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ESTABLISHING SOWING DENSITY AND OPTIMAL DOSAGE OF FERTILIZER FOR INCREASING PRODUCTION OF WINTER WHEAT AND BARLEY, UNDER CLIMATE CHANGE CONDITIONS

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Abstract

Polifactorial experience was located in North Baragan Plain, and experimental factors were: - sowing density, with three graduations (450 gs/sqm; 550 gs/sqm; 650 gs/sqm); - type and dose of fertilizer (chemical - NH_4NO_3 and urea, biological - AgroArgentum - 2 doses, and unfertilized). By carrying out chemical analyses of the soil before and after application of chemical and biological fertilizers in different vegetation phases, we established the dynamics of nutrients for every variant of fertilization, compared to unfertilized control. Compared with the control, has revealed a different dynamics of nitrogen in the soil, fertilized variants biological nitrogen supply being weaker than the control but in a continued increase from April to June. Instead, chemically fertilized variants were well supplied with nitrogen, but in a continuous decline, reaching as June have lower values than the control, especially variant fertilized with urea. Biological fertilisation with AgroArgentum Forte 100 ml/ha obtained differences significant positive compared to the average experience were obtained at densities between 550 and 650 gs/sqm variety Boema, with 1291 kg/ha and 1135 kg/ha more than control. Barley were recorded positive differences from the average experience (6421 kg/ha) only to versions with sowing densities 550 and 650 gs/sqm, chemically fertilized, the biggest positive difference is the variant 650 gs / sqm ammonium nitrate 150 kg/ha, with a difference of 1321 kg/ha, followed by variant 450 gs/sqm, AgroArgentum Forte 100 ml/ha) with a difference of 1004 kg/ha compared to the average experience.

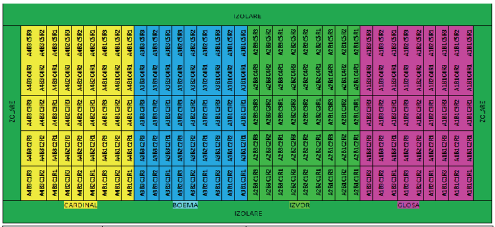
***Key words**: winter barley, wheat, sowing densities, fertilization.*

INTRODUCTION

The issue of climate change has become increasingly popular and is felt year after year, in the size and quality crop yields. Farmers are often forced to take special measures crop management, from setting fertilizers and their doses, to establish seeding density and treatments during the growing season.
There's market range of products, starting from seed, continuing with chemical and biological fertilizers, and treatments, so that farmers became an adventure in choosing the best solutions of obtaining productions quality.
Despite genetic improvements and the use of fertilizers and pesticides, cereal production is still closely linked to climate conditions, due to the fact it is grown in open fields over vast areas and, in many cases, without irrigation. (Tuttolomondo et al., 2009).
In North Baragan area, the annual average for the period 1900-2014 climate is defined by the following parameters: annual rainfall (agricultural year) - 445 mm, annual average air temperature – 11°C, potential evapotranspiration (after Thornthwaite) - 715 mm and a climatic deficit water annual average of 272 mm. It predicts a decrease in annual rainfall from 445mm to 440mm and an increase in average annual temperatures from 11°C to 11,3°C until 2025 (Visinescu et al., 2014).
This paper shows how the sowing densities (best three densities for our zone), the type and dose of fertilizer (chemical and biological) can influence production, given the current climate change from North Baragan Plain, in Romania. We can determine the optimal density in this way, how the mineral elements absorption by plants and set the type and dose of fertilizer effective for increasing production from winter wheat and barley.

MATERIALS AND METHODS

The experience described in this paper was polifactorial and located on a total area of 5250m^2 in Chiscani Experimental Centre of SCDA Braila, and comprised 60 variants and 180 experimental plots, arranged after-storey block method in three repetitions (Figure 1.).



VARIETY – A	SOWING DENSITY – B		TYPE AND DOSE OF FERTILIZATION – C	
BOEMA – A1	450 b.g./m²	B1	AgroArgentum Forte 100 ml/ha	C1
	550 b.g./m²	B2	AgroArgentum Forte 200 ml/ha	C2
	650 b.g./m²	B3	Urea – 150 kg/ha	C3
			Ammonium nitrate – 150kg/ha	C4
			Unfertilized	C5
IZVOR – A2	450 b.g./m²	B1	AgroArgentum Forte 100 ml/ha	C1
	550 b.g./m²	B2	AgroArgentum Forte 200 ml/ha	C2
	650 b.g./m²	B3	Urea – 150 kg/ha	C3
			Ammonium nitrate – 150kg/ha	C4
			Unfertilized	C5
GLOSA – A3	450 b.g./m²	B1	AgroArgentum Forte 100 ml/ha	C1
	550 b.g./m²	B2	AgroArgentum Forte 200 ml/ha	C2
	650 b.g./m²	B3	Urea – 150 kg/ha	C3
			Ammonium nitrate – 150kg/ha	C4
			Unfertilized	C5
CARDINAL – A4	450 b.g./m²	B1	AgroArgentum Forte 100 ml/ha	C1
	550 b.g./m²	B2	AgroArgentum Forte 200 ml/ha	C2
	650 b.g./m²	B3	Urea – 150 kg/ha	C3
			Ammonium nitrate – 150kg/ha	C4
			Unfertilized	C5

Figure 1. The scheme of experience location

Experimental factors were:
- sowing density, with three graduations (450 gs/m^2; 550 gs/m^2; 650 gs/m^2);
- type and dose of fertilizer applied in vegetation (chemical - NH_4NO_3 and urea, biological - AgroArgentum - 2 doses, and unfertilized)
- species and variety (barley – Cardinal, and wheat - Boema, Izvor and Glosa).

Maintenance works were:
- 19-20.03.2015 - applying mineral fertilizers (urea - C3, ammonium nitrate - C4) 150 kg / ha
- 25-26.03.2015 – applying foliar fertilizer AgroArgentum Forte in doses of 100 ml / ha (C1) and 200 ml / ha (C2) - 17/04/2015
- herbicide Granstar Super 40 g/ha and treatment against disease with fungicide Duett Ultra 0,7 l / ha.

We made measurements like plant density - after emergence and in spring, and also laboratory tests: chemical analysis on soil and plants: before fertilization, and at 30, 40, and 50 days. After harvest we made following measurements: plant height, no. plants/sqm; no. ears/sqm; average weight of the ear; average number of kernels/ear; kernels weight/sqm, humidity of kernels; MMB, MH, yield estimation at 14% humidity.

As statistical interpretation methods were used: variance analysis – ANOVA test, statistical averages method - AVERAGE test, and correlation method, using MS Excel.

RESULTS AND DISCUSSIONS

Climatic conditions in 2015 have shown that compared to the annual average temperature, there was a significant increase temperature in the period from January to March and May to July 2015, between 1.1 - 2,4°C (Figure 2).

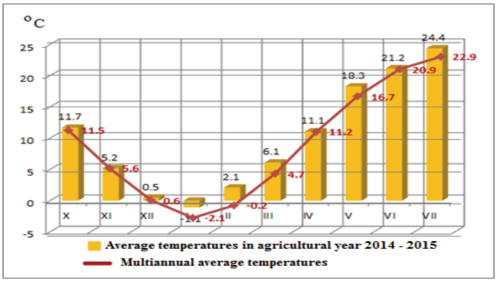


Figure 2. The graph of monthly average temperatures recorded during the vegetation period, compared with multiannual average temperature

Average monthly rainfall exceeded multiannual with 23 - 25mm in the period October to December 2014, ensuring optimum germination and tillering, also topped with 57mm, leaving the winter, but were lower in April and May, in May registering a difference of 37mm of the multiannual average (Figure 3).

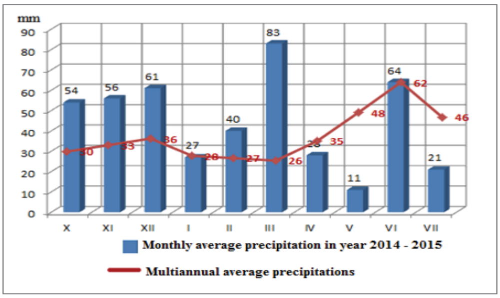


Figure 3. The graph monthly average rainfall recorded during the vegetation period, compared with average multiannual monthly rainfall

By carrying out chemical analyses of the soil before and after application of chemical and biological fertilizers in various phenophases was established nutrient dynamics for each variant of fertilization, compared to unfertilized control. Also, by comparing the values determined in control variant, it could highlight the dynamics of mineral elements absorption and establish critical phases of nutrition at winter wheat and barley.

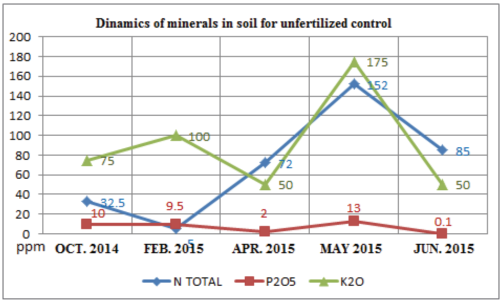


Figure 4. The graph for dynamics of nitrogen, phosphorus and potassium in soil at unfertilized control

After applying fertilizers, we made analysis for all variants fertilized differently, by harvesting every 20 individual samples, the method grid, the depth of 0 - 25cm of each variant, which were mixed, resulting in the final 5 samples average , belonging to the five variants of fertilization. Compared with the control, has revealed a different dynamics of nitrogen in the soil, fertilized variants biological nitrogen supply being weaker than the control but in a continued increase from April to June (Figure 5). Chemically fertilized variants were well supplied with nitrogen, but in a continuous decline, reaching as June have lower values than the control, especially variant fertilized with urea.

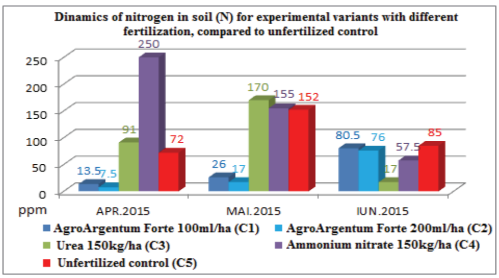


Figure 5. The graph for dynamics of soil nitrogen content compared to unfertilized variant

Phosphorus is an essential nutrient for plant growth and the role of phosphorus cannot be replaced by any other nutrient (Trifan, 2014). For these reasons, it needs a proper supply of plant phosphorous playing a key role in metabolism, participating in processes of photosynthesis, respiration, biosynthesis of carbohydrates, lipids, enzymes and phosphatides. Phosphorus is found in rocks that contain phosphorus as calcium phosphate, which is a tough insoluble form and slowly used by the plant. The concentration of phosphate ions in the soil solution is low (0.1-1.5 mg/l or 0.1-1.5 kg/ha) (Davidescu, 1981). Phosphorus is fixed in soil in three ways: clay by calcium bridges, the humus in the form of humic phosphate and active limestone. Phosphorus is soluble, but may become insoluble by precipitation in acid soil in the form of iron phosphate or alumina, crystallization in alkaline medium or diffusion of the layers of the clay. In the experience compared to the control, only C1 variant had a similar dynamic, with an increase in absorption of phosphorus from the soil in April and June. C2 variant was a progressive absorption, the largest being in phenophase of grains filling. Instead, the chemically fertilized variants, phosphorus absorption was more pronounced at ear formation (Figure 6).

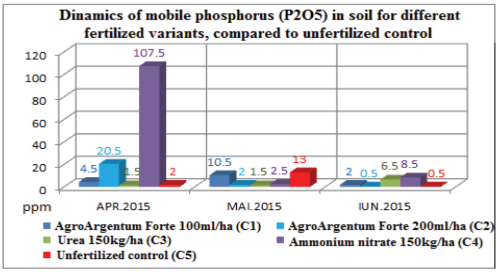


Figure 6. The graph of dynamics for phosphorus content in soil compared to the control

Potassium is widespread in nature, and for plant nutrition is an equally important as nitrogen and phosphorus. Physiological role of plant organisms is much greater than to animal, actively participating in water absorption; reduce perspiration; influences synthesis of carbohydrates, lipids and proteins; enhances photosynthesis; stimulates cell division and growth of plants (Trifan, 2013). In the experience, it was found that all experimental variants had the same dynamic absorption of potassium by plants, higher in April and June, except variant C2, which absorb increased gradually from April to June, when it was more intense than the other variants (Figure7).

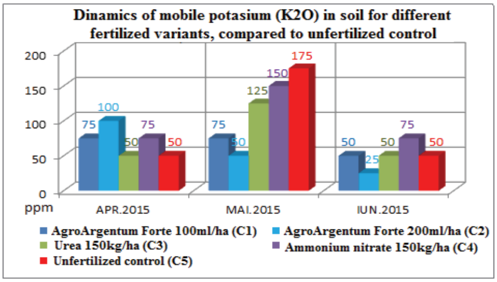


Figure 7. The graph of dynamics for potassium content in soil compared to the control

Besides supplying soil nutrients, soil reaction is a very important element required to be met and monitored as occurs in many physical and biological mechanisms of soil, including having a role in root absorption of mineral elements. Compared to unfertilized, the dynamics soil pH was one ascending, from leaving the winter, only variant fertilized with ammonium nitrate had the same growth trend, and the other, there was a decline in April, followed growth close pH control variant, in May, then decline in June (Figure 8).

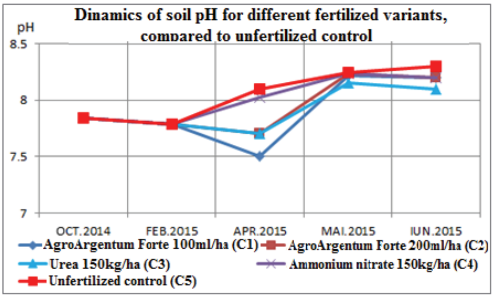


Figure 8. The graph of dynamics for soil pH compared to the unfertilized control

In intensively fertilized soils, the concentration of soluble salts can greatly increase, without taking into account the specific consumption of crops, soil quality and condition of supply minerals. The soil that was placed experience is desalted and dynamics of the total content of soluble salts in the soil, determined in aqueous extract soil: water by 1: 5, is plotted in Fig 9. Compared with the control variant, all experimental variants had a downward trend in the concentration of soluble salts in the soil from spring until harvest (Figure 9).

Calcium (Ca) plays an important role in increasing resistance to frost and drought and colloidal clay-humic complex composition. Ion exchange, on which root absorption occurs, could not do without calcium ions or absence of water.

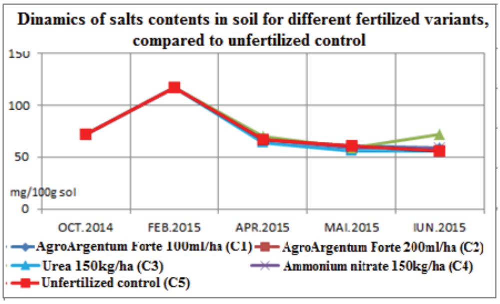


Figure 9. The graph of dynamics for salts contents in soil compared to the unfertilized control

In the experience compared to the untreated control, which was an increase in the concentration of calcium carbonate until April and then a progressive decline in the other experimental versions, there was a progressive decrease in the calcium carbonate in the soil since spring until harvest (Figure 10).

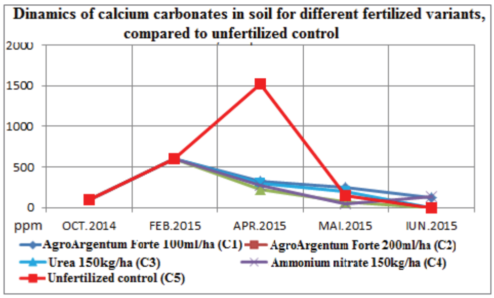


Figure 10. The graph of dynamics for calcium carbonates in soil compared to the unfertilized control

Biometric measurements were performed in different vegetation phases and at harvest to observe the influence of sowing density and different fertilizations, comparing the results with unfertilized variants and with average of experience. Based on results achieved in the experience we were able to make correlations between biometrics, in order to identify the influences of the main characteristics and physiological processes. Correlation coefficients are summarized in Table 1.

Thus, there were positive correlations between number of tillers and number of leaves (r = 0.256) (Figure 11), between number of tillers and root length (r = 0.256) between the number of leaves and root length (r = 0.235) (Figure 12), and between the length leaf and dry matter weight of leaves (r = 0.522) (Figure 12).

Table 1. Correlation coefficiences established between biometrics achieved in 14.04.2015

Specification	No. leaves	Length of leaves	Length of roots	Dry matter in leaves
No. tillers	0.894	-0.396	0.256	-0.508
No. leaves		-0.427	0.235	-0.569
Length of leaves			-0.177	0.522
Length of roots				-0.300

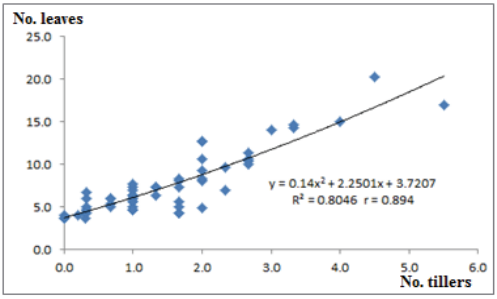


Figure 11. The graph of correlation between number of tillers and number of leaves, in experiences with different fertilizers and densities

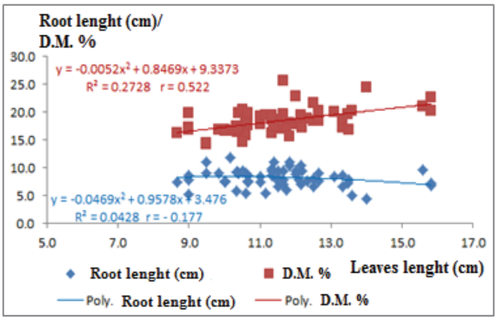


Figure 12. The graph of correlations between leaves length and root length or dry matter in leaves, in experiences with different fertilizers and densities

Negative correlations have been established between number of tillers and the leaf length (r = - 0.396) (Figure 13), between number of siblings and leaf dry weight (r = - 0.508) (Figure 14) between the number of leaves and leaf length (r = - 0.427) (Figure 15).

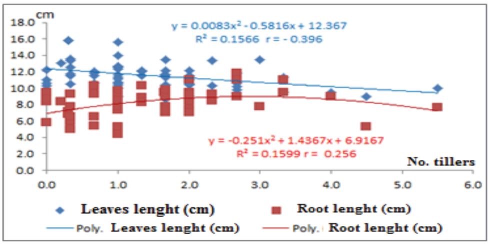


Figure 13. The graph of correlations between number of tillers with leaves length, and with root length, in experiences with different fertilizers and densities

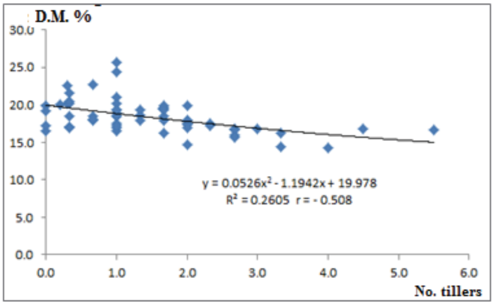


Figure 14. The graph of correlations between number of tillers and dry matter content in leaves, in experiences with different fertilizers and densities

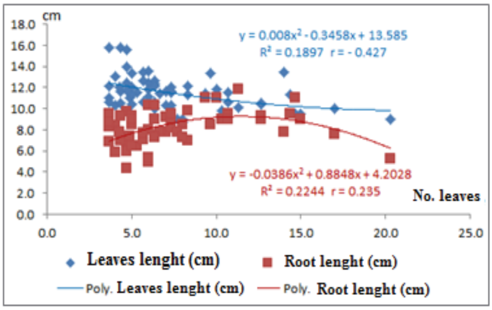


Figure 15. The graph of correlations between number of leaves and leaves length or root length, in experiences with different fertilizers and densities

Biometric measurements were performed at harvest, measurements of productivity indexes and the humidity, MMB, MH, for each experimental variant. The results were compared to unfertilized control and average of experience, both for wheat and for barley.

- Plant size, calculated as the average of repetitions, compared to unfertilized control, was superior to chemically fertilized variants, both wheat and barley in all three seeding densities (Figure 16).

- The average number of ears per plant to differentiate both the varieties and in different densities and fertilization compared with unfertilized so (Figure 17):

• for Boema variety at densities between 450 and 650 gs/sqm, the best results on the average number of ears/plant were obtained from fertilized variants AgroArgentum Forte, 200 ml, followed by chemically fertilized variants density of 550 gs/sqm;

• for Izvor variety, the best result for no environmental spice / herb was obtained variant C1 (AgroArgentum Forte 100 ml) at a density of 650 gs/m, followed in descending order of variations chemically fertilized in all three densities Drills practiced in the experience;

• for Glosa variety, the best result for this indicator was obtained variant fertilized with urea, density of 450 gs / m, followed by variant fertilized with ammonium nitrate density of 650 gs/sqm and fertilized variants AgroArgentum Forte 100 ml, in all three seeding densities practiced;

• for barley Cardinal variety, the best result on the number of ears/plant was obtained variant fertilized with AgroArgentum Forte 200ml / ha density of 650 gs/sqm, followed by variants fertilized with AgroArgentum Forte 100ml / ha in the other two densities.

- The average length of the ear compared to unfertilized was noted these types of fertilizer and densities (Figure 18):

• Boema variety variants fertilized biological density of 650 gs/sqm, followed by fertilized variants chemical with densities of 550 and 450 gs/sqm;

• Izvor variety, chemically fertilized variants density of 450 gs/sqm, followed by variants fertilized biological density of 650 gs/sqm;

• Glosa variety, chemically fertilized variants density of 550 gs/sqm, followed in descending order of variants fertilized with AgroArgentum Forte 200ml / ha in the other two densities.

• Cardinal variety barley, the best results on average ear length were obtained from fertilized variants AgroArgentum Forte and urea at densities between 450 and 650 gs/sqm compared to unfertilized.

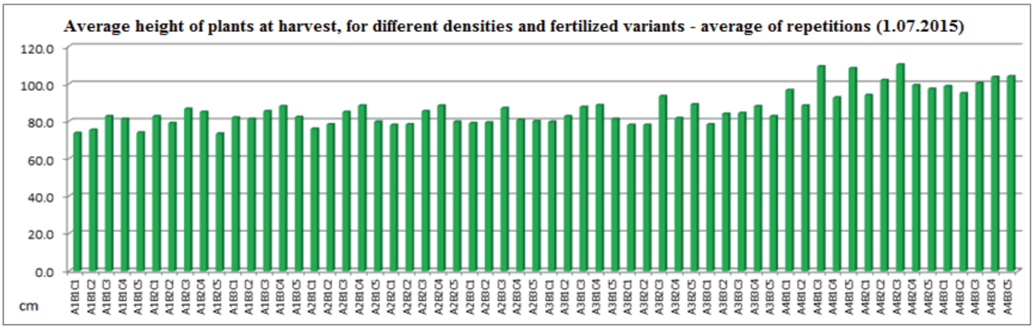


Figure 16. The graph of average values for plant height in the experience with different densities and fertilization on wheat and barley

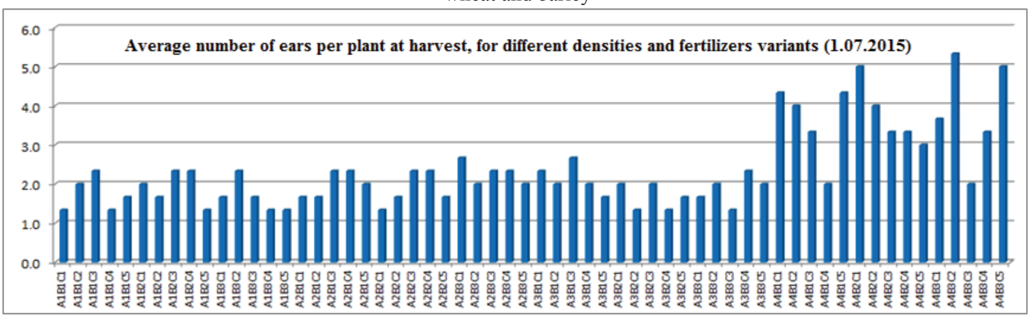


Figure 17. The graph of average values for number of ears per plant in the experience with different densities and fertilization on wheat and barley

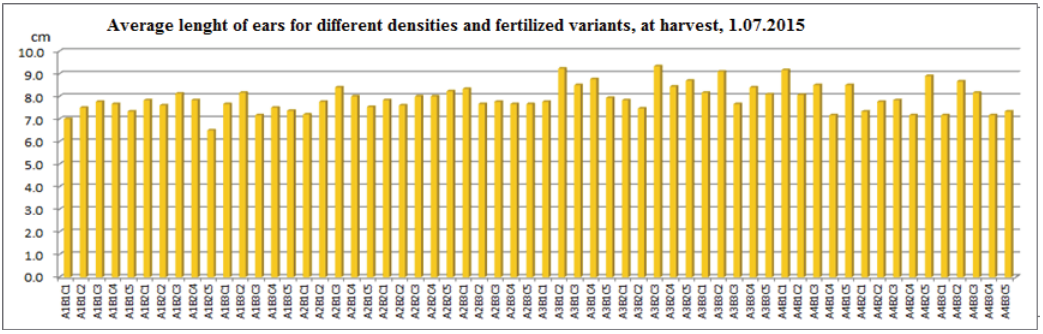


Figure 18. The graph of average values for ears length in the experience with different densities and fertilization on wheat and barley

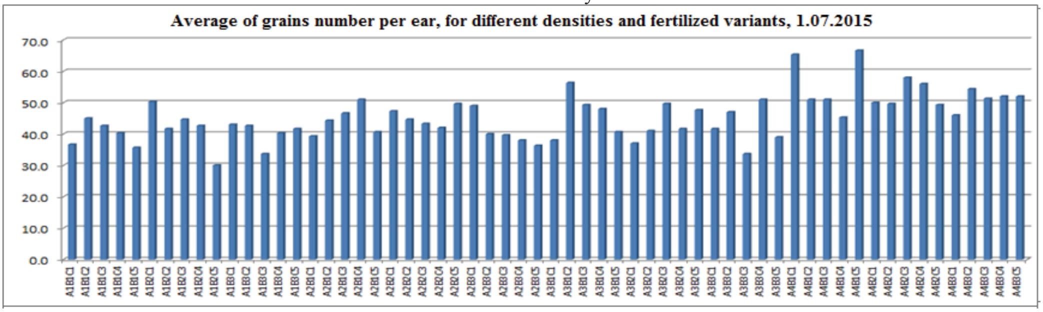


Figure 19. The graph of average values for grains per ear in the experience with different densities and fertilization on wheat and barley

- The average number of grains/ear compared to unfertilized was recorded the following results (Figure 19):
• Boema variety, the best results were recorded at a density of 550 gs/sqm fertilized variants biological, followed in descending order by chemically fertilized variants at the same density and other densities variants fertilized biological practiced.
• Izvor variety, the best results were recorded by chemically fertilized variants density of 450 gs/sqm, followed by variants fertilized biological density of 650 and 550 gs/sqm. Respectively
• Glosa variety, the best result was obtained variant fertilized with AgroArgentum Forte 200 ml/ha density of 450 gs/sqm, followed by versions for other densities practiced chemically fertilized.
• Cardinal variety barley, the best result was obtained biological variant fertilized with 100 ml / ha, density of 450 gs/sqm, followed by chemically fertilized variants with 550 gs/sqm and 650 gs/sqm densities.

Differences of productions were calculated use the average production control calculated for each experience, respectively for wheat and barley. Thus, at wheat experience, differences positive very significant compared to the average control (6291kg/ha) were obtained variant A2B3C3 (Izvor, 650 gs/sqm, fertilized with urea 150kg/ha), with a difference of 2361kg/ha, followed by A1B2C3 version (Boema variety, 550 gs/sqm, urea 150kg/ha), with a difference of 2104kg/ha, A2B3C4 variant (Izvor 650gs/sqm, ammonium nitrate 150kg/ha), with a difference of 2052kg/ha and A2B1C4 (Izvor, 450 gs/sqm, ammonium nitrate 150 kg/ha), with a difference of 1691kg/ha compared to the average experience control.

Biological fertilisation with AgroArgentum Forte 100 ml/ha, obtained differences significant positive compared to the average experience at densities between 550 and 650 gs/sqm Boema variety, with 1291 kg/ha and 1135kg/ha more than control (Figure 20).

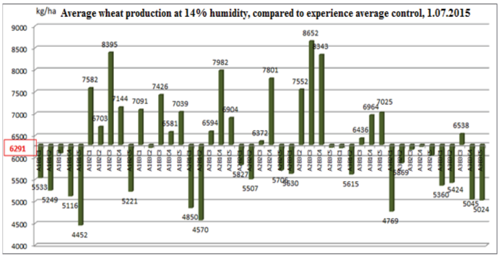


Figure 20. Differences in production compared to the average production obtained from wheat experience

In barley experience, we noticed a positive difference compared to control for the variants with 550 and 650 gs/sqm densities, chemically fertilized and density of 450 gs/sqm variant fertilized biological with AgroArgentum Forte 100ml/ha (Figure 21).

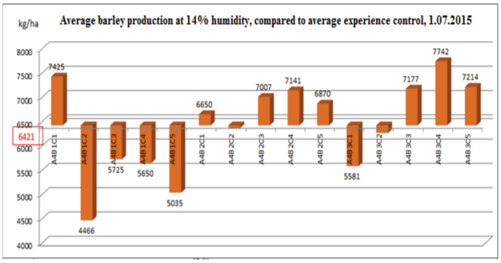


Figure 21. Differences in production compared to the average production obtained from barley experience

The weight of a thousand grains was compared for each species and experimental variant, with the average of experiences observing the following:

¬ for wheat differences significant positive compared to average only obtained varieties Boema and Izvor so: the Izvor variety looked like density 450 and 550 gs/sqm, fertilized biological, followed by Boema variety, fertilized biological densities of 450 and 550 gs/sqm and fertilized biological and chemical density of 650 gs/sqm (Figure 22).

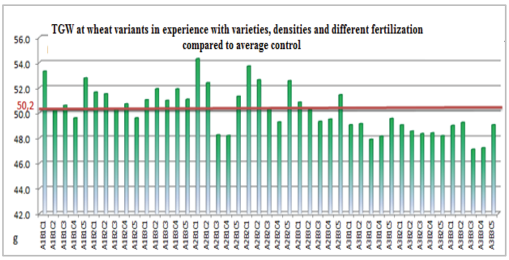


Figure 22. Thousand grains weight of wheat variants compared to average of experience

For winter barley, the highest values of TGW, compared with the average of experience were obtained at sowing density of 450gs/sqm, fertilized biological with AgroArgentum 200ml/ha, followed by ammonium nitrate 150kg/ha, and biological 100ml/ha and urea 150kg/ha (Figure 23).

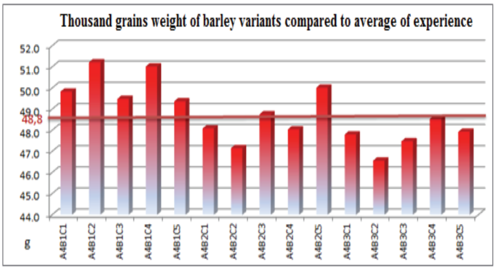


Figure 23. Thousand grains weight of barley variants compared to average of experience

Hectolitre mass was compared in the same manner as MMB for each species and experimental variant, with the average of experience we observed the following:

¬ for wheat the best values were following variants (Figure 24): Boema variety sown at 450gs/sqm and fertilized with AgroArgentum 100ml/ha (83kg/ha), followed by variants fertilized with 650gs/sqm density, and the density of 450 gs/sqm fertilized biological with dose 200ml/ha and variants seeded with a density of 550 gs/sqm chemically fertilized.

For a variety Izvor noted sown density variety of 450gs/sqm and fertilized with AgroArgentum 200ml / ha, followed by variant fertilized with ammonium nitrate seeding density of 550 gs/sqm. For Glosa variety, all variants fertilized with AgroArgentum 200ml / ha achieved above average hectolitre mass values, followed by variants fertilized with ammonium nitrate density of 550gs/sqm and 450gs/sqm. For winter barley, hectolitre mass values were noted compared with the experience average control were fertilized variants biological with dose 100ml/ha at densities between 450 and 650gs/sqm, with 200ml density of 550 and 650 gs/sqm and nitrate ammonium variant sown with 550gs/sqm (Figure 25).

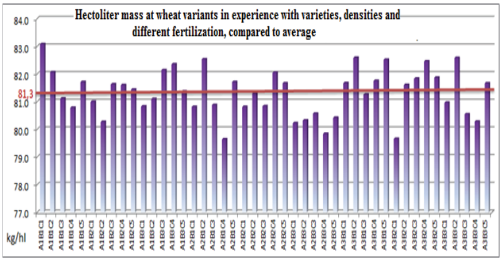


Figure 24. Hectolitre mass of wheat variants compared to average of experience

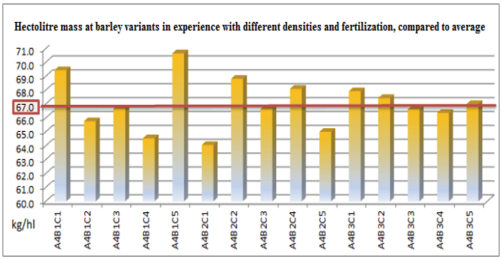


Figure 25. Hectolitre mass of winter barley variants compared to average of experience

CONCLUSIONS

Experience revealed a different dynamics of nitrogen in the soil, fertilized variants biological nitrogen supply being weaker than the control but in a continued increase from April to June.

Instead, chemically fertilized variants were well supplied with nitrogen, but in a continuous decline, reaching as June have lower values than the control, especially variant fertilized with urea.

The choice and dose density sowing fertilizer for growing wheat and barley to fall must always be correlated with soil conditions, climate and cultivars.

In North Baragan Plain we recommend the densities from 550 to 650 gs/sqm and fertilization with doses correlated to minerals concentration in soil and specific consumption of cultivated species because it is very important to keep soil in ecological parameters of fertility for a sustainable agriculture.

If, due undesirable climatic phenomena we obtain a lower density of winter barley or wheat, we can apply biological fertilizer type AgroArgentum Forte in dose of 100ml/ha, to increase the quantity and quality of production.

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