Dermestes maculatus*;

25.07: there were 14 samples identified, all of them belonging to *Carabidae* family: *Carabus nemoralis* (1 sample); *Anisodactylus signatus* (3 samples); *Anisodactylus binotatus* (3 samples); *Brachinus crepitans* (2 samples); *Amara aenea* (3 samples); *Amara communis* (2 samples);

01.08: there were 15 samples identified, 12 belonging to *Carabidae* family: *Carabus nemoralis* (3 samples); *Anisodactylus binotatus* (2 samples); *Anisodactylus signatus* (3 samples); *Amara communis* (3 samples); *Brachinus crepitans* (1 sample) and 6 to *Dermestidae* family (*Dermestes maculatus*);

07.08: there were 31 samples identified,11 belonging to *Carabidae* family: *Carabus nemoralis* (2 samples); *Anisodactylus binotatus* (2 samples); *Cicindela germanica* (7 samples) and 20 belonging to *Coccinellidae* family: *Coccinella 7-punctata*.

Within the crop of wheat (Table 2), the situation is as follows:

30.04: no samples were identified;

03.05: there were 10 samples identified, all of them belonging to *Dermestidae* family: *Dermestes maculatus*;

07.05: there were 5 samples identified, 2 belonging to *Carabidae* family: *Pterostichus cupreus* and 3 to *Dermestidae* family: *Dermestes maculatus*;

12.05: there were 9 samples identified, 6 belonging to *Carabidae* family: *Pterostichus cupreus* and 3 belonging to *Dermestidae* family: *Dermestes maculatus;*
15.05: there were 9 samples identified, 6 belonging to *Carabidae* family: *Pterostichus cupreus* and 3 belonging to *Dermestidae* family: *Dermestes maculatus*;
18.05: there were 30 samples identified, all of them belonging to *Carabidae* family: *Pterostichus cupreus* (5 samples), *Anisodactylus poeciloides* (8 samples); *Amara aenea* (10 samples); *Cicindela germanica* (7 samples);
22.05: there were 30 samples identified, 28 belonging to *Carabidae* family: *Pterostichus cupreus* (8 samples); *Carabus nemoralis* (7 samples); *Brachinus texanus* (5 samples); *Amara communis* (5 samples); *Anisodactylus binotatus* (3 samples); and 2 belonging to *Dermestidae* family: *Dermestes maculatus*;
25.05: there were 21 samples identified, all of them belonging to *Carabidae* family: *Pterostichus cupreus* (4 samples); *Amara communis* (4), *Pterostichus analis* (5 samples).
05.06: there were 13 samples identified, all of them belong to *Carabidae* family: *Carabus obsoletus* (10 samples), *Carabus nemoralis* (3 samples);
08.06: there were 9 samples identified, all of them belonging to *Carabidae* family: *Pterostichus cupreus* (4 samples); *Carabus obovatus* (5 samples);
13.06: there were 8 samples identified, belonging to *Carabidae* family: *Pterostichus cupreus;*
21.06: there were no samples identified;
05.07: there was 1 sample identified, belonging to *Carabidae* family: *Carabus nemoralis*;
12.07: there were 17 samples identified; all of them belonging to *Carabidae* family: *Pterostichus melanarius* (7 samples); *Amara communis* (4 samples); *Cicindela germanica* (6 samples);
18.07: there were 25 samples identified, all of them belonging to *Carabidae* family: *Pterostichus cupreus* (9 samples); *Pterostichus melanarius* (4 samples); *Anisodactylus signatus* (5 samples); *Anisodactylus binotatus* (5 samples); *Cicindela germanica* (2 samples);
25.07: there were 6 samples identified, all of them belonging to *Carabidae* family: *Calosoma inquisitor*;
01.08: there were 15 samples identified, all of them belonging to *Carabidae* family: *Carabus violaceus* (10 samples); *Calosoma inquisitor* (5 samples);
07.08: there were 30 samples identified, all of them belonging to *Carabidae* family: *Pseudophonus griseus* (15 samples); *Amara consularis* (15 samples).

Table 1. Entomofauna of Coleopteras (Coleoptera) sampled within the maize crop by means of Barber soil traps in the Ezareni station from April 30th to August 7th of 2018

Current number	Family	Species	Number of samples	Total samples
1	*Carabidae*	*Amara aenea*	14	193
2		*Amara communis*	9	
3		*Anisodactylus binotatus*	10	
4		*Anisodactylus poeciloides*	5	
5		*Anisodactylus signatus*	18	
6		*Brachinus crepitans*	24	
7		*Brachinus texanus*	9	
8		*Calosoma inquisitor*	6	
9		*Carabus granulatus*	2	
10		*Carabus lineatus*	9	
11		*Carabus nemoralis*	48	
12		*Carabus serratus*	2	
13		*Cicindela germanica*	19	
14		*Pterostichus melanarius*	18	
15	*Coccinellidae*	*Coccinella septempunctata*	33	43
16		*Harmonia axyridis*	10	
17	*Dermestidae*	*Dermestes maculatus*	27	27
TOTAL ENTOMOFAUNA OF COLEOPTERAS				**263**

Table 2. Entomofauna of Coleopteras (Coleoptera) sampled within the wheat crop by means of the Barber soil traps in the Ezareni station from April 30th to August 7th of 2018

Current number	Family	Species	Number of samples	Total samples
1	Carabidae	*Amara aenea*	10	207
2		*Amara communis*	13	
3		*Amara consularis*	15	
4		*Anisodactylus binotatus*	8	
5		*Anisodactylus poeciloides*	8	
6		*Anisodactylus signatus*	5	
7		*Brachinus texanus*	5	
8		*Calosoma inquisitor*	11	
9		*Carabus nemoralis*	11	
10		*Carabus obovatus*	5	
11		*Carabus obsoletus*	10	
12		*Carabus violaceus*	10	
13		*Cicindela germanica*	13	
14		*Pseudophonus griseus*	15	
15		*Pterostichus analis*	5	
16		*Pterostichus cupreus*	52	
17		*Pterostichus melanarius*	11	
18	*Coccinellidae*	*Coccinella septempunctata*	30	30
19	*Dermestidae*	*Dermestes maculatus*	21	21
TOTAL ENTOMOFAUNA OF COLEOPTERAS				**258**

CONCLUSIONS

It can be concluded that, during the year of research 2018, within the maize crop, from the total of 263 samples, the most significant number of samples belongs to *Carabidae* family (193), followed by *Coccinellidae* family (43) and Dermestidae family (27). The most dominant species of *Carabidae* family is: *Carabus nemoralis* (48 samples collected), and the leastest are: *Carabus granulates* and *Carabus serratus* (*each 2* samples), The most dominant species of the *Coccinellidae* family is: *Coccinella 7-punctata* with a number of 33 samples collected.

Within the wheat crop, from the total of 258 samples, the most significant number of samples belongs to *Carabidae* family (207), followed by *Coccinellidae* family (30) and *Dermestidae* (21 samples). The most dominant species of *Carabidae* family is: *Pterostichus cupreus* (52 samples) and the leastest are: *Brachinus texanus*, *Anisodactylus signatus*, *Carabus ovotatus* and *Pterostichus analis* (each 5 samples). The *Coccinellidae* family is represented by the *Coccinella septempuntata* (30 samples collected) and the *Dermestidae* family is represented by *Dermestes maculatus* (21 samples).

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STUDIES ON *Diaporthe eres (Phomopsis oblonga)* AS A NEW PATHOGEN OF WATER HYANCITH *(Eichhornia crassipes)* IN ROMANIA

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Abstract

Water hyacinth (Eichhornia crassipes) is a free-floating aquatic weed, known as the worst invasive one in many tropical and subtropical regions worlwide. This weed affect agricultural crops, navigation, irrigation and water quality as well. Sustainable management of water hyacinth is based on chemical, physical and biological means. The aim of this study, conducted at USAMV of Bucharest in 2018, was to identify fungal pathogens of water hyacinth in Romania as candidate for biological control agents and an environmentally safe solution. Diaporthe species are known as saprobes, endophytes or pathogens in many plants. As fungal pathogens, some species are associated with foliar spots, twig canker, shoots blight, wood and fruit rot. We report here the detection, morphological and molecular identification, the pathogenicity and host specificity on water hyacinth of one isolate of D. eres (Phomopsis oblonga). To our knowledge, this is the first report of D. eres a pathogen specific to water hyacinth in Romania.

Key words*: Diaporthe eres (Phomopsis oblonga), new report, water hyacinth.*

INTRODUCTION

Water hyacinth (*Eichhornia crassipes*) is an oceanic macrophytes and one of the worst sea-going weeds in the world. About 20 species are spread across the world in the late nineteenth century and early twentieth century (Wilson et al., 2005).
The genus *Diaporthe* includes more than 900 species, saprobes, endophytes or important as fungal plant pathogens (Uecker, 1988; Rehner & Uecker, 1994; Crous, 2005; Mostert et al, 2000; Rossman et al., 2007; Rossman & Palm-Hernández, 2008).
Phomopsis species (*Diaporthe anamorphs*) are traditionally identified on the basis of the morphological features of fructifications, the characteristics of colonies on artificial culture media and association with the host plant (Brayford, 1990; Mostert et al., 2001a; Chi et al., 2007). The redefinition of the *Phomopsis/ Diaporthe* species is underway, some species being renamed on the basis of a combination of molecular, morphological, cultural and phytopathological data (Udayanga et al., 2011). Several *Phomopsis* species were isolated and characterized as plant pathogens, as endophytes from the living tissues and also as saprophytes from the dead material (Promputtha et al., 2007; Udayanga et al., 2011). Some *Phomopsis* species have been reported as potential herbicides for controlling invasive and destructive weeds (Table 1) due to host specificity, persistence in the environment, their lifestyle and extended spores (Rosskopf et al., 2000a; 2000b; Ortiz-Ribbing & Williams, 2006).
With the trend towards organic farming and the limited use of herbicides, more attention is payed to the use of biological control agents (Ash, 2010; Bailey et al., 2010). Thus, research on biological weed control should address the most urgent and weed control problems where conventional pest management does not work and biocontrol would have potentially significant benefits for users (Auld & Morin, 1995; Greaves et al., 1998; Charudattan et al., 1990).
Therefore, pathogens that act on invasive plants should be re-evaluated, identify new ones and categorized as potential biocontrol agents (Charudattan, 1990; Ortiz-Ribbing & Williams, 2006).

Table 1. *Phomopsis* species as biological control agents of weeds

Pathogen	Host/target plant
Phomopsis spp.	*Carthamus lanatus*
P. emicis Shivas	*Emex australis*
P. convolvulus Ormeno	*Convolvulus arvensis*
P. amaranthicola Rosskopf, Charud., Shabana and Benny	*Amaranthus* sp.
P. cirsii Grove	*Cirsium arvense*

In this context, we believe that our results - identifying an isolate with the potential of microbial herbicide for water smile are among the priorities of this field.

MATERIALS AND METHODS

Detection, isolation and identification of Phomopsis oblonga (Diaporthe eres) in water hyacinth (Eichhornia crassipes)

During the observations made on the behavior of the common water hyacinth to different herbicides, a series of symptoms were identified to be caused by phytopathogenic agents.

Leaf fragments with spot symptoms have been superficially disinfected and incubated in a humid chamber as well on artificial culture medium (Potato Glucose Agar). Incubation was performed at 22-24°C.

Developed colonies were identified both by direct examination, based on morphological characters, and microscopic examination (fructification morphology). Pure culture of the tested isolates are maintained in the collection, on PGA medium.

Confirmation of identification based on morphological characters was accomplished by molecular methods. Thus, cultures of the origin isolate as well as isolates obtained after artificial inoculations were subjected to DNA extraction. Polymerase Chain Reaction (PCR) was conducted with universal ITS1/ITS4 primers. The amplification products were sequenced and the sequences obtained were analyzed using BLAST (the Basic Local Alignment Search Tool (https://blast.ncbi.nl.m. nih. gov/Blast.cgi, NCBI Nation Center for Biotechnology Information).

Pathogenicity test of Phomopsis oblonga (Diaporthe eres).

The specificity and pathogenicity of our *Phomopsis oblonga* (*D. eres*) isolate was analyzed by artificial contamination of water hyacinth (*Eichhornia crassipes*) according to Koch's postulate.

Spores and mycelial suspensions were obtained from pure cultures of the tested isolate. Artificial contaminations were carried out by spraying (26.10.2017). The tested variants were represented by control and artificially contaminated plants (as four plants of water hyacinths/ variant, initially; during the study the plants have been multiplied). The tests were done in basins.

Observations were carried out 14-30 days after the date of inoculation, with the presence of characteristic symptoms on the leaves (initially yellowish - brownish or brown spots). One last observation was done 61 days after inoculation.

There have been noted, on foliar level:

a. Frequency of attack (F, %), as:

F% = (n × 100)/N, where: F - frequency of attack; n - number of plants or organs of the attacked plant; N - total number of plants or organs of the attacked plant.

b. Intensity of attack (I, %) or severity of attack:

I% = Σ (i x f)/N (Al-Waily, 1988), where: I -the intensity of attack rated by scoring; f - number of plants showing the intensity (i); N - total number of plants or organs of the attacked plant. The product (i x f) is calculated for each attack intensity class.

A 5-grade scale was used to measure the severity of the symptoms (Mickenny, 1923): 0 = healthy leaves, no symptoms; 1 = symptoms on 25% of the leaf surface; 2 = symptoms on 50% of the leaf surface; 3 = symptoms on 75% of the leaf surface; 4 = symptoms on the entire surface of the leaves (100%), necrotic tissues, death.

c. Attack rate (AR, %):

AR% = (F x I)/100, where: F - frequency (%) and I - attack intensity (%).

RESULTS AND DISCUSSIONS

Results on the specificity and pathogenicity of Diaporthe eres (Phomopsis oblonga) in water hyacinth

The specificity and pathogenicity of the *P. oblonga* isolate was tested by artificial inoculation of water hyacinth plants.

Our results highlight the specificity of the analyzed isolate, the presence of the species *Diaporthe eres (Phomopsis oblonga)* being confirmed. The confirmation was based on morphology of colonies and fructifications as well as molecular. Thus, the culture obtained from the reisolations was subjected to molecular identification tests.

A sequence of 527 nucleotides was obtained:
GACCCTTTGTGAACTTATACCTTACTGTTGCCTC
GGCGCTAGCTGGTCCCTCGGGGCCCCTCACCCTC
GGGTGTTGAGACAGCCCGTCGGCGGCCAACCTA
ACTCTTGTTTTTACACTGAAACTCTGAGCACAAA
ACATAAATGAATCAAAACTTTCAACAACGGATC
TCTTGGTTCTGGCATCGATGAAGAACGCAGCGA
AATGCGATAAGTAATGTGAATTGCAGAATTCAG
TGAATCATCGAATCTTTGAACGCACATTGCGCCC
TCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGT
CATTTCAACCCTCAAGCCTGGCTTGGTGATGGG
GCACTGCTTCTTACCCAAGAAGCAGGCCCTGAA
ATTCAGTGGCGAGCTCGCCAGGACCCCGAGCGC
AGTAGTTAAACCCTCGCTCTGGAAGGCCCTGGC
GGTGCCCTGCCGTTAAACCCCCAACTTCTGAAA
ATTTGACCTCGGATCAGGTAGGAATACCCGCTG
AACTTAAGCATATCAATAAGCGGAGGA.

A similarity of 100% of our isolate was obtained using BLAST analyse with *D. eres (P. oblonga)* strains.

Symptoms of water hyacinth leaves after artificial infections and *P. oblonga* pathogen isolation are shown in Figure 1.

Figure 1. Symptoms of the *Diaporthe eres* (*Phomopsis oblonga*) on the water hyacinth leaves (photo Al-Gburi)

The pathogenicity of our isolate on the leaves of the water hyacinth was confirmed according to Koch postulate. Leaves with fungal infection were disinfected and incubated on the PGA culture medium. After 3-4 days, new mycelial growths have been observed on the culture medium. Those fragments were transferred to obtain pure cultures.

Suspensions of spores and mycelium were used to inoculate the leaves of water hyacinth plants. From plants that developed symptoms similar to those observed on the plants where the fungus was initially isolated, reisolation was performed.

Based on the morphological characters and molecular tests the presence of *D. eres* species was detected and identified as a specific pathogen to water hyacinth (Figure 2).

Figure 2. Isolation from infected leaves and inoculation in Petri dishes with culture medium (photo Al-Gburi)

Following the artificial infection tests, the potential of the *P. oblonga* isolate as a herbicide was analyzed.

Aspects during the articicial inoculation tests are shown in Figures 3 and 4.

Figure 3. Symptoms with the appearance of brown or black spots on leaves

Figure 4. Spraying the plants of the water hyacinth - artificial contamination with *D. eres* isolate

The effect of the fungi on the leaves was estimated by measuring the effect of the pathogenic fungi on the leaf surface.
The frequency of the leaves with characteristic symptoms was 86.62% and the intensity of the attack was 68.45%.
The frequency of attacked leaves after inoculation was further classified as: 8.45% with the note 1 for the attack intensity; 9.15% with the note 2 for the attack intensity; 14.79% with the note 3 for the attack intensity and 54.22% with the note 4 for the intensity of the attack (Table 2).
There is a high frequency of leaves in classes 3 and 4, classes in which the affected area is 75% and 100%, respectively.
The healthy (13.38%) and infected leaves (86.62%) were counted and sorted according to their attack degree. The attack intensity was 6.97% and the attack rate was 4.65% after 61 days after the artificial contamination.

Tabel 2. Frequency of leaves with symptoms characteristic of *D. eres* (*P. oblonga*) depending on the intensity of the attack (artificial infections)

Frequency (%)	Intensity	
	(note)	**Surface attacked** (%)
8.45	1	25
9.15	2	50
14.79	3	75
54.22	4	100

We highlight high values of these two indicators, which confirm the high degree of leaf colonization and the expansion of the attack over time.
The rate of attack calculated based on frequency and intensity was 59.29%, a value that we consider very good for a biological control agent. We have noticed the preservation of the herbicide potential of the *P. oblonga* isolate after 61 days on newly emerging leaves compared to the application of a classical herbicide, where this effect is not recorded. This fact constitutes an argument in addition to the orientation of studies in the direction of microbicides.
We believe that our isolate has the potential of a biological control agent. Current studies are carried on to determine the dose and the possibility of a herbicide treatment, reducing the dose of chemical molecules.

We report, for the first time in Romania and worldwide, the potential of the species *Diaporthe eres (Phomopsis oblonga)* as a biological control agent (bio-herbicide) of aquatic weed species like water hyacinth.

CONCLUSIONS

We report for the first time in Romania and globally the potential of *Phomopsis oblonga (D. eres)* as a biological control agent (bio-herbicide) of aquatic weed species of the water hyacinth type.
The use of fungi on water hyacinth plants had a clear effect by reducing the level of plant growth.

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PROSPECTING THE INFLUENCE OF POTTING SUBSTRATE AND AM INOCULATION ON *Iris pseudacorus* L.

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Abstract

Iris pseudacorus is an ornamental macrophyte with phytoremediation capacity and medicinal value. In this research, it was used as model plant for study of four commonly occurring micromycetes: arbuscular mycorrhizae (Glomeromycota), fine root endophytes (Mucoromycotina), dark septate endophytes (Ascomycota) and Olpidium sp. (Chytridiomycota). Experiment was established with two substrate types: peat and bark humus, and inoculation treatment with three graduations: 2 and 5 AMF species and non-inoculated respectively. Root samples were collected for microscopic analysis after 3 months in pots and open field. Results show that all AM colonization parameters were higher in field compared to pots, but influence of AM inoculation decreases in field due to established background soil microflora. Frequency of DSE and Olpidium sp. was much higher in pots. Bark humus had a lasting positive effect on plant development. Compared to field, pot growing media could be more prone to microbiome disbalance perhaps due to lack of stability in natural-occurring mechanisms that act to regulate complex interaction dynamics. Understanding conditioning relationship between soil micromycetes across contrasting growing conditions could help addressing practical challenges associated with use of microbial inoculants in agriculture.

Key words: *nutrient transfer, storage organ, micro-organism interaction, rhizosphere, microbiome stability.*

INTRODUCTION

Throughout time *Iris pseudacorus* also known as ‘yellow flag’ was attributed special meaning as well as practical uses. It was adopted as heraldic symbol by king Clovis I and several stories explain how he came to use this flower on his coat of arms after conversion to Christianity (Silverthorne, 2002; Giner-Sorolla, 2011). Evidence from archaeological excavations in Gdansk region indicates that flowers of *Iris pseudacorus* represented a source of dyes during XII-XIII centuries (Macchia et al., 2016). *Iris pseudacorus* was known also as medicinal plant in Europe (Crişan & Cantor, 2016), and rhizomes were used by English country people with syrup of buckthorn to treat dropsy (Frederick, 1821). Seeds of this plant can be used as coffee substitute (Engin et al., 1998). *Iris pseudacorus* still has practical applications today, because flowers are sources of colouring agents for cosmetic and food industry while rhizomes can provide natural dyes or components for ink preparation (Pippen, 2015; Crişan et al., 2018). *Iris pseudacorus* L. as an ornamental grows best in pond or bog gardens but can be introduced also in herbaceous border. Plant is characterized by yellow flowers, fibrous rhizomes pink in colour when sectioned. Both diploids and tetraploids are cultivated (White et al., 1997). There are cultivars with variegated foliage which can extend their ornamental contribution to landscape beyond spring bloom (Ondra, 2007). A consistent body of research is dedicated to phytoremediation capacity of *Iris pseudacorus*. Thus, studies proved potential of this species to treat urban wastewater (Zhang et al., 2017), to decontaminate water of certain agricultural pesticides (Wang et al., 2013) and heavy metals (Caldelas et al., 2005), or soils from petrochemical residues (Wang et al., 2016). Previous studies on arbuscular mycorrhizae in *Iris pseudacorus*, demonstrated that inoculation with species *Diversispora epigaea, Glomus aureum, Rhizophagus irregularis, Rhizophagus clarus,* enhanced plant tolerance to toxic metals in the environment (Wężowicz et al., 2015). Aim of this study was to prospect the influence of two commonly used potting substrates and AM inoculation with commercial products on *Iris* *pseudacorus* plants. To achieve this, two objectives were considered:

- describing functional relationship between micromycetes in pot/field conditions with implications for soil-plant health balance;
- identification of inoculation persisting effect after transplanting in the field with implication for plant development and efficiency of inoculum application.

MATERIALS AND METHODS

The experiment was initiated in pots and continued in open field, after plants were transplanted (Figure 1). Starting biologic material of this study was represented by *Iris pseudacorus* shoots of similar size detached with roots from mother-rhizomes belonging to mature plants that overwintered in greenhouse. Plant material was washed with chlorine solution and had roots and longer leaves trimmed. Pot experiment was established in April 2018 and organized according to bifactorial design.

Factor A: unsterilized potting substrate with 2 levels - a_1 = mix of bog-peat decomposed medium-high, wood fibres, dolomite, perlite; a_2 = fermented bark humus, peat, perlite.

Factor B: AMF inoculum with 3 levels - b_1 = non-inoculated; b_2 = inoculated with commercial product containing 5 AMF species (*Funneliformis mosseae, Funneliformis geosporus, Claroideoglomus clarodeum, Rhizophagus intraradices, Glomus microaggregatum*); b_3 = inoculated with commercial product containing 2 AMF species *(Funneliformis mosseae, Rhizophagus intraradices)*. Calculation of dose application for each of the two inoculation products followed producer instructions. For both products AMF propagules were contained in an organo-mineral matrix.

Figure 1. *Iris pseudacorus* potted in two types of substrate, inoculated with two types of arbuscular mycorrhizae products and then transplanted in field (Original, 2018)

From the combination of the two factors resulted 6 experimental variants: V1 = peat + non-inoculated; V2 = bark humus + non-inoculated; V3 = peat + 5 AMF; V4 = bark humus + 5 AMF; V5 = peat + 2 AMF; V6 = bark humus + 2 AMF. Pots were kept outdoor on a porch to be sheltered from rain. Water was supplied by flooding system at few days interval. It was ensured that water could not travel from pots of one variant to another in order to prevent cross-transport of propagules or nutrients. No phytosanitary treatment was applied to plants. After 3 months in pots (July 2018), root samples were collected for microscopic analysis. Then, the plants had leaves trimmed and were transplanted together with whole root system and pot substrate in open field in Botanical Garden UASVM Cluj-Napoca, in randomized blocks. Because when removing weeds, the mycelia development in rhizosphere can be disturbed, mulch foil was applied prior to planting. Soil type in the garden is clay-loam with good NPK supply, low humus level and pH 6.7. After 3 months in the field (Oct. 2018), were conducted measurements for plant development and root samples were collected for microscopic analysis. Roots were prepared for microscopic observation following ink-vinegar staining method (Vidican & Stoian, 2016). Root colonization by arbuscular mycorrhizae *(Glomeromycota)* assessment was conducted according to method of Trouvelot et al. (1986) for 90 root segments per variant: 30 segments × 3 repetitions. A total number of 1080 root segments were assessed for 540 from potted plants and 540 from field, under Optika microscope at 100× - 400×. AM indicators

were calculated using Mycocalc software (https://www2.dijon.inra.fr/mychintec/).
In addition, were recorded observations for presence of other fungal colonizers (Figure 2): dark septate endophytes *(Ascomycota)*, fine root endophytes *(Mucoromycotina), Olpidium (Chytridiomycota)* for same root segments.

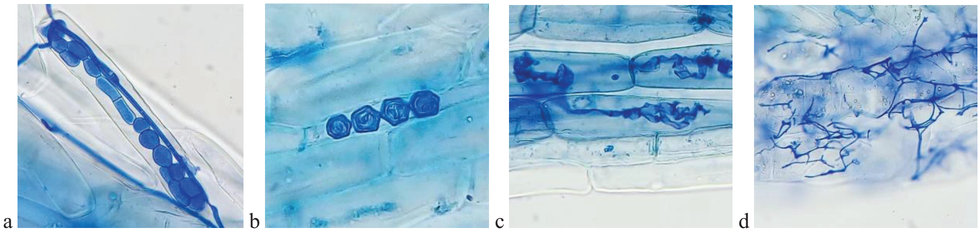

Figure 2. Micromycetes inside roots: a) *Ascomycota* – DSE*;* b) *Chytridiomycota – Olpidium;* c) *Glomeromycota* – AM*;* d) *Mucoromycotina* - FRE (Original, 2018)

Parameters subject to analysis were:
- F% = frequency of occurrence for AM, DSE, FRE, Olp. in roots;
- m% = intensity of the mycorrhizal colonization in the root fragments;
- M% = intensity of the mycorrhizal colonization in the root system;
- a% = arbuscule abundance in mycorrhizal parts of root fragments;
- A% = arbuscule abundance in the root system;
- plant height after 3 months in the field (6 months after initial inoculation in pots);
- number of leaves per plant after 3 months in the field (6 months after initial inoculation in pots).

Data analysis was conducted with Microsoft Excel 2016 and StatSoft Statistica 12.5.

RESULTS AND DISCUSSIONS

Predominant arbuscular mycorrhizae colonization observed both in pots and field corresponds to *Paris* morphotype. But compared to arbuscules from the field samples, in pot conditions intra-cellular coils often presented a swollen appearance. A few numbers of root segments from pots and field had arbuscules that showed an intermediate morphology or even *Arum*-like, but occurrence was very low. Comparing Table 1 and Table 2 can be observed that in pot conditions, arbuscular mycorrhizae parameters such as intensity in root fragments and arbuscularity both in root fragments as well as in root system is correlating significantly positive with experimental variants. By comparison, in field conditions for same parameters, there is no positive correlation. This comes to show that after 3 months in the open field and 6 months since initial inoculation in pots, the variant does not exercise a strong or significant influence anymore. This is more clearly illustrated by the fact that in pot conditions all colonization parameters correlate positively with inoculation, and significantly positive with intensity of colonization in root fragments. In field conditions between inoculation treatment and colonization parameters are no positive correlations found. Because, by this time plants have new roots and are being colonized also by fungi natural occurring in the soil and initial inoculation does not exercise as much of an influence. In addition, in pot conditions, there is noticeable a positive correlation between substrate type and all arbuscular mycorrhiza parameters, with significant positive coefficient for arbuscularity in root fragments. This indicates that this factor can affect the development of mycorrhiza and should be taken in consideration by farmers when choosing potting substrates with intend to also apply commercial AMF inoculum. In field conditions can be identified a significant correlation between frequency and intensity in root system while in pot conditions this was not the case. The explanation is that in pot conditions other factors exercised a strong influence, such as substrate type and abundance of other fungal endophytes resulting from weak balancing interaction. In field conditions, was also identified a significant positive correlation between intensity in mycorrhizal parts of root fragments and intensity in root system, and arbuscularity in mycorrhizal part of root fragments and root system. Both in pots and field conditions can be observed a significant positive correlation between arbuscularity in mycorrhizal parts of root fragments and root system with nearly perfect coefficient in pot conditions.

Table 1. Correlation matrix for arbuscular mycorrhizae parameters in *Iris pseudacorus* from pots (July 2018)

Variables	Variant	Substrate	Inoculation	F%	m%	M%	a%	A%
Variant	-	0.293	**0.956**	0.178	**0.535**	0.424	**0.470**	**0.487**
Substrate	0.293	-	0.000	0.421	0.279	0.373	**0.468**	0.418
Inoculation	**0.956**	0.000	-	0.057	**0.475**	0.329	0.348	0.381
F%	0.178	0.421	0.057	-	0.211	-0.005	-0.051	-0.005
m%	**0.535**	0.279	**0.475**	0.211	-	-0.004	0.384	0.454
M%	0.424	0.373	0.329	-0.005	-0.004	-	**0.545**	**0.474**
a%	**0.470**	**0.468**	0.348	-0.051	0.384	**0.545**	-	**0.986**
A%	**0.487**	0.418	0.381	-0.005	0.454	**0.474**	**0.986**	-

Note: Bold Pearson coefficient values designate significant correlation between variables at $p < 0.05$

Table 2. Correlation matrix for arbuscular mycorrhizae parameters in *Iris pseudacorus* from field (Oct. 2018)

Variables	Variant	Inoculation	F%	m%	M%	a%	A%
Variant	-	**0.956**	0.066	-0.036	0.004	**-0.490**	-0.353
Inoculation	**0.956**	-	-0.110	-0.192	-0.190	-0.439	-0.416
F%	0.066	-0.110	-	0.382	**0.763**	0.076	0.394
m%	-0.036	-0.192	0.382	-	**0.835**	**0.491**	**0.734**
M%	0.004	-0.190	**0.763**	**0.835**	-	0.367	**0.765**
a%	**-0.490**	-0.439	0.076	**0.491**	0.367	-	**0.810**
A%	-0.353	-0.416	0.394	**0.734**	**0.765**	**0.810**	-

Note: Bold Pearson coefficient values designate significant correlation between variables at $p < 0.05$

In field conditions this coefficient is slightly lower in value perhaps because the soil particularities are influencing mycorrhiza spreading. This strong relationship between variables could hint to uniformity of nutrient exchange structures distribution across roots.

Also, both in pots and field conditions was identified a significant positive correlation coefficient between intensity in root system and arbuscularity in root system. In pot conditions, all plants grown on bark humus had a faster development in first three weeks. Only after about a month plants from peat substrate started to reach similar height. After 3 months in pots, plants had their leaves trimmed and were transplanted in the field. From Figure 3 can be seen that after 3 months in field plants belonging to non-inoculated bark humus pot substrate (V2) were the tallest and had highest number of leaves per plant. Second tallest plants corresponded to variant inoculated with 5 AMF species and grown on bark humus (V4), while second highest number of leaves was found in plants inoculated with 2 AMF species and grown also on bark humus substrate (V6). Shortest plants and with smallest number of leaves per plant were found for variant corresponding to non-inoculated plants grown previously in pots with peat (V1). Because carbon fixed by photosynthesis is the trade-off for arbuscular mycorrhizal fungi nutrient transfer to plants, it could be speculated that non-inoculated plants did not had to partition biomolecules between host metabolic activity and fungi at the same rate as inoculated plants, and thus plants grown in rich nutrient humus substrate had more resources available to carry an accelerated growth without an intense root colonization to drain carbon. In addition, potted plants grown in this nutrient rich substrate were probably able to accumulate more resources in the storage organ and after transplanting in field had the advantage of more nutrients available to be relocated in for plant growth before the root system even adjusted well to new conditions, suggesting that this substrate brings important advantages for establishment of plants following transplantation.

Among variants, differences are smaller for plant height but larger for number of leaves per plant as seen in Figure 3. Assessment for 3 other categories of fungal root endophytes showed that in pot conditions their frequency can be strikingly different compared to field conditions.

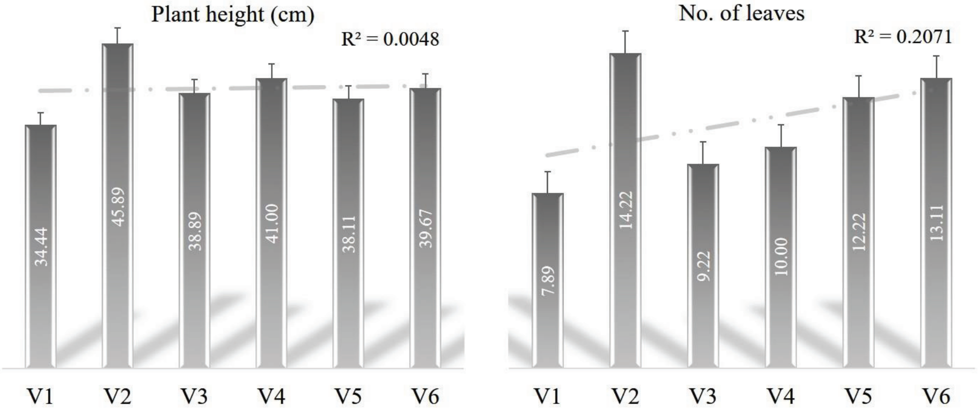

Figure 3. Average plant height and number of leaves per plant in *Iris pseudacorus* after 3 months in field (2018)

From Figure 4 can be observed that frequency of dark septate endophytes and *Olpidium* sp. was much higher in pots than in field conditions. Contrary, fine root endophyte is identified only in two variants in pots (V3, V6), while in field conditions occurs in all variants. However, both in pots and field FRE frequency maintains low. Results interpretation of this research is based on presumption that commercial inoculum used was free of potential contamination of propagules belonging to other fungal groups, such as DSE.

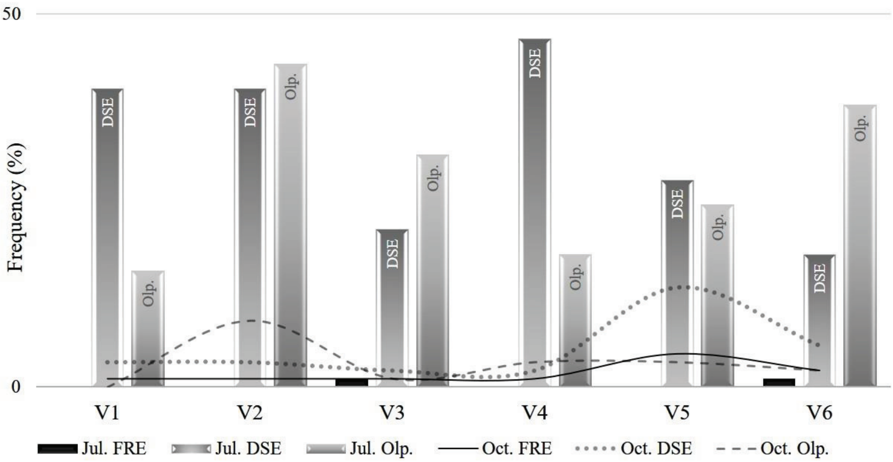

Figure 4. Comparative occurrence of FRE, DSE and *Olpidium* in *Iris pseudacorus*: after 3 months in pots (Jul. 2018), after 3 months in open field (Oct. 2018)

It can be clearly seen how in field conditions the distribution of all three fungal endophytes is balanced, and for neither of them frequency exceeded 15%. Due to the fact that no phytosanitary treatments were applied, the lower frequency of these can be associated with a more complex soil microflora in the field. In field conditions, pathogen *Olpidium* sp. decreases in all variants but particularly in AM-inoculated ones (V3-V6). In pots, V2 presents highest frequency of *Olpidium* sp. and although in field conditions frequency decreases in value, it remains the highest among variants. It can be observed that inoculated plants from peat substrate (V3, V5) had a lower colonization by dark septate endophytes compared to plants non-inoculated grown also on peat (V1). This might indicate a negative interaction between *Glomeromycota* fungi and *Ascomycota* endophytes. When comparing average values for entire experiment corresponding to each endophytic parameter studied (Figure 5) it is evident that all AM colonization indicators were higher in field conditions than in pots: almost twice as high for frequency, and 3 to 4-times as high for intensity of AM colonization in mycorrhizal parts of root fragments and in root system respectively. DSE and *Olpidium* frequency in pot conditions reached average frequency of 32% and respectively 28%. In field conditions, for none of these two the overall average frequency exceeds 5%. This suggests two things. First, microflora in pot conditions could be more prone to disbalance lacking perhaps a certain degree of resilience required for resorting natural regulating mechanisms existing in field soil. Secondly, there could be a certain level of arbuscular mycorrhizae diversity required for a successful interaction with respect of plant rhizosphere microbiome in the sense that these would prevent other fungal endophytic groups to become overwhelming colonizers with detrimental implication for both success predictability of inoculation and intended effects.

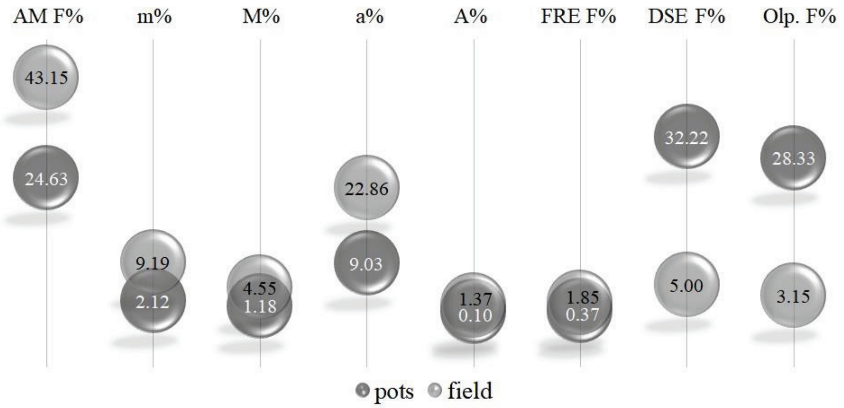

Figure 5. Experiment average values for studied parameters of AM, DSE, FRE., Olp. (2018)

Previous studies demonstrated positive influence of arbuscular mycorrhizae over vegetative characteristics in *Iris germanica* following supplementary inoculation in field conditions and similar pedo-climatic conditions (Crişan et al., 2017). Another study demonstrated that mycorrhization of *Iris* plants increased the absorbing rate of both nitrogen and phosphorous (Chen Y. et al, 2014) demonstrating that also for *Iris* plants, AM can have beneficial effects. Also, it seems that substrate particularities play a decisive role in rhizosphere microbiome stability and dynamics, because can exercise suppression of AM development with results hinting as concurring cause a biological component. Thus, ecosystem services of AMF depend to a large degree on the specific soil microbiome (Svenningsen et al., 2018).

In conclusion, increase of colonization by unintended fungi such as *Ascomycota* endophytes or pathogenic *Olpidium* sp. in pots, could be a result of weak interaction-based auto-regulation mechanism and unbalanced competition. In field conditions although the colonization is becoming equilibrated across fungal endophytes while arbuscular mycorrhizae develops better, the inoculation is not exerting a very strong influence due to background established community. These might cause the effects of inoculation in field to be hard to distinguish while in pots there is the risk of being either in negative interaction with less-beneficial fungi or to be overrun by these, leading to a less satisfactory overall result. In future a better understanding of the relationship existing between soil micromycetes could help optimising the use of fungal inoculants.

CONCLUSIONS

Experiment average values for AM colonization parameters were higher in field conditions compared to pots while DSE and *Olpidium* frequency reached much higher levels in pots than in field.

Results suggest that some of the most commonly used pot substrates might exhibit proclivity to microbiome disbalance perhaps due to weakening or reduced complexity of natural-occurring mechanisms that act to regulate soil microflora interaction and dynamics in field, and in this case making the effects of AM inoculation less predictable.

FRE was detected only in two variants in pot conditions but was found in all six variants in field conditions, although in both cases the occurrence maintained at low levels.

Bark humus substrate had a lasting positive effect on plant development.

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RESEARCH ON EFFECTIVENESS OF SOME FUNGICIDES TREATMENTS ON JONATHAN APPLE VARIETY FOR APPLE SCAB CONTROL IN VOINEȘTI AREA

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Abstract

The Voinești production basin is one of the most important fruit growing areas for apple crop. The load of pathogens in these plantations is very high due to climatic conditions and monoculture for a long period of time in the area. Venturia inaequalis is one of the main diseases affecting apple orchards. A major challenge in commercial apple orchards within humid production regions is the available fungicide options for apple scab (Venturia inaequalis (Cooke) Wint.) management. The objectives of this study were to compare the efficacy of five potential alternative fungicides for management of apple scab and to evaluate their effectiveness. Pest incidence, pest severity of the attack and yield of the Jonathan apple variety, one of the most sensitive in the area, were also analyzed by ARM software. The standard products Score 250 EC (0.225 l/ha) and Syllit 400 SC (2.0 l/ha) treatments resulted in the best scab control and consequently, high economic productivity.

***Key words**: apple scab, fungicides, effectiveness, pest incidence, pest severity, yield.*

INTRODUCTION

The apple tree, one of the oldest fruit tree species (being mentioned even in Genesis), has a high adaptability to the climate conditions. It is grown from the plain to the mountains on every continent except the Arctics.

Due to the role that fruits play in human nutrition and its ecological plasticity, it occupies an important place in world fruit production, ensuring, together with banana and orange, 2/3 of the global fruit harvest (Popescu et al., 1992).

Being very well adapted to the temperate climate, whose extremes bear better than the other species of fruit trees and considered the dominant species in this area (Hoza, 2000), it also ensures in our country the highest percent in fruit crops.

Depending on the environmental conditions and the measures taken, the apple is yearly attacked by a large number of diseases and pests which, if not controlled, compromise the production of susceptible varieties and weaken the trees vigor. The most widespread and perhaps the most harmful pathogen agent is apple scab, which, for sensitive varieties much demanded on the market (Delicious gold, Starkinson, Jonagold), the yield of the current year decreases by 70-80%, the remaining fruits will be of inferior quality, useful only for processing, and production of next year will be 10-20% of the potential (Tomșa & Tomșa, 2003).

The apple scab, caused by the fungal pathogen *Venturia inaequalis* (Cooke) G. Wint., is responsible for significant economic losses in apple orchards in the Voinești Area. Research on apple scab is associated with other pathogens of major importance for apple crop and which are key diseases for this crop, such as moniliosis, which causes significant damage e and for which the varieties' reaction and treatments are always appropriate in apple protection research (Chitulescu & Cristea, 2017; Cristea et al., 2017).

If not managed, the disease can cause extensive losses following humid and cool weather conditions during the spring months. Direct losses result from fruit infections and indirect losses from defoliation, which can reduce tree vigor, winter hardiness, and subsequent yield (Carisse & Rolland, 2004).

Farmers strive for preventing and counteracting the impact of this disease with fungicides treatments along with other agro technical practices (Jinga, 2013).

For apple scab management, fungicide programmes are widely used, specially targeting critical periods during the growing season: beginning of shoot growth, mouse-ear stage, green bud stage, flowering, fruit fall after flowering, beginning of ripening.

On the basis of these realities, this paper aims to highlight the importance and the opportunity of fungicide treatments for combating rapine in the Voineşti fruit basin during the vegetation period to ensure safe and qualitatively and quantitatively stable crops (Petre et al., 2000).

MATERIALS AND METHODS

The research was carried out between April and September 2018, at the Tree Growing Research and Development Station Voineşti, in a 16-year-old apple orchard, the Jonathan variety, with rows of free-weed trees alternating with grass covered intervals. During the period of vegetative rest, autumn tillage was carried out by ploughing on the intervals between rows. Pruning works for growth and bearing control were carried out early spring, before the growing season began.

The trial was conducted using the randomized complete block method in four repetitions. Each plot had 5 trees. During the vegetation period, depending on climatic conditions, 4 foliar treatments were applied at 12-16 days.

In May, June, July and August, the assessments aimed at determining the evolution of pathogen attack *V. inaequalis* (apple scab). The 4 treatments were applied in the following stages: 1st - end of flowering (BBCH 69); 2nd - second fruit fall (BBCH 73); 3rd - fruit about 80% of final size (BBCH 78); 4th - beginning of ripening - first appearance of cultivar - specific colour (BBCH 81).

The application equipment was a mist blower Solo 423 atomizer, suitable for fungicide treatments in orchards (Figure 1).

The tested variants (commercial products, active ingredients and application dose rate) are presented in Table 1.

Table 1. Tested variants in the trial

Variant	Product	Active ingredient	Rate (l, kg/ha)
1	Untreated	-	
2	Systhane Forte	miclobutanil 240 g/l	0.2
3	Folicur Solo 250 EW	tebuconazol 250 g/l	0.75
4	Syllit 400 SC	Dodine 400 g/l	2
5	Shavit F72 WDG	triadimenol 20 g/kg + folpet 700 g/kg	2
6	Score 250 EC	difenoconazol 250 g/l	0.225

100 leaves per tree and 50 fruits per tree were assessed. Assessments were made on the frequency (F, %) and the intensity (I, %) of pathogen attack and the degree of attack (DA, %) and efficacy (E, %) were calculated. The degree of attack was calculated using the formula: F% x I%/100. The efficacy of fungicide was calculated according to Abbott`s formula: (degree of attack in untreated control - degree of attack in treated plot)/ degree of attack in untreated control x 100. All data were subjected to statistical analysis provided by ARM-8 software (V. Jinga, 2013). At harvest time, the yield/tree was also recorded by weighing all the fruits per tree.

Jonathan apple variety is recognized as susceptible to apple scab. Symptoms were assigned to apple scab if there were lighter green areas compared to the surrounding leaf tissue, or pale yellow or olive-green spots on the upper surface of leaves.

The lessions expand and become brown – olive colored as a of the asexual spores production (*Fusicladium* conidia) (Gheorghieş & Cristea, 2001).

Scab lesions that form on young leaves may expand to more than 1 cm in diameter. Ontogenetic resistance of older leaves, however, usually results in smaller lesions or no visible symptoms (Gessler & Stumm, 1983).

On branches and shoots one can see exfoliation and modified tissues that may endanger even the tree life (Dulugeac F.A., 2011).

The fruits have lesions similar to those on the leaves. They age on and may cause cracks. If assessed late in the summer or just before harvest, the late infected fruits had black, circular, very small (0.1-4 mm diameter)

lesions called 'pin-point scab' that would appear during storage (Carisse & Jobin, 2006).
The sexual phase of the fungus is characterized by oval or pyriform perithecia, immersed in the tissue, provided with a long neck, ending with an opening pore surrounded by brown, stiff bristles. In the perithecia, the fungus forms asci with bicellular ascospores, with two-row located unequal cells (Gheorghieş & Cristea, 2001).

Figure 1. Field treatment with mist blower Solo 423 atomizer suitable for fungicide treatments in orchards

RESULTS AND DISCUSSIONS

In the Voinesti fruit-growing Area, in 2018, the weather conditions were atypical, different from the normal ones. March began with very low negative temperatures (-18°C) and continued with high temperature fluctuations over the three decades. The amount of precipitation was high (126 mm). In April it approached the multiannual national average, then May, June and July were very rainy (111, 404 and 193 mm, respectively) (Table 2). This has led to increased incidence of foliar diseases in apple orchards, requiring phytosanitary treatments.
The need for these treatments is shown in Table 2 and Table 3 where it is observed that in the untreated control plot, the degree of attack of the pathogen reached 40.72% on the leaves and 32.30% on the fruit.
Also, fruit production of the variant without anti-fungal treatments was significantly diminished and of poor quality, as shown in Chart 1. There was a sudden increase of *V. inaequalis* incidence and severity in the second part of the experiment due to abundant rainfall.

The commercial products tested in this study showed high and very high effectiveness. This lays out the importance of these measures. Syllit 400 SC and Score 250 EC had performed best - 85.52% and 87.00%, respectively on attacked leaves. On fruits, their effectiveness was higher, namely 92.15% and 97.29%.
The Systhane Forte product did not reach the level of the other tested products, having the lowest values of efficacy: 67.70% and 65.06%, respectively.
Folicur Solo and Shavit F72 had a regular efficacy and could be recommended in scab control programs. These two products controlled apple scab in similar percent - 74.07 and 78.58, respectively on leaves while on fruits - 92.15 and 94.74%, respectively.
Fruit production was determined at the harvest time and varied across variants. This stressed the need for phytosanitary treatments. A mean of 16.3 kg of fruits per tree was recorded for the control sample. The fruits were small, deformed, suberified, cracked, spotted and inappropriate for commercialization. Highest value of yield per tree (31.2 kg) was recorded for the treatment with Score 250 EC.
Most infected fruits showed distinct brown or black spots with margins that were often irregular. When severe, the skin splits and irregularly shaped fruits resulted.
The organoleptic characteristics of the fruits in the control sample were significantly lower compared to the rest of the variants.
Variants 4 and 6 had the highest commercial value by size, weight, and color specific to the variety.
The yield values showed significant differences between the phytosanitary treatments and the control variant, as shown in Figure 2.

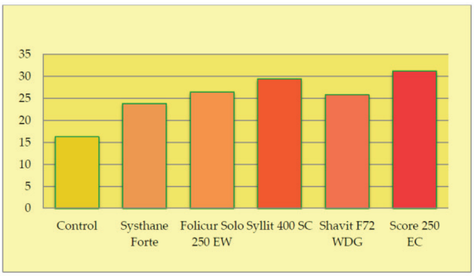

Figure 2. Mean yield (kg/tree) per treatment and control sample

The treatment with Score 250 EC recorded a nearly double-fruit yield per tree, increasing from 16.3 kg to 31.2 kg. A similar result was obtained with the treatment of Syllit 400 SC where the values reached 29.7 kg of fruit per tree. Variants 3 and 5 showed a fairly good productiveness, with yields of 26.5 and 25.8 kg of fruit per tree, respectively.

Table 2. Precipitation and temperature during 2018 growing vegetation season

	Month									
	Jan.	Febr.	March	Apr	May	June	July	Aug.	Sept	
Periods	The growing season 2018: Precipitation (mm) for 10-day periods									Sum
1-10	0.20	4.10	11.00	28.00	10.00	103.00	133.00	11.00	17.00	317.3
11-20	10.30	34.00	71.00	3.00	48.00	159.00	4.00	1.00	1.00	331.30
21-30	0.00	4.20	4400	9.00	53.00	142.00	56.00	40.00	7.00	355.20
Sum	10.50	42.30	126.00	40.00	111.00	404.00	193.00	52.00	25.00	1003.80
	The growing season 2018: Mean air (^oC) for 10-day periods									Mean
1-10	4.27	4.45	2.30	13.75	21	22.6	20.8	24.3	22.25	15.08
11-20	0.25	2.4	7.65	17.6	17.15	22.8	22.6	24.25	20.50	15.02
21-30	-0.36	-3.81	4.73	18.85	20.45	19.35	23.86	24.41	14.95	13.60
Mean	1.39	1.01	4.89	16.73	19.53	21.58	22.42	24.32	19.23	14.57

Table 3. The assessments data of apple scab on leaves

Variant	1st Application				2nd Application				3rd. Application				4th Application			
Product	F%	I%	DA%	E%	F%	I%	DA%	E%	F%	I%	DA%	E%	F%	I%	DA%	E%
Control	21.00	10.75	2.26		28.50	15.50	4.42		59.50	24.75	14.73		91.50	44.50	40.72	
Systhane Forte	16	7	1.12	50.39	19.25	11.25	2.17	50.98	35.75	19.20	6.86	53.39	56.2	23.40	13.15	67.70
Folicur Solo 250EW	14.5	6	0.87	61.46	15.25	10.75	1.64	62.89	35.00	13.75	4.81	67.32	49.8	21.20	10.56	74.07
Syllit 400 SC	11.75	5.00	0.59	73.98	13.50	7.45	1.01	77.23	29.00	11.20	3.25	77.94	44	13.40	5.90	85.52
Shavit F72 WDG	12	5.5	0.66	70.76	13.20	8.80	1.16	73.70	31.40	11.60	3.64	75.27	46.4	18.80	8.72	78.58
Score 250 EC	11	5	0.55	75.64	12.50	7.80	0.98	77.93	28.80	10.40	3.00	79.66	43.4	12.20	5.29	87.00

Table 4. The assessments data of apple scab on fruits

Variant	1st Application				2nd Application				3rd. Application				4th Application			
Product	F%	I%	DA%	E%	F%	I%	DA%	E%	F%	I%	DA%	E%	F%	I%	DA%	E%
Control	20.5	11.8	2.42		29.6	16.8	4.97		54.25	28.6	15.52		82.4	39.2	32.30	
Systhane Forte	13.4	9.5	1.27	47.37	18.4	12.5	2.3	53.75	35.2	18.8	6.62	57.35	43	26.25	11.29	65.06
Folicur Solo 250EW	12.8	8	1.02	57.67	16.2	10.6	1.72	65.47	26.75	18.2	4.87	68.62	19.5	13	2.54	92.15
Syllit 400 SC	11.8	5.2	0.61	74.63	14.75	7.2	1.06	78.64	19.25	11.4	2.19	85.86	16.6	6	1.00	96.92
Shavit F72 WDG	12.2	7.5	0.92	62.17	15.6	10.2	1.59	68.00	24.4	13.8	3.37	78.30	19.4	8.75	1.70	94.74
Score 250 EC	11.4	5.5	0.63	74.08	13.8	7.4	1.02	79.46	18	11.6	2.09	86.54	16.2	5.4	0.87	97.29

CONCLUSIONS

Field trial conducted in apple orchard in Voinesti area demonstrated the importance of *Venturia inaequalis* control management. Apple crop is an ancient practice in Voinesti area which ensures the living for many inhabitants. Yet, the crops are damaged every year by a large number of pests and pathogens. These harmful agents may reduce the yields and even endanger the life of trees. *V. inaequalis* is the most dangerous disease for apple crop which may cause serious damages in orchards. High quality of fruits and yield is not possible without disease control management. A good level of efficacy and a significant reduction in

disease incidence and severity is possible when fungicides such as Syllit 400 SC or Score 250 EC are applied in critical stage. However, this practice has to be integrated with other agro technical measures in order to protect both the apple orchards and the environment.

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RESEARCH ON FRUITS QUALITY OF DIFFERENT TOMATO (*Lycopersicon esculentum* Mill.) CULTIVARS IN VIDRA AREA, ILFOV COUNTY

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Abstract

Under field conditions, during 2016, were studied 15 cultivars of tomatoes. When the fruit reached commercial maturity, the following quality indices were determined: water content and total dry substance (gravimetric method), soluble dry substance (refractometric method), titratable acidity (titrimetric method), total carbohydrates (Fehling Soxhlet method) and vitamin C (iodometric method). The best results on the quality of tomato fruits were obtained with the following cultivars: St. Pierre (7.33% total dry substance, 4.2% soluble dry substance, 0.67% acidity, 3.50% carbohydrate and 19.36 mg vitamin C), Caspar F1 (5.98% total dry substance, 3.8% soluble dry substance, 0.60% acidity, 3.20% carbohydrate and 21.12 mg vitamin C), Mirsini F1 (5.68% total dry substance, 4.0% soluble dry substance, 0.64% acidity, 3.30% carbohydrate and 21.12 mg vitamin C), Heintz (5.67% total dry substance, 3.7% soluble dry substance, 0.80% acidity, 3.10% carbohydrate and 24.64 mg vitamin C) and Darsirius (5.21% total dry substance, 3.9% soluble dry substance, 0.69% acidity, 3.20% carbohydrate and 19.36 mg vitamin C).

Key words*: cultivars, fruits quality, total dry substance, vitamin C.*

INTRODUCTION

In Romania, the tomatoes (*Lycopersicum esculentum* Mill.) are highly appreciated for their pleasant taste and nutrient content (Munteanu, 2003).

Tomato fruits are rich in water, which have a value of 93-94% (Maier, 1969).

According to Mitchell et al. (1991), the fruit water accumulation and fresh fruit yield is reduced by the deficit of irrigation, but was obtained higher concentrations of potassium, hexoses and citric acids. The irrigation with saline water has no influence on total fresh fruit, but the water content was slightly reduced.

Also, there was observed that the fruit diameter is strongly correlated with the water potential gradient of the fruit and stem (Johnson et al., 1992).

The total acidity is expressed in citric acid, and almost half from total acids are free acids. Soluble sugars contribute to the freshness and pleasant taste of tomato (Munteanu, 2003).

Vitamins in tomato fruits are diverse, but not in very large quantities. In 100 grams fresh matter, there are 0.8-0.9 mg of vitamin A, 0.12-0.13 mg of vitamin B complex, 20-60 mg vitamin C and 0.10-0.25 mg vitamin PP (Stan et al., 2003).

Mandru et al. (2018) determined in laboratory conditions the biochemical composition of tomatoes fruits.

Also, Buzatu et al. (2018) determined in laboratory conditions the biochemical composition in different cultivars belonging to the *Solanaceae* family.

MATERIALS AND METHODS

During period of vegetation, were made observations and determinations on the beginning of flowering, on the formation of the first fruits, the colour of the immature and

mature fruits and the weight of the fruit (Table 1).
When the fruits reached commercial maturity, in laboratory conditions, the following quality indices were determined: water content and total dry substance (gravimetric method), soluble dry substance (refractometric method), titratable acidity (titrimetric method), total carbohydrates (Fehling Soxhlet method) and vitamin C (iodometric method).

Table 1. Biometric observations on tomatoes cultivars (Vidra, 2016)

Variety/ hybrid	Beginning of flowering	Date of the formation of the first fruits	Color of the immature fruit	Color of the mature fruit	Weight fruit (g)
1. Kristinica	22.06	06.07	green sholder	intense red	90
2. Darsirius	06.07	20.07	green	dark red	74
3. Măriuca	07.07	22.07	green	red	120
4. Caspar F1	22.06	07.07	green	bright red	112
5. Romec 554 J	25.06	12.07	green	bright red	55
6. Chihlimbar	06.07	20.07	whitish	yellow-orange	145
7. Viorica	30.06	18.07	green sholder	dark red	69
8. Vipon	26.06	18.07	green sholder	intense red	71
9. Pontica 102	01.07	20.07	green sholder	intense red	94
10. Perfect Peel F1	20.06	04.07	green	bright red	57
11. Missouri	15.06	28.06	green sholder	dark red	92
12. Heintz	23.06	06.07	green	red	132
13. Marmande	22.06	07.07	green	red	158
14. St. Pierre	19.06	04.07	light green	red	185
15. Mirsini F1	15.06	27.06	green	red	210

RESULTS AND DISCUSSIONS

Climate conditions have influenced the quality of the fruits, especialy the vitamin C (Table 2).
In Table 3 is presented the biochemical composition of tomato fruits.
The chemical composition of tomato fruits is influnced by variety, by the weather conditions, by the crop technology, by the growing area and by the harvest method (Munteanu, 2003).
Analyzing the data presented in the Table 3, it might be noticed an average water content of 94.71%, compared to 93-96% values mentioned in the literature.
The total dry matter content ranged between 7.33 for St. Pierre and 4.28% for Kristinica, the cultivars average being 5.29%.
The cultivars that exceeded the average were Caspar F1, Chihlimbar, Viorica, Heintz, Marmande, St. Pierre and Mirsini F1. The average of varieties and hybrids were 5.29%, compared to the average from the literature, 5.5%.
Due to abundant rainfall in August and September (Table 2), the soluble dry substance content ranged from to 4.2% to St. Pierre and 2.5% Pontica 102, with an average of 3.43%.
The literature specify a quantity of dry matter soluble in tomatoes greater than 5.0%.
All cultivars studied had a lower content of soluble dry matter.
The acidity of tomato fruit, of Missouri variety, expressed in g of citric acid/100g of fresh substance, was 0.47%, being close to the value indicated in the literature 0.45 g citric acid/ 100 g s.p.
The highest value was recorded to the Pontica 102 variety (1.0 g citric acid/100 g s.p.), but also a low content of soluble dry substance (2.5%). Thus, the Missouri variety has the closest value (0.47 g citric acid/100 g s.p.).
The carbohydrate content was below the average indicated by the literature (3.8%).
The highest value was recorded in the St. Pierre (3.50%), and lowest value in the Pontica 102 (2.10%).
The rainfall from August and September also influenced this parameter.
The fruit content of vitamin C was between 16.72 mg/100 g of fresh substance (Chihlimbar variety) and 24.64 mg/100 g fresh substance

(Heintz variety), the average being 20.36 mg. The mean value in the literature is 24 mg.
The cultivars Romec 554 J, Caspar F1, Vipon, Perfect Peel F1, Marmande and Mirsini F1 had higher values compared to the average. Although it is a character of the variety, vitamin C content can be strongly influenced by climatic conditions (Lee & Kader, 2000).
In Figures 1, 2, 3 and 4 are presented the fruits of the experimented cultivars.

Table 2. Climate data in the field (Vidra, 2016)

Month	Temperature (^{0}C)			Relative air humidity (%)			Rainfall (mm)
	minimum	maximum	medium	minimum	maximum	medium	
June	16.1	28.4	21.9	56.8	89.5	71.3	33.5
July	17.0	31.0	23.7	48.1	78.3	59.7	2.0
August	17.5	30.6	23.4	49.5	77.2	60.6	110.0
September	13.1	26.3	18.9	50.9	80.2	62.8	43.5

Table 3. The biochemical composition of tomato fruits (Vidra, 2016)

No.	Variety/hybrid	Water content (%)	Total dry substance (%)	Soluble dry substance (%)	Acidity (g citric acid at 100 g s.p.).	Carbohydrate (%)	Vitamin C (mg/ 100g s.p.)
1	KRISTINICA	95.72	**4.28**	3.4	0.72	2.80	18.48
2	DARSIRIUS	94.79	**5.21**	**3.9**	**0.69**	**3.20**	19.36
3	MĂRIUCA	95.71	4.29	**3.5**	0.55	2.90	20.24
4	CASPAR F1	94.02	**5.98**	**3.8**	0.60	**3.20**	**21.12**
5	ROMEC 554J	95.06	4.94	3.0	0.77	2.50	**22.88**
6	CHIHLIMBAR	94.27	**5.73**	**3.6**	0.93	3.00	**16.72**
7	VIORICA	94.30	**5.70**	3.4	0.54	2.80	20.24
8	VIPON	95.71	4.29	3.4	0.51	2.83	**21.12**
9	PONTICA 102	95.65	4.35	**2.5**	**1.00**	**2.10**	17.60
10	PERFECT PEEL F1	94.76	5.24	2.8	0.70	2.30	**22.88**
11	MISSOURI	95.09	4.91	3.0	**0.47**	2.49	18.48
12	HEINTZ	94.33	**5.67**	**3.7**	0.80	**3.10**	**24.64**
13	MARMANDE	94.20	**5.80**	3.2	0.77	2.70	**21.12**
14	ST. PIERRE	92.67	**7.33**	**4.2**	0.67	**3.50**	19.36
15	MIRSINI F1	94.32	**5.68**	**4.0**	0.64	**3.30**	**21.12**
Avarage		**94.71**	**5.29**	**3.43**	**0.69**	**2.85**	**20.36**
Values in the literature		**93-96 (94.5)**	**4 – 7 (5.5)**	**5.0**	**0.45**	**3.8 (1.8-4.3)**	**24**

Figure 1. Caspar F1 hybrid (original photo)

Figure 2. Heintz variety (original photo)

Figure 3. St. Pierre variety (original photo)

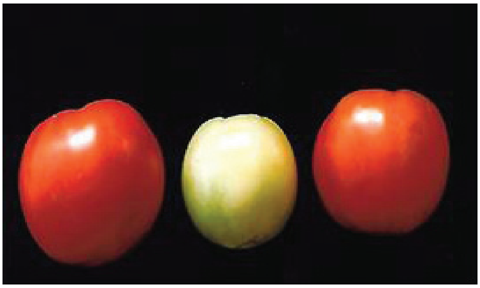

Figure 4. Mirsini F1 hybrid (original photo)

CONCLUSIONS

Values obtained at the water content of tomato fruits were in the limits stipulated in the literature, for all tested varieties and hybrids, the water content was an average of 94.71%, and in the literature it is in a range of 93- 96%.
Under the climatic conditions of 2016, the most favourable values for fruits quality were obtained in the following cultivars:

- St. Pierre variety (7.33% total dry substance, 4.2% soluble dry substance, 0.67% acidity, 3.50% carbohydrate and 19.36 mg vitamin C);
- Caspar F1 hybrid (5,98% total dry substance, 3,8% soluble dry substance, 0,60% acidity, 3,20% carbohydrate and 21,12 mg vitamin C);
- Mirsini F1 hybrid (5,68% total dry substance, 4,0% soluble dry substance, 0,64% acidity, 3,30% carbohydrate and 21,12 mg vitamin C);
- Heintz variety (5.67% total dry substance, 3.7% soluble dry substance, 0.80% acidity, 3.10% carbohydrate and 24.64 mg vitamin C);
- Darsirius variety (5.21% total dry substance, 3.9% soluble dry substance, 0.69% acidity, 3.20% carbohydrate and 19.36 mg vitamin C);
- Romec 554 J variety and Heintz variety have high levels of vitamin C (24.64 mg) and the Perfect Peel F1 hybrid has recorded high vitamin C levels - 22.88 mg.
- The Pontica variety recorded the highest value of citric acid/100 g s.p. - 1.0 g and a lower content of soluble dry substance (2.5%), compared to the limits set in the literature.

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STEPS IN ORGANIC FRACTION OF MUNICIPAL SOLID WASTE COMPOSTING AND COMPOST QUALITY EVALUATION

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Abstract

The amount of solid waste generated in Romania has increased in recent years mainly because of the people lifestyle. Since 2015, all local communities are working for a sustainable waste management using composting as the main method of recycling the organic fraction of municipal solid waste (OFMSW). Composting is a way of obtaining a product from the biological oxidative transformation of OFMSW with less carbon and nitrogen, but more stable, which is called compost and that could enhance plant growth. This paper refers to quality evaluation of compost produced from OFMSW within Covasna-Boroşneu Mare Integrated Waste Management Centre. There were used empirical methods, physical and chemical analysis, germination tests with cress (Lepidium sativum L.) and plant growing tests with lettuce (Lactuca sativa L). No presence of ammonia was identified within empirical test, and the C/N ratio has a typical value for a mature compost but, in the seed germination tests and plant growing tests the plants are dead. The phytotoxicity could be explained by the higher salts content of compost or by other substances that haven't been analiyzed.

Key words: *compost mixtures, compost maturity, germination test, plant growth test, salts content.*

INTRODUCTION

The amount of household waste generated both, in urban and rural areas of Romania, has increased in the last 30 years mainly not because of demographic growth but because of the changes in people lifestyle and the increase of consumption. Recently (2016), in Romania, the average production of municipal waste was of 261 kg/capita and, in 2017, the average increased at 272 kg per capita (Eurostat, 2017). Nevertheless, these quantities are under the European Union (EU) average, which was of 486 kg/capita in 2017. However, the quantities are high and, in addition to the remarkable increase of wastes generation, their diversity, their polluting capacity, the dangerousness and the environmental impact should be considered in order to implement an appropriate management strategy (Oliveira et al., 2017). The major problem of the waste management in Romania was related especially to the selective collection which has not been widely deployed. Thus, a large amount of waste reached to landfill which is not an environmentally friendly method. Romania has a recycling rate (including composting) of 13%, while the elimination rate on landfill is of 69%. Based on an analysis of the existing and firmly planned policies in the area of waste management, Romania is considered at risk of missing the 2020 target of 50% preparation for re-use/recycling of municipal waste (CE, 2018). There are several treatments available which can produce valuable products such as biofuels, energy and fertilizers. However, if the waste management framework does not operate efficiently, OFMSW may be unnecessarily wasted (Mihai & Ingrao, 2018). For that reasons, since 2015, with the new Romanian National Plan for Waste Management (HG 942/2017), all local communities are working for a sustainable waste management. In many cases, composting was introduced as the main method of recycling the organic fraction of municipal solid waste which is considered a suitable waste management method in many European countries (Kapanen & Itävaara, 2001) and the most environmentally friendly technologies (Barrena et al., 2014).

Composting is a way of obtaining a stable product from biological oxidative transformation, similar to that which naturally occurs in the soil (Bertoldi et al., 1983), a sum of complex metabolic processes performed by different microorganisms that, in the presence of oxygen, use nitrogen (N) and carbon (C) available to produce their own biomass (Roman et al., 2015). If is correctly handled, composting (Bertoldi et al., 1983) provides a hygienic transformation of organic wastes in a homogeneous material which occurs under aerobic conditions (presence of oxygen), with adequate moisture and temperature, the recycling of nutrients, and the consequent reuse of the organic fraction of the waste, thus reducing environmental pollution (Oliveira et al., 2017; Azim et al., 2018). In this process, additionally, the microorganisms generate heat and a solid substrate, with less carbon and nitrogen, but more stable, which is called *compost* and that could enhance the plant growth (Komilis et al., 2011; Roman et al., 2015).

Using organic fertilizers, such as compost, in order to improve the soil content in organic matter and consequently the long-term soil fertility and productivity became widespread around the world. Organic waste composting benefits for soil structure and fertility, as well as for plant growing have been more and more emphasized. Compost application can reduce some of the negative consequences that urbanization has upon soil properties and processes, and can improve carbon storage, patterns of nutrient cycling and nutrient use efficiency, water capacity of the soil, as well as biocontrol of pathogenic microorganisms (Termorshuizen et al., 2006; Trillas et al., 2006). The humic substances formed during the composting process promote the building of soil fertility, and there is an actual increase in organic matter content in the soil (Bertoncini et al., 2008). For a good compost quality, composting process must be conducted with the respect of some important parameters (substrate mixture, C/N ratio, temperature, aeration, humidity etc.). Two properties are usually used for the characterization of compost quality namely “stability” and “maturity”.

Compost stability is related to the microbial decomposition or microbial respiration activity of the composted matter (Iannotti et al., 1993). Maturity of compost indicates the presence or absence of phytotoxic effects on crops (Komilis et al., 2011). Immature composts are usually phytotoxic (mostly due to the production of organic acids but not only) and may have a negative impact on plant growth (Epstein, 1997). Applying immature compost as soil fertilizer can inhibit seed germination, destroy roots, prevent plants from growing, decreases the oxygen concentration and redox potential and increases the mineralization rate of the organic carbon in soil (Said-Pullicino et al., 2007). Moreover, it is known that mature composts can better sustain the biological pest control, while immature composts can’t (Ling et al., 2010). Applying incompletely decomposed waste or non-stabilized and immature composts on soils may lead to immobilization of nutrients necessary for plants and can cause phytotoxicity that can be defined as a delay in seed germination, an inhibition of plant growing or any other adverse effect caused by specific substances (phytotoxins) or inappropriate growing conditions (Baumgarten & Spiegel, 2004).

Stability and maturity of compost cannot be established by a single parameter (Bernal et al., 2009). Moreover, due to the variation of materials and composting technologies, it can’t be available one single method to appreciate the compost stability and maturity (Benito et al., 2003; Chang & Chen, 2010). Thus, several methods and tests were proposed to evaluate these two compost quality properties (Epstein, 1997; Aslam et al., 2008; Azim et al., 2018): empirical methods, such as appearance, color, smell, granulometry, texture, temperature (Jimenez & Garcia, 1989); physical techniques, such as self-incineration after moisturizing (Brinton et al., 1995), respirometric methods (Barrena Gomez et al., 2005; Tremier et al., 2005; Scaglia & Adani, 2008) and sieving tests; physical and chemical analyses, such as moisture, KCl pH (Avnimelech et al., 1996), C/N ratio (Jimenez & Garcia, 1989) and the NO_3^-/NH_4^+ ratio, humification index (humic acids/fulvic acids ratio) (Veeken et al., 2000; Jouraiphy et al., 2005; Huang et al., 2006), water-soluble carbon concentration, dissolved organic carbon (Zmora-Nahum et al., 2005); colorimetric and spectroscopic methods (UV-Visible, Fluorescence), FTIR - Fourier transform infrared, NMR - Nuclear Magnetic Resonance) (Lim & Wu, 2015); biological

studies on plant growing (Said-Pullicino et al., 2007; Cesaro et al., 2019).
There are also several phytotoxicity tests used for the estimation of compost maturity as follows: germination tests (including root assessments) (Zucconi et al., 1985), growth tests (assessment of top-growth and sometimes root mass), germination and growth combinations, and other methods such as enzyme activities (Herrmann & Shann, 1993). Germination tests indicates an instant degree of phytotoxicity, while growing tests will be affected by the changes in the stability or maturity of the compost tested: in the early stages there may be damaging effects on growth and beneficial effects later, with different conclusions depending on the time of assessment (Zucconi & Bertoldi, 1987).
This study was conducted in order to complete the master studies and is a small part of a research regarding the quality of different types of compost that could be used as soil amendments. This paper focus on the assessment of compost phytotoxicity using some empirical methods, physical and chemical parameters, seed germination test and plant growth tests. The compost originated from an aerobic treatment of organic fraction of municipal solid waste.

MATERIALS AND METHODS

Composting materials and compost production

The compost was produced by classical method of mechanical aerated piles within the Covasna-Boroşneu Mare Integrated Waste Management Centre. The municipal solid wastes were not selected at source but within the Waste Management Centre which is a hard and expensive process. The organic substrates for composting were: vegetal waste resulted from urban parks, pruning of trees and shrubs, gathering of tree and shrub leaves, grass clippings and organic materials, food waste from households. The composting material was arranged in prismatic shaped piles, aerated using a machine and sprinkled with leachate diluted with water in order to ensure moisture. The composting process lasted 5 months. Samples of compost were taken in plastic bags, from eight different places of the compost pile. All these samples were mixed and homogenized into a final sample of approx. 40 l. Then, the compost was sieved out using different sieves and various granulation compost were obtained: fine granulation, <8 mm, about 50%, medium granulation, 8-20 mm, about 40% and high granulation, over 20 mm, about 10%). At the end, the compost with fine granulation (<8 mm) was sieved out using sieves with about 4 mm holes. Thus, from the 40 l compost sample, around 5-6 liters with granulation of 0-4 mm were obtained and used afterwards in the experiments.
The compost physical and chemical characteristics were analyzed within the Laboratory for Soil Pollution and Rehabilitation of the Research Institute for Pedology and Agrochemistry of Bucharest. For this study, no metal analysis were provided.

Compost quality evaluation

In this study, for compost quality assessment we used (i) empirical methods (appearance, colour, smell, granulometry, temperature), (ii) physical and chemical analysis (bulk density, moisture, pH, C/N ratio, total N content), (iii) seed germination test and (iv) plant growth tests.

Empirical methods

The compost was analyzed at the end of the composting process regarding the appearance, color, smell, granulometry and the temperature.

Physical and chemical analyses

Several physical and chemical analyses of the compost were done: moisture; dry matter (gravimetric analyses); total forms of mineral elements: wet mineralization (H_2SO_4+H_2O_2) using HACH Digesdahl method; distillation and dosing of nitrogen (N) using Kjeldahl method; dosing of phosphorus (P) was performed by spectrophotometry and the potassium content (K) was determined using the flam-photometric method; total salts content; the organic matter content was determined through dry oxidation (LOI - loss on ignition), thus measuring the calcination losses (600°C, 2 h) and then the content in total organic C was calculated by multiplying the obtained result by 0.54.

Experimental design and statistical analyses

Seed germination test design

In order to perform the germination test we used cress (*Lepidium sativum* L.) seeds and compost tea. The compost tea was produced in a vessel by mixing 1 l of compost with 1 l of distilled water (pH 6.56; EC - electric conductibility = 0.00) and left for 24 hours, in which period it was mixed a few times. The resulting juice (compost tea) was filtered and poured into a 1-liter clear glass bottle. Petri dishes with a 9-cm diameter were used, where a filter paper layer was inserted and moistened with compost tea.

There were carried out 4 treatment variants (V) in 4 replicates: V_1: 100% compost tea; V_2: 50% compost tea + 50% distilled water; V_3: 25% compost tea + 75% distilled water; V_4: 100% distilled water.

The cress sowing was done in 16^{th} of May 2018. In Petri dishes there were sowed 50 cress seeds on filter paper layer moistened with compost tea. The seeds were placed in rows, then covered with filter paper and moistened with the compost tea prepared for each treatment variant. All Petri dishes were placed for germination at natural room temperature conditions which was 22°C ± 2°C.

The seed germination happened in 19^{th} of May, but in the next day, the seedlings started to die. From 21^{st} to 28^{th} of May, each day the dead seedlings were counted (Photo 1). For each variant there was calculated the death seedlings average of the four replicates. The number of death seedlings was correlated with the number of days that passed from the germination day.

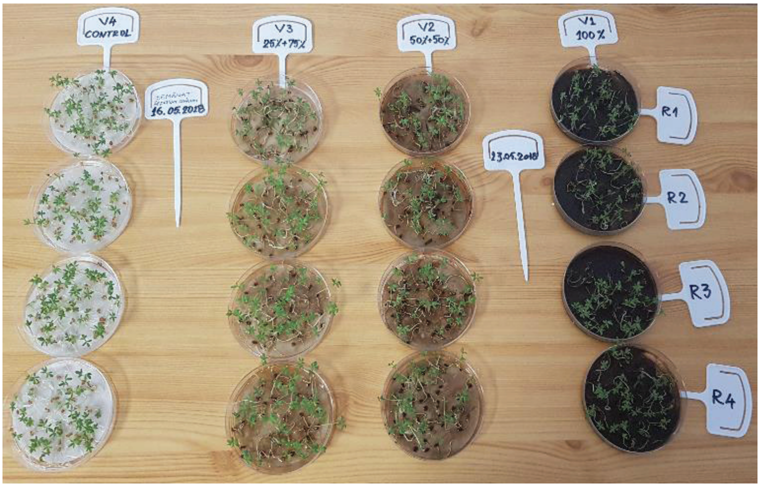

Photo 1. Cress (*Lepidium sativum* L.) seedelings in the fifth day after total germination

Plant growing tests design

For the plant growing tests there were prepared 4 treatment variants with different compost mixtures between OFMSW compost and a peat compost (Hawita Baltischer FT - Topfsubstrat): V_1 - 100% compost; V_2 - 75% compost + 25% Topfsubstrat; V_3 - 50% compost + 50% Topfsubstrat; V_4 - 25% compost + 75% Topfsubstrat. Lettuce seedlings (*Lactuca sativa* L. *var. capitata* L.) were planted on May 21, 2018 in rectangular pots of 7 x 7 x 6.5 cm. All experimental variants were made in four replicates. After planting the lettuce, the pots were watered with fresh water.

RESULTS AND DISCUSSIONS

Empirical methods

At the end of the composting process, the compost had a granular structure (Azim et al., 2018), dark brown colour and a pleasant smell, similar to recently ploughed soil, which could reveal the presence of actinomycetes in the last part of the composting process (Mustin, 1987). Also, the compost was easy to handle and the temperature was close to the ambient one or low. There was no ammonia smell and no organisms, such as arthropods, were found. However, some wood materials were found that did not decompose until the composting process was completed.

Physical and chemical characteristics

The compost physical and chemical characteristics are showed in Table 1. The bulk density of the compost was of 0.582 kg/dm^3. Typical wet bulk densities of the compost varies from 500 to 900 kg m^{-3} (Agnew & Leonard, 2003). The C/N ratio was about 16.43 which seems to be within the limits of the values reported in the scientific literature. According to Zmora-Nahum et al. (2005), composts are usually considered mature when C/N ratio is of 10-15, while Fung et al. (1999) defined as mature composts with C/N ratios of 17.5-20. Mustin (1987) stated that a compost from organic fraction of municipal solid waste, after 10 weeks, should have a C/N ratio between 18 and 19 which is in agreement with Bertoldi (1983) who reported that in mature compost the C/N ratio should be less than 20.

The compost pH was 8.67 which corresponds to the range of values from 7 to 9 that are indicated by Avnimelech et al. (1996) for the mature compost. But, in some other studies the limits between 5.5 and 8 are considered as optimal for the matter that can be composted (Bertoldi, 1983), and for an OFMSW mature compost (140 days) the pH was between 7.8 and 8.1 (Mustin, 1987; Komilis & Tziouvaras, 2009; Vázquez et al., 2015; Cesaro et al., 2019).

Table 1. OFMSW compost physical and chemical characteristics

	pH	U (%)	DM[1)] (%)	Organic carbon (%)	N-Kjeldahl (%)	P (%)	K (%)	C/N
Compost	8.67	34.62	65.38	17.26	1.05	0.30	2.21	16.43

[1)] DM: dry matter

In the case of compost tea, for each of the concentrations prepared for the proposed treatment variants of the seed germination test, the electric conductivity (EC) and the pH were analysed (Table 2). The compost tea at 100% electrical conductivity value was of 5200 µs cm^{-1} which is comparable with the values reported by Chelinho et al. (2019) for urban waste composts which were between 4300 and 6440 µs cm^{-1}. But, in many other studies there were reported low values of EC for OFMSW compost: 4220 µs cm^{-1} (Asquer et al., 2017), 3600 µs cm^{-1} (Vázquez et al., 2015), 3000 µs cm^{-1} (Zhang et al., 2018). With the dilution, the EC values dropped at 2900 µs cm^{-1} in compost tea 50% and at 1300 µs cm^{-1} in 25% compost tea.

Table 2. Chemical analyses for OFMSW compost tea mixtures and distilled water

	EC (µs cm^{-1})	pH
Compost tea 100%	5200	8.67
Compost tea 50%	2900	8.55
Compost tea 25%	1300	8.45
Distilled water	0	6.56

The compost mixtures (OFMSW compost + Hawita Baltischer FT - Topfsubstrat) were analyzed regarding the total content of salts (TSC) and the pH. As it is shown in Table 3, the compost itself has high contents of salts (0.92%) and, as result, the pH values were high (8.67). But, in the compost mixtures, the total content of salts decreased from 0.92 ms cm^{-1} at 100% compost to 0.59 ms cm^{-1} at 25% compost. The pH values decreased from 8.67 at 100% compost to 7.37 at 25% compost. Unfortunately, only the total salt content was analyzed, which does not allow us to specify what kind of salts had a higher content.

Table 3. OFMSW compost and compost mixtures chemical analysis

	Total salts content (%)	pH
Compost 100%	0.92	8.67
Compost 75% + 25% Topfsubstrat	0.84	8.39
Compost 50% + 50% Topfsubstrat	0.68	7.62
Compost 25% + 75% Topfsubstrat	0.59	7.37

Seed germination test

As already said, the cress seed germination happened in 19th of May. Unfortunately, the seedlings began to die shortly after germination. For 10 days, from 21st to 28th of May the dead seedlings were counted. As we expected, no dead cress seedling was observed in the variant with distilled water (V4). But, in all variants with compost tea, the cress seedlings have died since the first day, and over the 10 days period their number has increased. Thus, as it could be observed in the Figure 1, the highest average number of dead seedlings was recorded in V4 (100% compost tea), from 22 dead seedlings in the first day to 46 seedlings in the tenth day. In the variant with 50% compost tea (V3), the average number of dead seedling in the first day was of 19, and in the tenth day was of 39. In the variant with 25% compost tea (V3), the average number of death seedlings was lower, 14 respectively, but has grown to 37 in the tenth day. Once the time pased, the number of dead seedlings raised (Figure 2). At the end of May, in the variant with 100% compost tea, almost all cress seedlings were dead (Photo 2). However, the death of seedlings was not caused by their age but by the presence of certain substances in the growing environment. As no presence of ammonia was identified within empirical test, and the C/N ratio has a typical value for a mature compost, the phytotoxicity could be explained by the higher content of salts (Komilis and Tziouvaras, 2009). In addition, some other substances that we didn't analiyzed, such as heavy metals, organic acids (Komilis and Tziouvaras, 2009) and/or high level of biodegradable organic substances mai cause toxic responses in the test (Kapanen & Itävaara, 2001).

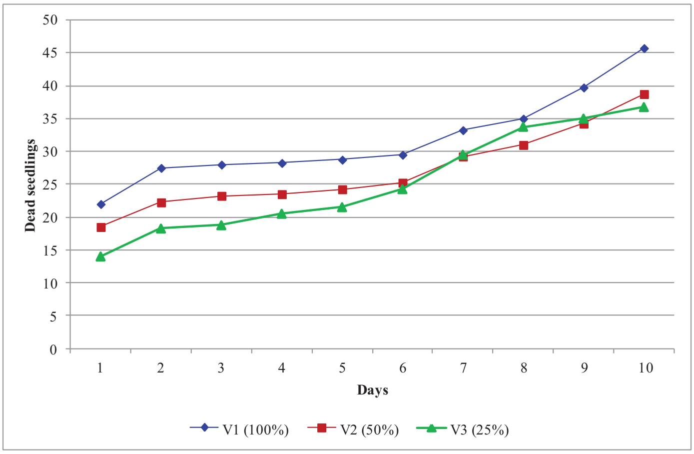

Figure 1. The daily average of cress (*Lepidium sativum*) dead seedlings

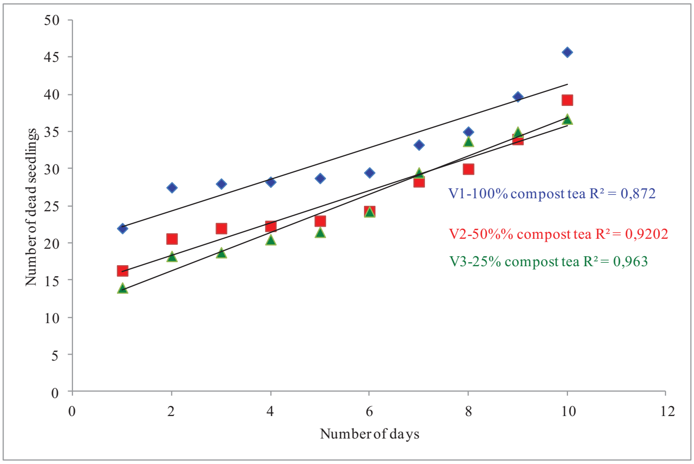

Figure 2. Correlation between number of days and number of dead seedlings of cress (*Lepidium sativum*)

Plant growing test

In the second experiment we used 40 days old lettuce (*Lactuca sativa* L.) seedlings produced on peat substrate in greenhouse (Photo 3) which were planted on May 21, 2018. The lettuce plants died 3 days after planting in the variant with 100% compost. After several days, the lettuce seedling planted in the variants with 50% and 25% compost died also (Photo 4). The most resistent to the growing support were the lettuce seedlings in the variant with 25% compost. Most likely the total soil salts content was very high, and the lettuce being a salts sensitive plant that could be the cause of which the plants suffered and finally died.

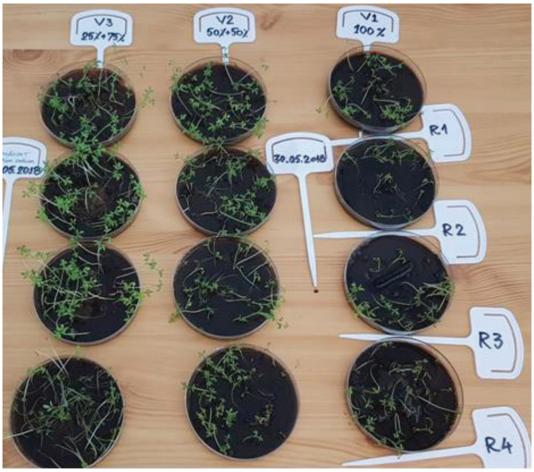

Photo 2. Dead cress (*Lepidium sativum*), seedlings in 30 of May 2018

Photo 3. Lettuce (*Lactuca sativa* L.) seedlings before planting

Photo 4. Dead lettuce (*Lactuca sativa* L.) seedlings after planting (from 21 to 30 of May 2018)

CONCLUSIONS

The composting process is considered a suitable waste management method and the most environmentally friendly technology. For a good compost quality, composting process must be conducted with the respect of some important parameters (substrate mixture, C/N ratio, temperature, aeration, humidity etc.). To be used as soil fertilizer, the OFMSW compost must be characterized by two essential properties, i.e maturity and stability. Using an incompletely decomposed waste or non-stabilized and immature composts on soils may lead to immobilization of nutrients necessary for plants and can cause phytotoxicity that can be defined as a delay in seed germination, an inhibition of plant growing or any other adverse effect caused by specific substances or inappropriate growing conditions. For the assessment of compost maturity different parameters and methods should be used.

In this study there were used some empirical methods, physical and chemical analysis, seed germination test and plant growth tests in order to assess the compost maturity. Empirical methods are not enough, and chemical analyzes should be extended to different substances that can be found in waste or that can be formed during the composting process which can have phytotoxic effects on plants. In addition, for a good compost quality, a proper separation at the source of the waste and a differentiated collection are required.

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OBSERVATIONS REGARDING THE USEFUL ENTOMOFAUNA OF SOME APPLE ORCHARDS AND CABBAGE CROP

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Abstract

The purpose of this research paper is to identify the useful entomofauna from some apple orchards and cabbage crop. The observations were made in the Adamachi station, which belongs to "Ion Ionescu de la Brad" University of Applied Life Sciences and Environment of Iasi, Romania. The biological material was sampled by mean of Barber soil traps from May 7th to August 1st of 2018, at intervals between 4 and 9 days. The dates of samples were as follows: 07.05, 14.05, 22.05, 30.05, 02.06, 07.06, 14.06, 21.06, 28.06, 04.07, 11.07, 18.07, 23.07, 01.08. One with another, 14 samples were made. The traps were placed every 6 in a row, and inside of them a mixt of water and powder in proportion of 16% was added. After finishing the experiments, the insects were brought to the laboratory of Entomology. Here they were counted and identified. In the apple orchards, from the Coleoptera order, the dominant species were: -Brachinus crepitans (Carabidae)-50 samples; Phytodecta fornicata (Chrysomelidae)-30 samples; Coccinella septempunctata (Coccinellidae)-42 samples.

In the cabbage crop, from the Coleoptera order, the dominant species were: -Anisodactylus signatus (Carabidae)-22 samples; Phytodecta fornicata (Chrysomelidae)-12 samples; Adalia bipunctata (Coccinellidae)-16 samples.

Key words: *Carabidae, Dermestidae, Chrysomelidae, Coccinellidae, soil traps.*

INTRODUCTION

Carabidae family includes ground beetles, with fast moving, which move to the surface of the soil, and only seldom walk on the trees. There are over 40,000 species known around the world, from which 2,700 are known in Europe. Almost all species of this family are predators for invertebrates, some of the being specialized for a certain type of food.

Coccinellidae family has species of round or oval species, almost hemispherical, with spots on the wings with color spots and contrasting patterns. The most species of *Coccinellidae* are benefical predators which prefer the aphids as main feed.

According to the author (Foltz, 2002), there are more than 5.000 species all around the world. The most representative species of the *Coccinellidae* family are: *Coccinella septempunctata*, *Adalia variegata*, *Chilocorus bipustulatus*, *Adalia bipunctata*.

Chrysomelidae family are often named "gold insects" because of their special colours. These species are small and a little bigger coleopteras, their shape is almost the same with the species from *Coccinellidae* family, but they are very dangerous. Some characters bring them close to the insects from *Cerambycidae* family. There are over 26,000 species known and studied. They appear mostly during the day.

MATERIALS AND METHODS

In order to carry out the researches, the insects were collected from one station: Adamachi from Iasi county, belonging to "Ion Ionescu de la Brad" University, by using the method of Barber soil traps. The experiments have taken place between May and August of 2018. The traps were placed within crop of apple trees, each five in a row. As a conservative liquid, water and washing powder have been used, in order to prevent the maceration of insects. There were each 14 samples in total, the first one took place on May 7th, and the last one on August 1st.

RESULTS AND DISCUSSIONS

The samples of the biological material were carried out at the following dates: 07.05, 14.05, 22.05, 30.05, 02.06., 07.06., 14.06, 28.06, 04.07, 11.07, 18.07, 23.07, 01.08.

In the apple orchards, for the year of research of 2018, (Table 1), the situation is as follows:
07.05: there were 14 samples identified, all of them belonging to *Carabidae* family: *Amara communis* (3 samples): *Harpalus tardus* (3 samples); *Poecilus chalcites* (4 samples), *Helops pernitens* (4 samples);
14.05: there were 9 samples identified: 4 of them belonging to *Carabidae* family: *Brachinus crepitans* and 5 to *Coccinellidae* family: *Stethorus punctillum*;
22.05: there were 4 samples identified, all of them belonging to *Carabidae* family: *Brachinus crepitans*;
30.05: there were 12 samples identified, 4 of them belonging to *Carabidae* family: *Carabus nemoralis* and 8 to *Coccinellidae* family: *Coccinella septempunctata*;
02.06: there were 20 samples identified, 5 samples belonging to *Chrysomelidae* family: *Phytodecta fornicata*, 5 belonging to *Coccinellidae* family: *Coccinella septempunctata,* 10 belonging to *Carabidae* family: *Cicindela germanica*;
07.06: there were 17 samples identified, 7 belonging to *Carabidae* family: *Brachinus crepitans* and 10 belonging to *Chrysomelidae* family: *Phytodecta fornicata*;
14.06: there were 15 samples identified, 8 belonging to *Carabidae* family: *Brachinus crepitans*; and 7 belonging to *Coccinellidae* family: *Coccinella septempunctata*;
21.06: there are 18 samples identified, 5 of them belonging to *Carabidae* family: *Brachinus crepitans*, 8 belonging to *Chrysomelidae* family: *Phytodecta fornicata* and 5 belonging to *Coccinellidae* family: *Coccinella septempunctata*;
28.06: there were 10 species identified, 5 of them belonging to *Carabidae* family: *Amara aenea* and 5 belonging to *Coccinellidae* family: *Coccinella septempunctata*;
04.07: there were 30 samples identified, all of them belonging to *Carabidae* family: *Brachinus crepitas* (10 samples)*,* 10 to *Harpalus aeneus* and 10 to *Harpalus tardus*;
11.07: there were 33 samples identified, 23 belonging to *Carabidae* family: *Brachinus crepitans* (12 samples), 11 to *Bembidion properans* and 10 belonging to *Coccinellidae* family: *Coccinella septempunctata*;
18.07: there were 12 samples identified, 7 of them belonging to *Chrysomelidae* family: *Phytodecta fornicata*, 3 to *Dermestidae* family: *Dermestes maculatus* and 2 to *Coccinellidae* family: *Coccinella septempunctata*;
23.07: there were 20 samples identified, all of them belonging to *Carabidae* family: *Pterostichus cupreus* (10 samples) and 10 to *Pterostichus melanarius*;
01.08: there were 22 samples identified, 10 of them belonging to *Carabidae* family: *Anisodactylus signatus*, 7 to *Brachinus texanus* and 5 to *Chrysomelidae* family: *Oulema melanopus.*
In the cabbage crop (Table 2), the situation is as follows:
07.05: there were 12 samples identified, all of them belonging to *Carabidae* family: *Anisodactylus signatus* (5) and *Amara aenea* (3) and 4 belonging to *Elateridae* family: *Agriotes lineatus;*
14.05: there were 21 samples identified, 13 of them belonging to *Carabidae* family: *Brachinus crepitans* (7); *Pterostichus cupreus* (6); and 8 belonging to *Coccinellidae* family: *Coccinella septempunctata*;
22.05: there were 7 samples identified, 5 of them belonging to *Chrysomelidae* family: *Phytodecta fornicata* and 2 belonging to *Dermestidae* family: *Dermestes maculatus;*
30.05: there were 15 samples identified, 3 of them belonging to *Carabidae* family: *Harplaus tardus* and 7 belonging to *Coccinellidae* family: *Adonia variegata* and 5 belongs to *Chrysomelidae* family: *Lilioceris merdigera*;
02.06: there were 20 samples identified; 8 of them belonging to *Carabidae* family: *Anisodactylus signatus*, 6 belonging to *Chrysomelidae* family: *Phytodecta fornicata* and 1 belonging to *Coccinellidae* family: *Adalia bipunctata* and 5 belonging to *Elateridae* family: *Agriotes lineatus*;
07.06: there were 17 samples identified, 7 belonging to *Carabidae* family: *Brachinus crepitans* and 10 belonging to *Coccinellidae* family: *Nephus quadrimaculatus* (4) and *Adonia variegata* (6);
14.06: there were 11 samples identified, 6 belonging to *Carabidae* family: *Amara aenea*; 1 to *Chrysomelidae* family: *Phytodecta fornicata*, 4 to *Coccinellidae* family: *Adonia*

variegata (1) and *Coccinella septempunctata* (3);
21.06: there were 9 samples identified, all of them belonging to *Carabidae* family *Anisodactylus signatus* (5) and *Harpalus tardus* (4);
28.06: there were 13 samples identified, 5 of them belonging to *Carabidae* family: *Anisodactylus signatus* (2) and *Harpalus tardus* (3) and 3 belonging to *Coccinellidae* family: *Adalia bipunctata* (3) and 5 belonging to *Elateridae* family: *Agriotes lineatus* (5);
04.07: there were 13 samples identified, 3 of them belonging to *Carabidae* family: *Anisodactylus signatus* (2) and *Amara aenea* (1) and 6 belonging to *Coccinellidae* family: *Adalia bipunctata* and 1 belonging to *Dermestidae* family: *Dermestes maculatus* and 3 belonging to *Chrysomelidae* family: *Lilioceris merdigera*;
11.07: there were 17 samples identified, 11 belonging to *Carabidae* family: *Brachinus crepitans* (5) and *Harpalus tardus* (6) and 6 belonging to *Elateridae* family: *Agriotes lineatus*;
18.07: there were 4 samples identified, 2 belonging to *Carabidae* family: *Pterostichus cupreus* and 2 belonging to *Coccinellidae* family: *Adalia bipunctata*;
23.07: there were 9 samples identified, 3 of them belonging to *Carabidae* family: *Pterostichus cupreus* and 3 to *Coccinellidae* family: *Adalia bipunctata* and 3 belonging to *Chrysomelidae* family: *Lilioceris merdigera*;
01.08: there were 4 samples identified, 2 belonging to *Carabidae* family: *Harpalus tardus*, 1 belonging to *Coccinellidae* family: *Adalia bipunctata* and 1 belonging to *Dermestidae* family: *Dermestes maculatus*.

Table 1. Entomofauna of Coleopteras (Coleoptera) sampled within the orchard of apple trees by means of Barber soil traps in the Adamachi station from May 7th to August 1st of 2018

Current number	Family	Species	Number of samples	Total samples
1	*Carabidae*	*Amara aenea*	5	151
2		*Amara communis*	3	
3		*Anisodactylus signatus*	10	
4		*Bembidion properans*	11	
5		*Brachinus crepitans*	50	
6		*Brachinus texanus*	7	
7		*Carabus nemoralis*	4	
8		*Cicindela germanica*	10	
9		*Harpalus aeneus*	10	
10		*Harpalus tardus*	13	
11		*Helops pernitens*	4	
12		*Poecilus chalcites*	4	
13		*Pterostichus cupreus*	10	
14		*Pterostichus melanarius*	10	
15	*Chrysomelidae*	*Oulema melanopus*	5	35
16		*Phytodecta fornicata*	30	
17	*Coccinellidae*	*Coccinella septempunctata*	42	47
18		*Stethorus punctillum*	5	
19	*Dermestidae*	*Dermestes maculatus*	3	3
TOTAL ENTOMOFAUNA OF COLEOPTERAS				**236**

Table 2. Entomofauna of Coleopteras (Coleoptera) sampled within the cabbage crop by means of Barber soil traps in the Adamachi station from May 7th to August 1st of 2018

Current number	Family	Species	Number of samples	Total samples
1	*Carabidae*	*Amara aenea*	10	80
2		*Anisodactylus signatus*	22	
3		*Brachinus crepitans*	19	
4		*Harpalus tardus*	18	
5		*Pterostichus cupreus*	11	
6	*Chrysomelidae*	*Phytodecta fornicata*	12	22
7		*Lilioceris merdigera*	10	
8	*Coccinellidae*	*Adalia bipunctata*	16	45
9		*Adonia variegata*	14	
10		*Coccinella septempunctata*	11	
11		*Nephus quadrimaculatus*	4	
12	*Dermestidae*	*Dermestes maculatus*	4	4
13	*Elateridae*	*Agriotes lineatus*	20	20
TOTAL ENTOMOFAUNA OF COLEOPTERAS				**171**

CONCLUSIONS

It can be concluded that, during the year of research 2018, within the orchard of apple trees, from the total of 236 samples, the most significant number of samples belongs to *Carabidae* family (151), followed by *Coccinellidae* family (47), *Chrysomelidae* (35), *Dermestidae* (3). The most dominant species of *Carabidae* family is: *Brachinus crepitans* (50 samples collected), and the leastest are: *Amara communis* (3 samples collected).

The most dominant species of the *Coccinellidae* family is: *Coccinella septempunctata*, with a number of 42 samples collected. From *Chrysomelidae* family, the most dominant species is *Phytodecta fornicata* (30 samples).

Within the cabbage crop, from the total of 171 samples, the most significant number of samples belongs to *Carabidae* family (80), followed by *Coccinellidae* family (45), *Chrysomelidae* (22), Elateridae (20) and *Dermestidae* (4).

The most dominant species from the *Carabidae* family is: *Anisodactylus signatus* (22), followed by *Brachinus crepitans* (19) and *Harpalus tardus* (18) and the leastest are: *Amara aenea* (10 samples).

The most dominant species from the *Coccinellidae* family is: *Adalia bipunctata* (16), followed by *Adonia variegata* (14) and the leastest is: *Nephus quadrimaculatus* (4 samples). From the *Crysomelidae* family, the most dominant species is: *Phytodecta fornicata* (12 samples), followed by *Lilioceris merdigera* (10 samples).

From the *Elateridae* family, one species was identified: *Agriotes lineatus* (20 samples).

As a comparison between these two crops, it could be seen that the number of samples belonging to *Carabidae* family (151) within the apple orchards is bigger than the number of samples belonging to the same family from the cabbage crop (80).

Also, the number of samples belonging to *Coccinellidae* family is bigger with the apple orchard (47) in comparison to cabbage crop (45).

Samples from the *Elateridae* family have been identified only within the cabbage crop (20).

The smallest number of samples belongs to *Dermestidae* family (3) within the apple orchard while within the cabbage crop the number of samples from the same family is 4.

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THE EVALUATION OF THE BIOMASS QUALITY OF CARDOON, *Cynara carduncululus*, AND PROSPECTS OF ITS USE IN MOLDOVA

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Abstract

Asteraceae is one of the largest families of flowering plants, which are the most promising from economic point of view. We investigated some biological peculiarities and the quality of the biomass of the introduced perennial species Cynara cardunculus var. altilis in the National Botanical Garden (Institute), Chişinău. Research data demonstrated that cardoon, Cynara cardunculus, in the second and next growing seasons, was characterized by intensive growth and development rate that allowed obtaining up to 44-71 t/ha fresh mass and 10-14 t/ha dry matter. It was established that the concentration of nutrients in the prepared silage was 12.5% protein, 28.0% cellulose, 23.0% hemicellulose, 2.6% lignin, 8.4% ash; the dry matter digestibility was 72.3%. The biochemical methane production potential of Cynara cardunculus silage substrate reached 348 l/kg organic matter. The dry biomass, after harvesting the seeds, can be used to produce solid biofuel. The specific density of the briquettes reached 918 kg/m^3, with 19.0 MJ/kg gross calorific value, the ash content in briquettes was 2.8%.
We consider that Cynara cardunculus var. altilis is an excellent source of nectar and pollen for honeybees, and its biomass may be valuable fodder and feedstock for renewable energy production.

Key words: *biological peculiarities, biomethane, Cynara cardunculus, fodder value of silage, physical and mechanical characteristics of dry biomass.*

INTRODUCTION

Asteraceae or *Compositae* is one the largest families of flowering plants, consists of 1911 accepted plant genera and 32913 species. In addition to its large size, the family has a great diversity in growth form, ranging from annual and perennial herbs, dwarf shrubs, shrubs, trees, climbers, succulents, aquatic plants, rosette plants, cushion plants, ericoid, prostrate, grass-like and spine scent. From a human perspective, it is highly relevant because it includes economical, culinary, medical plants as well as numerous ornamentals, but also a great number of weedy representatives.
The Plant List (2013) includes 44 named species from the genus *Cynara*, subfamily *Tubuliflorae*, family *Asteraceae*, 11 of which are accepted species names. Since ancient time, *Cynara* species have been used in traditional medicine for their recognized therapeutic effects: hepatoprotective, anticarcinogenic, antioxidative, antibacterial, diuretic, anticholesterol and antihyperglycemic. *Cynara cardunculus* is an accepted species, native to the Mediterranean region, the Middle East, north-western Africa and the Canary Islands, and has been introduced and has spread in many temperate regions of the world. Recent studies regarding the classification of the genus *Cynara* have sparked debate, on the basis of the study of morphology and phytogeography, it was concluded that wild cardoon is the ancestor of the cultivated globe artichoke and cardoon. The Plant List, 2013, recognized a single species and these plants as varieties: globe artichoke *Cynara cardunculus* var. *scolymus* (L.) Fiori, the wild cardoon *Cynara cardunculus* var. *sylvestris* (Lam.) (L.) Fiori and the leafy cultivated cardoon *Cynara cardunculus* var. *altilis* DC.
Cynara cardunculus is a perennial C_3 plant species, with diploid chromosome number (2n = 2x = 34) and annual growth cycle, usually growing 75-150 cm tall, but occasionally reaching up to 2 m in height. The root system is very developed, consists of the main taproot can grow to the depth of 2 m with variable number of secondary fibrous roots as well as of a rhizome, more or less expanded, containing buds, both single and gathered in groups. The stem is erect and branched in its upper part,

rigid, longitudinally strongly ribbed, greyish-green coloured and covered in a cottony down, has a diameter of about 2-4 cm. The leaves form a basal rosette that can be very large - up to 120 cm long and 30 cm wide. Alternate leaves, green-greyish coloured and more or less incised, are present on the main and other order stems. Leaf shape and size depend on the genotype and on the growth stage. The inflorescence occurs singly at the top of a branch on a thick stalk, 1-6 cm long. The flower heads are almost round in shape and grow to be 4-5 cm across. Each head has several hundreds of florets, which are hermaphrodite, tubular and fitted in a well-developed receptacle. At the full anthesis, the florets have very long stigmata (6-7 cm), usually blue-violet coloured. The flowering is centripetal and proterandric. Pollination is entomophilous and reproduction is mainly by cross-fertilization, because of the previously mentioned proterandry mechanism (stigmatic surfaces mature two or three days after pollen shedding). The fruit is a tetragon-shaped or flattened achene, 6-8 mm long, dark-coloured or greyish, uniform or mottled. At physiological ripening of achenes (50-60 days after pollination), heads can reach a weight ranging from 10 to 120 g. Achenes have a prominent pappus with large feathery hairs (25-40 mm long) that contributes to the wind dispersion.

This species reproduces by seed, asexually from pieces of cut root, and also re-grows each year from a long-lived underground crown and taproot. It is well-adapted to the xerothermic conditions of southern Europe, is quite tolerant to salinity and intolerant to prolonged waterlogging, and prefers slightly acidic soils to the alkaline pH 6.5 - 8.2, clay and heavy soils are not recommended. The plant is quite sensitive to frost in the seedling stage but established plants are more frost tolerant.

The cardoon is a very important perennial herbaceous plant and it has been cultivated for many years as a traditional food source, fresh flowers are used as a vegetable rennet for milk clotting, in order to manufacture valuable regional cheeses in some parts of the southern Europe. *Cynara cardunculus*, characterized by large yields, offers a wide spectrum of economic utilizations. The leaves are rich in polyphenols, have strong antioxidant properties and have been used for medicinal and cosmetics purposes. The underground part of the plant has been used as a source of inulin for the pharmaceutical industry, functional and dietary products, biologically active and food supplements; the aerial biomass parts, as green or ensiled forage, have been used as raw material for biorefineries and for the production of renewable energy and building elements. Achenes provide a food source for birds, can be used for oil production, for human consumption, and after oil extraction, the cake could be used for animal feed, for biodiesel production.

According to Cajarville et al. (1999) green forage had high nutritive value, low levels of fibre and lignin, and very high digestibility for organic matter (86%), while ensilage is the most appropriate way for preserving it for long periods.

As regards the yield, Raccuia & Melilli (2004) found average root yield for globe artichoke and cardoon genotypes of 9.8 t/ha with average inulin yield of 3 t/ha.

Cardoon is a non-wood plant, the stalks as well as the hairs and pappi in capitula for paper production, can produce well delignified pulps with high yields, low rejects and very good strength properties (Gominho et al., 2001).

In the Republic of Moldova, only globe artichoke *Cynara cardunculus* var. *scolymus* has been introduced and studied to determine its features as a medicinal plant (Calalb & Bodrug, 2009).

In the last decades, the European policies of energy, agriculture and environment have had a growing interest for biomass crops and for *Cynara cardunculus* in particular, and in recent years, it has been intensively researched as suitable feedstock for solid (pellets, briquettes, chips), liquid (biodiesel) and gaseous (biomethane, syngas) biofuel in many scientific centres and universities (Abelha et al., 2013; Dahl & Obernberger, 2004; Fernandez et al., 2006; Grammelis et al., 2008; Ierna & Mauromicale, 2010; Ottaiano et al., 2017; Pesce et al., 2017; Toscano et al., 2016).

The objective of this research was to evaluate some biological peculiarities and the quality of the biomass of the introduced perennial species cardoon, *Cynara cardunculus* var. *altilis*, and the possibility to use aboveground biomass as fodder for animals and multi-purpose feedstock for renewable energy production in the Republic of Moldova.

MATERIALS AND METHODS

The introduced perennial species cardoon, *Cynara cardunculus* var. *altilis* which was cultivated in 2016-2018, in the experimental plot of the National Botanical Garden (Institute) served as subject of the research, and the traditional crop sunflower, *Helianthus annuus*, was used as control.
The green mass of *Cynara cardunculus* was mowed in the first year in the middle of September, and in the second and in the third years of growth - in early flowering stage (late June - early July), but the control *Helianthus annuus* - in the full flowering stage (end of July). The green mass was shredded and compressed in well-sealed containers. After 45 days, the containers were opened, and the organoleptic assessment and biochemical composition of the silage was determined in accordance with the Moldavian standard SM 108. Some assessments of the main biochemical parameters: protein, ash, acid detergent fibre (ADF), neutral detergent fibre (NDF) and acid detergent lignin (ADL), total soluble sugars (TSS), digestible dry matter (DDM), digestible organic matter (DOM) have been determined by near infrared spectroscopy (NIRS) technique PERTEN DA 7200. The concentration of hemicelluloses (HC) was approximated from subtraction of the ADF from the NDF, while the concentration of cellulose (Cel) of each sample was estimated by subtracting the ADL from the ADF.
The carbon content of the substrates was obtained from data on volatile solids, using an empirical equation reported by (Badger et al., 1979).
The biochemical biogas potential (Yb) and methane potential (Ym) were calculated according to the equations of Dandikas et al. (2014) based on the chemical compounds - acid detergent lignin (ADL) and hemicellulose (HC) values:

- biogas $Yb = 727 + 0.25\ HC - 3.93\ ADL$;
- methane $Ym = 371 + 0.13\ HC - 2.00\ ADL$.

The stems of cardoon and sunflower were mowed manually in the first days of September, after harvesting the seeds. The dry biomass was chopped and milled in a beater mill equipped with a sieve with diameter of openings of 10 mm. The following scientific research on biomass for the production of solid biofuel was carried out: the moisture content of the plant material was determined by CEN/TS 15414 in an automatic hot air oven MEMMERT100-800; the content of ash was determined at 550ºC in a muffle furnace HT40AL according to CEN/TS 15403; automatic calorimeter LAGET MS-10A, with accessories, was used for the determination of the calorific value, according to CEN/TS 15400; the particle size distribution was determined using standard sieves; the cylindrical containers were used for the determination of the bulk density; the briquetting was carried out by using the equipment developed in the Institute of Agricultural Technique "Mecagro"; the mean compressed (specific) density of 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, under the conditions of the Republic of Moldova, in the year when the seeds were sown in mid-April, the mass emergence of the seedlings of cardoon occurred in 12-19 days after sowing. Thus, this plant requires, for germination, more moisture and higher soil temperature, with 2-4°C, as compared with sunflower. During 20-25 days, the underground part developed more intensively, in the epigeic part, 3-5 leaves emerged, then the growth and development rate intensified. In the middle of September, the cardoon showed a "rosette", since its stalk was very short (4-5 cm) and it had 30-35 leaves, alternate and pinnate. The leaves reached a length of more than 65 cm and the width was over 25 cm, they were characterized by a well-developed petiole and a large midrib. It was dark green coloured or ashen on the top of the leaf and greyish on the bottom of the leaf, because of its thick hairiness. *Cynara cardunculus* var. *altilis* did not flower in their first year, rather their energy was focused on the development of its deep taproot. The plant's aboveground parts in autumn, when the temperatures were below -5ºC, died off, but the underground part overwintered. Long periods without snow or thaws are typical in winter, frequent in our region, which negatively influence the overwintering of *Cynara cardunculus* annual plants.

The green mass yield in the first year, harvested in mid-September, reached 3.40 kg/ m^2. The dry matter content of harvested biomass was 14.8%, its chemical composition 23.6% protein, 9.2% ash and structural carbohydrates 32.6% NDF, 18.3% ADF, 1.6% ADL, 22.0% total soluble sugars.

The digestibility of dry matter was very high - 96%. Thus, *Cynara cardunculus* green mass can be fed to animals together with coarse fodder, such as grass hay and cereal straw.

Table 1. Some agro-biological peculiarities of *Cynara cardunculus* plants in second growing season

Indices	*Helianthus annuus*	*Cynara cardunculus*
Sowing	15.04	-
Emergence of plantlets	05.05	10.04
Inflorescence initiation period	10.07-20.07	16.06-28.07
Flowering period	22.07-27.07	30.06-31.07
Seed ripening	14.09	31.08
Plant height, cm	178	201
The total yield :		
- fresh mass, kg/m^2	5.03	7.12
- dry matter, kg/ m^2	0.94	1.41
Leaves + heads in biomass, %	56.8	57.8

In our study, in the second growing year, has been established that after the winter plant development restarted, an apical bud appeared on the caule apex, there was an induction period, which depended on temperature and photoperiod, the leaf rosette, developed and spread in April, the stalk began to elongate in May. The main flower heads (capitula) appeared in June, and the period of flowering of other heads began in July, the seed ripening ended in August, accompanied by the progressive desiccation of the aboveground biomass, the stems became dry in September (Table 1). The green mass yield of *Cynara cardunculus* in the second year, harvested in early July, reached 7.10 kg/m^2, in the harvested areal biomass, there were 45% leaves, 42% stalks and 13% heads, but the productivity of *Helianthus annuus* was 5.03 kg/m^2 with 26% leaves, 43% stalks and 31% heads.

In the third growing season (2017-2018 y.) new regrowth occurred after the autumn rains, *Cynara cardunculus* plants sprouted in the end of September, the leaf rosette developed in October. The plants overwintered normally, but the harsh weather conditions from the spring of 2018, characterised by high temperatures and lack of precipitation, affected all the stages of ontogenetic development, as well as the growth and development rate of plants. We found out that plant development started much earlier that year, stem elongation in April-May, full blossom - in June, achenes reached ripeness in late July - early August, fully dry aerial biomass - in August. In the middle of June the plants were 125-135 cm tall, the green mass productivity was 4.4 kg/m^2 with 23% dry matter content.

Bolohan et al. (2013), investigating the crop yield of *Cynara cardunculus* plants under the climatic conditions of south-eastern Romania, have found that leaf fresh matter production of *Cynara cardunculus* plants, in the first growing season, ranged from 31483 to 41044 kg/ha or 5358-6195 kg/ha dry matter in the dependence of cultivars. Under the conditions Catania, Italy, the green mass productivity of *Cynara cardunculus* cv. 'Altilis 41', harvested in the growth stage of 8 capitula and seed ripening, late June, reached 19.1 t/ha dry mater, with 37.7% leaf, 27.7% stalk and 34.6% inflorescence material (Pesce et al., 2017).

Silage is one of the key components of the feed for herbivorous domestic animals, but in recent decades, it has also been used as feedstock for anaerobic digestion in biogas reactors. The main principles of silage preservation are a rapid achievement of a low pH by lactic acid fermentation and the maintenance of anoxic conditions. Lactic acid bacteria play a key role in ensuring the success of the ensiling process. They are capable of converting fermentable carbohydrates that are present in forage crops at a high rate to lactic acid and, to a lesser extent, acetic acid.

When opening the glass vessels with silage made from green mass of *Cynara cardunculus*, there was no gas or juice leakage from the preserved mass, but from the vessels with *Helianthus annuus* silage, carbon dioxide - a by-product of fermentation - was moderately eliminated. The silages obtained from

Asteraceae species were of agreeable colour and had specific aroma, the consistency was retained, in comparison with the initial green mass, without mould and mucus. During the organoleptic assessment, it was found that the colour of the *Cynara carduncculus* silage was homogeneous olive, with pleasant smell, similar to pickled vegetables but, in the *Helianthus annuus* silage, the stems were yellow and the leaves - dark green, its scent was similar to the smell of fresh coniferous wood.

The materials consolidated well and the fermentation was complete with similar acidic pH values 3.77-3.82. It has been determined that the amounts of organic acids, in the silages prepared from *Asteraceae* species, differed essentially. *Cynara carduncculus* silage was characterised by a very low content of organic acids (43.1 g/kg), in comparison with *Helianthus annuus* silage (76.4 g/kg). Most organic acids were in fixed form. In the silage from *Cynara carduncculus*, the content of fixed lactic acid reached 21.6 g/kg and free lactic acid - 12.6 g/kg DM. The butyric acid content was below the detected level in fixed form (1.4 g/kg DM) in the *Cynara carduncculus* silage (Table 2).

Table 2. The fermentation quality of the silages from *Cynara carduncculus* plants, second growing season

Indices	*Helianthus annuus*	*Cynara carduncculus*
pH index	3.82	3.77
Content of organic acids, g/kg	76.4	43.1
Free acetic acid, g/kg	9.3	4.0
Free butyric acid, g/kg	0.0	0.0
Free lactic acid, g/kg	20.3	12.6
Fixed acetic acid, g/kg	10.2	3.5
Fixed butyric acid, g/kg	0.1	1.4
Fixed lactic acid, g/kg	36.5	21.6
Total acetic acid, g/kg	19.5	7.5
Total butyric acid, g/kg	0.1	1.4
Total lactic acid, g/kg	56.8	34.2
Acetic acid, % of organic acids	24	18
Butyric acid, % of organic acids	1	3
Lactic acid, % of organic acids	75	79

The dry matter content in the studied silages was low - about 19.1-19.7%. It was determined that the biochemical composition of the silage dry matter varied depending on the species: raw protein 102-125 g/kg, raw cellulose 230-291 g/kg, ash 84-99 g/kg, structural carbohydrates: NDF 401-503 g/kg, ADF 252-306 g/kg, ADL 26-35 g/kg. In *Cynara carduncculus* silage, the amount of protein was high and acid detergent lignin (ADL) - low, the digestibility of nutrients was significantly higher, the concentrations of calcium and carotene were acceptable, but phosphorus - very low (Table 3).

Table 3. Biochemical composition and feed value of the silages from the studied *Asteraceae* species

Indices	*Helianthus annuus*	*Cynara carduncculus*
Raw protein, g/kg DM	102	125
Raw cellulose, g/kg DM	230	291
Ash, g/kg DM	99	84
Acid detergent fibre, g/kg DM	252	306
Neutral detergent fibre, g/kg DM	401	531
Acid detergent lignin, g/kg DM	35	26
Dry matter digestibility,%	68.2	72.3
Organic matter digestibility,%	61.4	68.3
Calcium, %	-	1.11
Phosphorus, %	-	0.18
Carotene, mg/kg	4.0	13.5

Some authors mentioned various findings about the quality of silage. According to Cajarville et al. (1999) the quality of the *Cynara carduncculus* silage varied depending on the wilting time: 15.0-21.8% dry matter, 832-836 g/kg organic matter, pH 4.03-4.28, lactic acid 91.2-167 g/kg, acetic acid 31.2-34.6 g/kg, butyric acid not detected, crude protein 133-136 g/kg, crude fibre 129-147 g/kg, neutral detergent fibre 240-281 g/kg, water soluble carbohydrates 140-159 g/kg.

Pesce et al. (2017) determined that *Cynara carduncculus* produced silage with 32.8-37.1% dry matter, had a pH level 3.3-4.1, contained 0.8-1.4% lactic acid, 1.0-1.9% acetic acid, 0.1-0.3% butyric acid, 12.8-14.6% protein, 2.0-2.8% fats, 5.3-8.5% ash, 72.6-44.7-48% NDF and 28.1-37.4% ADF, in dependence of the growing seasons.

The *Cynara carduncculus* silage, after 160 days of ensiling, from whole plants mowed in full bloom stage, was characterized by 20.6% dry matter, 8.79% ash, pH 4.13, 72.3 g/kg lactic acid, 21.5 g/kg acetic acid and 49.5 g/kg ethanol. However, the silage prepared from whole plants mowed in the seed ripening stage, contained 44.7% dry matter, 9.53% ash, pH 4.90, 8.6 g/kg lactic acid, 31.6 g/kg acetic acid and 0.7 g/kg ethanol (Ferrero et al., 2018).

The nutritive value and the fermentation characteristics of artichoke, *Cynara scolymus*, by-products were 150.1 g/kg crude protein, 524.1 g/kg NDF, 411.7 g/kg ADF, the highest matter digestibility at 96 h incubation *in vitro*:

786 g/kg DMD and 804 g/kg OMD (Sallam et al., 2018).

Fresh artichoke by-products are suitable for ensiling, with a pleasant smell, good silage characteristics, crude protein content 88 g/kg dry matter and fibre content 509 g/kg dry matter (Meneses et al., 2007)

According to the results obtained by Martinez-Teruel et al. (2007), the silage of the artichoke by-product had a fermentation of the acetic type, 44.9% organic matter digestibility, 53.0% *in vitro* disappearance of neutral detergent fibre.

Biorefining offers a way for combining feed and bioenergy production. Biomass based raw materials can be converted into the more valued energy forms using biochemical methods such as ethanol fermentation, methane fermentation and thermochemical methods such as pyrolysis and gasification.

The stability and productivity of anaerobic digestion is mostly influenced by the content of organic matter, its biochemical composition, biodegradability and ratio of carbon and nitrogen (C/N). The silages investigated in the present study revealed C/N ratios in a wide range, on average 26-30, which is regarded as optimal for methanogenesis.

Table 4. Biochemical methane potential of silage substrate from the studied *Asteraceae* species

Indices	*Helianthus annuus*	*Cynara cardunculus*
Organic matter, g/kg	901.00	916.00
Carbon,%	50.00	51.00
Nitrogen,%	1.63	2.00
Carbon/nitrogen	30	26
Lignin, g/kg	35	26
Cellulose, g/kg DM	217	280
Hemicellulose , g/kg DM	149	230
Biogas, l/kg ODM	626	681
Biomethane, l/kg ODM	320	348

It was determined that the substrate of *Cynara cardunculus* silage was characterised by a high content of organic matter, cellulose, hemicellulose and low content of lignin, as compared with *Helianthus annuus* silage. The estimation of biogas and methane yields, based on the concentration of acid detergent lignin and hemicellulose of *Cynara cardunculus* substrate, reached values of 681 l/kg and 348 l/kg, but in *Helianthus annuus* substrate - 626 l/kg and 320 l/kg, respectively (Table 4).

Pesce et al. (2017) found that in the substrate from *Cynara cardunculus* cv. 'Altilis 41', carbon and nitrogen ratio was 22-27 and the methane yield varied from 243 to 248 l/kg, the annual biomethane production ranging from 3647 to 4501 m^3/ha, depending on the growing seasons. Ferrero et al. (2018) determined that the biogas and methane production potential of *Cynara cardunculus* varied from 422 to 577 l/kg and from 209 to 293 l/kg, the production potential was affected by the stage of maturity and the conservation period.

The knowledge of the engineering properties of biomass, such as moisture content, ash content, particle size distribution, bulk and specific density, heating value, is important for the design and operation of processing facilities for handling, storage, transportation and conversion to solid fuels, heat and power. Our study showed that *Cynara cardunculus* milled chaffs, have the highest percentages of particles larger than 5 mm (41.2%), and the lowest values for the particles of 1-2 mm (16.1%), in comparison with *Helianthus annuus* chaffs (Table 3). This is probably an effect of the anatomical nature of *Cynara cardunculus*, the level of pith microstructures and sclerenchyma fibres in the bark, which influences the passage of particles through the sieve meshes and leads to a decrease in the bulk density of milled chaffs.

It was found that *Cynara cardunculus* biomass contained a higher amount of ash, which caused a decrease in the gross calorific value.

We could mention that the briquettes produced from *Asteraceae* species in our study were very solid and not cracking, their specific density reaching values of 907-918 kg/m^3. The bulk density of briquettes from *Cynara cardunculus* was 479 kg/m^3, but *Helianthus annuus* - 454 kg/m^3 (Table 5).

According to literature *Cynara* biomass showed good performance as feedstock for the production of heat and power. Fernández et al. (2006) mentioned that the highest and the lowest heating value of *Cynara cardunculus* whole biomass were 4083 and 3795 kcal/kg, respectively.

The results obtained by Grammelis et al. (2008) for cardoon dry biomass, harvested in Central Greece, were as follows: 7.9-8.2% moisture, 6.9-7.2% ash and higher calorific value 13.7-16.3 MJ/kg dry basis.

Table 5. Some physical and mechanical properties of biomass and briquettes from *Cynara carduncululus*

Indices	*Helianthus annuus*	*Cynara carduncululus*
Particle size distribution:		
<5mm	9.1	41.2
4-5mm	14.2	12.5
3-4 mm	20.9	14.4
2-3 mm	25.7	15.7
1-2 mm	17.7	8.5
1 mm	12.4	7.6
Biomass properties:		
moisture content, %	11.5	9.9
ash content,%	1.6	2.8
gross calorific value, MJ/kg	19.3	19.0
bulk density, kg/m3	118	107
Solid biofuel properties:		
specific density, kg/m^3	907	918
bulk density, kg/m^3	454	479

In Portugal, Abelha et al. (2013) reported, for 5-30 mm chips of the whole aboveground *Cynara* biomass, a bulk density of 125 kg/m^3 and a densification of biomass into durable compact pellets with bulk density that increased to about 500-600 kg/m^3. The aboveground cardoon biomass presented calorific values of 18-22 MJ/kg dry matter, depending on the plant fraction (Gominhoa et al., 2018). The results obtained by Toscano et al., 2016, for cardoon pellets were: 11.2% moisture, 6.3% ash, 20399 J/kg high heating value and 19247 J/kg lower heating value, 0.55% nitrogen, 0.12% chlorine and 0.65% sulphur content. Hăbăşescu, 2011, stated that the pellets from sunflower stems had net calorific value of 14.8 MJ/kg and the ash content was 3.78%, the pellets from corn stems were characterized by 14.2 MJ/kg and 5.14%, respectively, and wheat straw - by 14.3 MJ/kg and 6.25%, respectively. Dahl & Obernberger (2004), reported that the pellets from cardoon contained 17.4% ash and 1.1% nitrogen, with bulk density 561 kg/m^3 and gross calorific value 20.3 MJ/kg.

CONCLUSIONS

The preliminary studies carried out showed that:

1. *Cynara carduncululus*, in the second and next growing seasons, was characterized by intensive growth and development rate that allowed obtaining up to 44-71 t/ha fresh mass or 10-14 t/ha dry matter.
2. The *Cynara carduncululus* silage contained 12.5% protein, 28.0% cellulose, 23.0% hemicellulose, 2.6% lignin, 8.4% ash; the dry matter digestibility was 72.3%.
3. The biochemical methane production potential of *Cynara carduncululus* silage substrate reached 348 l/kg OM, but *Helianthus annuus* - 320 l/kg OM.
4. The specific density of the briquettes reached 918 kg/m^3, with 19.0 MJ/kg gross calorific value and the ash content 2.8%.

We consider that *Cynara carduncululus* is an excellent source of nectar and pollen for honeybees, and its biomass may be valuable feed for livestock and multi-purpose feedstock for the production of renewable energy.

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