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YIELD CAPACITY OF ELBRUS DURUM WHEAT UNDER THE INFLUENCE OF ORGANO-MINERAL FERTILIZER PRODUCTS

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Abstract

During the period 2014-2017, a field experiment was conducted at the Experimental and Implementation Base of the Department of Crop Production at the Agricultural University of Plovdiv, in which the effect of two organo-mineral products was studied: Megafol (3000 mL/ha) and Megafol protein (3000 mL/ha) on the yield capacity of Elbrus durum wheat. There was also untreated control. The fertilizers were applied in the phases of tillering, shooting-up and ear formation. The experiment was made after the precursor chickpea by the method of fractional plots in four repetitions with a size of 10 m^2 of a harvest plot. As a result of the experience, the following was proved: The organo-mineral fertilizer products tested had a positive effect on the yield capacity of Elbrus durum wheat. The highest grain yield of durum wheat of Elbrus variety was obtained in the variant processed in the phase of tillering with the organo-mineral product Megafol (3000 mL/ha), where the yield capacity increased averagely for the experimental period with 479 kg/ha (13.8%) more than unprocessed control. The new organo-mineral products helped to increase the values of the structural elements of the crop such as: number of spikelets, number of grains and mass of grains per plant.

Key words*: durum wheat, organo-mineral products, yield.*

INTRODUCTION

Over the last few years, with the admission of Bulgaria to the European Union, there has been a rise in durum wheat production. The area sown with durum wheat in Bulgaria has increased up to 18,000 ha, but the yield of grain per hectare is lower from 15% to 25% compared to common wheat. The positive impact of the use of organo-mineral products and biologically active substances in enhancing the productive capacity of a number of cereals has been demonstrated in experiments conducted abroad (Petr, 2005; Wolber et al., 2006) and in Bulgaria (Delibaltova et al., 2009; Kolev et al., 2011). The published scientific literature presents data on preparations that increase the resistance of plants to various stress factors, such as high and low temperatures (Delchev et al., 2001; Delchev et al., 2011, Kolev et al., 2015).

In this study, we set out to identify the impact of new organo-mineral products on the productivity of Elbrus durum wheat.

MATERIALS AND METHODS

During the period 2014-2017, a field experiment was conducted at the Experimental and Implementation Base of the Department of Plant Growing at the Agricultural University of Plovdiv, in which the effect of two organo-mineral products was studied, namely: Megafol (3000 mL/ha) and Megafol protein (3000 mL/ha) on the production of Elbrus durum wheat. The results of the variants treated with the organo-mineral products tested were compared with an untreated control. Spraying with organo-mineral products was carried out in the phases of tillering, shooting up and ear formation of durum wheat. The experiment was carried out after chickpea precursor, repeated 4 times, with size of the cultivated plot of 10 m^2, on alluvial-meadow soil (FAO, Molic Fluvisols), characterized by an average sandy-clay mechanical composition, humus content of 1-2%, pH 7.7, with presence of carbonates up to 7.4% and absence of salts. In the 0-20 cm soil layer, the contents of the basic nutrients were as follows: N - 15.6 mg/1000 g, P_2O_5 - 32 mg/100 g, K_2O - 47 mg/100 g (Popova & Sevov, 2010).

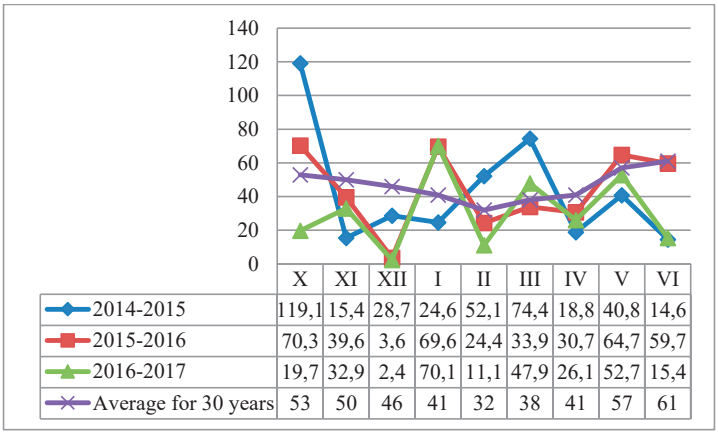
Durum wheat of Elbrus variety is sown in the optimal period from 20.10 to 05.11, with a sowing rate of 500 germinating seeds/m^2 and mineral fertilization with 120 kg/ha of nitrogen and 80 kg/ha of phosphorus, with all the

phosphorus fertilizer and 1/2 of the nitrogen being imported before sowing and the rest of the nitrogen in the early spring as a further nutrition. During the experiment, all agrotechnical measures of the approved technology for cultivation of durum wheat were observed (Yanev et al., 2008), except for the tested organo-mineral products applied in the three phenological phases of the plant development.

The number of tillers per m^2, the number of ear-bearing stems per m^2, the number of spikelet per ear (pcs), the number of grains per ear (pcs), the mass of grains per ear (g), and the yield of grain (t/ha) were reported. The statistical processing of the data obtained on the surveyed indicators was carried out with the BIOSTAT software (Penchev, 1998).

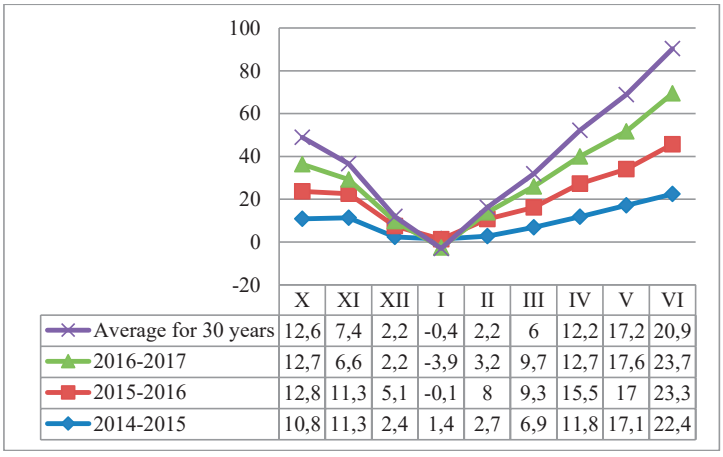
RESULTS AND DISCUSSIONS

The rainfall during the durum wheat growing season was as follows: 2014/2015 - 655.8 mm, 2015/2016 - 388.5 mm and 2016/2017 - 264.2 mm compared to the value of 419.0 mm over a thirty-year period. During the studied years, favourable for the growth and development of durum wheat with good rainfall distribution was the year 2017 (regardless of the less but better distributed rainfall during the critical phenophases of the plant development), and when also higher yields were obtained of all the grain variants. Unfavourable for the development of the plants was the first year, 2014/2015, due to the drought in April, when the structural elements of the production develop, see Figures 1 and 2.



	X	XI	XII	I	II	III	IV	V	VI
2014-2015	119,1	15,4	28,7	24,6	52,1	74,4	18,8	40,8	14,6
2015-2016	70,3	39,6	3,6	69,6	24,4	33,9	30,7	64,7	59,7
2016-2017	19,7	32,9	2,4	70,1	11,1	47,9	26,1	52,7	15,4
Average for 30 years	53	50	46	41	32	38	41	57	61

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



	X	XI	XII	I	II	III	IV	V	VI
Average for 30 years	12,6	7,4	2,2	-0,4	2,2	6	12,2	17,2	20,9
2016-2017	12,7	6,6	2,2	-3,9	3,2	9,7	12,7	17,6	23,7
2015-2016	12,8	11,3	5,1	-0,1	8	9,3	15,5	17	23,3
2014-2015	10,8	11,3	2,4	1,4	2,7	6,9	11,8	17,1	22,4

Figure 2. Monthly temperatures (average)

Number of tillers per m^2

Tillering is a process that begins in the early stages of growth and depends mainly on the sowing density, moisture supply and nitrogen supply of the plants (Garsia del Moral et al., 1991; Simane, 1993). Similar results were observed for this phenophase by Fuccillo et al. (2015). He found that in the case of favourable plant development, if there were differences, they were mainly due to the use of resources such as soil moisture, nutrients and light. The process has a strong connection with the yield results.

Tillering can partially or completely compensate for the differences in the number of plants. It helps for their recovery after a bad winter. According to Garsia del Moral et al. (2003), the tillering and the number of ears per m^2 are positively affected by good moisture supply and low temperatures, while water and nitrogen deficiency severely limit this process. Some researchers, Peterson, (1984), Rickman (1983), report that tillering is highly sensitive to lack of water. It can be reduced to a half if there was a drought during this phase. Other authors consider lower tillering capacity as the main reason for lower yields. As a result of many years of phenological observations (Krasteva et al., 2006), has established that the number of ears per m^2 is related to the tillering capacity of the plants and is formed mainly by the end of March and the beginning of April. According to her, the lower yield at high densities is due to productive tillering capacity, which reduces the possibility of high sowing density. Researchers (Slafer et al., 1993) cite high temperatures as one of the main causes of reduced tillering, especially in dense crops. Under ideal conditions, the varieties would better unleash their potential. Similar results shed light on the causes of reduced yield in dry winters by Lioveras (2004). He indicated as a reason for a reduced yield the reduced number of ear-bearing stems, due to reduced tillering.

The results in Table 1 show that the highest number of tillers per m^2 was reported in plants treated with the product Megafol in tillering phenophase, averaging 473 pcs/m^2.

Table 1. Number of tillers per m^2 and number of ear-bearing stems per m^2 (average 2014-2017)

Phases of growth	Organo-mineral products	Number of tillers per m^2	%	Number of ear-bearing stems per m^2	%
Tillering	Control	408	100	307.5	100
	Megafol	473	115.9	389	126.5
	Megafol protein	444	108.8	357.5	116.3
Shooting-up	Control	396.5	100	304	100
	Megafol	446	112.5	348.5	114.6
	Megafol protein	418.5	105.5	315	103.6
Ear formation	Control	388.5	100	327	100
	Megafol	405	104.2	330	100.9
	Megafol protein	394.5	101.5	328	100.3

In plants treated during the same phenophase with the product Megafol Protein, a better result was reported for the Elbrus variety - 444 pcs/m^2. The results in the phenophase of shooting up are similar, maintaining the same trend - a greater number of tillers per square meter in the Elbrus variety - 446 pcs/m^2, treated with the product Megafol, followed by plants treated with Megafol Protein, respectively 418.5 pcs/m^2. The results obtained in the treatment of plants during the phenophase of ear-formation are lower than the application of these preparations in phenophase of tillering and shooting up. This leads to the conclusion that the two organomineral products Megafol and Megafol Protein have the best effect when administered in the tillering phenophase.

Number of ear-bearing stems per m^2

The results presented in Table 1 show that the number of ear-bearing stems per m^2 in the Elbrus variety varies from 328 pcs/m^2 to 389 pcs/m^2 when treated with the organo-mineral products tested in the different phenophases during the vegetation of the plants. The best results for the Elbrus variety have been reported with the use of Megafol in phenophases of tillering and shooting up. The number of ear-bearing stems is higher, respectively by 81.5 pcs/m^2 when treated in

tillering phenophase and by 44.5 pcs/m^2 in shooting up phenophase. The highest number of ear-bearing stems when using the product Megafol Protein is reported in the same phenophases, but the values obtained are lower compared to Megafol.

Number of spikelets

The greater number of spikelets under favourable conditions during flowering and fertilization is a guarantee for the formation of well-grained ears. Extremely favourable weather conditions during this period are a good prerequisite for the formation of a large number of durum wheat spikelets.

The data from the experiment given in Table 2 shows that the application of Megafol in tillering phenophase of Elbrus durum wheat gives the best result according to the criterion number of spikelets, respectively 21.5 pcs. Good results were also obtained in the treatment of plants in the shooting up phenophase, respectively 20.1 pcs. Treatment with Megafol Protein in tillering phase gives the best results - 20.0 pcs for the Elbrus variety. A relatively large number of spikelets are also formed with treatment in phenophase of shooting up, while the least number of spikelets are formed when applying the two tested products in the ear-formation phenophase. The experiment carried out showed that the smallest number of spikelets are in the untreated controls, which allows us to conclude that the use of organo-mineral products Megafol and Megafol Protein in the tillering phase has the most beneficial effect on the number of spikelets in durum wheat of Elbrus variety.

Table 2. Biometrical data (average 2014-2017)

Phases of growth	Organo-mineral products	Number of spikelets	Number of grains in the ear	Grain mass in the ear, g
Tillering	Control	19.4	37.8	1.787
	Megafol	21.5	44.2	2.039
	Megafol protein	20.0	40.2	1.851
Shooting-up	Control	18.8	37.2	1.623
	Megafol	20.1	41.9	1.839
	Megafol protein	19.2	39.4	1.718
Ear formation	Control	17.8	34.9	1.569
	Megafol	18.7	39.7	1.657
	Megafol protein	18.3	35.4	1.631

Number of grains in the ear

This indicator is strongly linked to yield. This has been proven by many researchers. Philip et al., (2018) found that the major factor for the formation of yield in durum wheat was the greater number of grains of the ear. According to Bergman (1991), the increase in yield is due to the increased number of grains in the ear. The indicator is closely linked to the conditions during the formation of spikelets and flowers. Rajkine (1960) reports an established relationship between the number of grains formed and the duration of flowering. The moisture supply during flowering of the durum wheat and the formation of the grain is of great importance both for the number of grains in the ear and for their normal development. Another researcher, Araus et al. (2005), points out that one of the main directions of modern selection is to increase the number of grains in the ear. According to Sayre (1997), the increased yield achieved over the last 30 years is probably related to the increased number of grains. Essential for achieving the productive capacity of the variety, as well as for the yield volume, is the number of grains in the ear of the main tiller. The formation of more grains depends a lot on the climatic conditions during flowering and fertilization.

Table 2 shows that the application of the orano-mineral product Megafol in the tillering phase of durum wheat gives the best result in terms of the number of grains in the ear of Elbrus variety, respectively 44.2 pcs. Good results were obtained in the shooting up phase, respectively 41.9 pcs., while the least increase is obtained by treatment in the phase of ear-formation, which is 39.7 pcs.

Treatment with the organo-mineral preparation Megafol Protein in the tillering phase gives the best results - 40.2 pcs. The smallest is the number of grains in the untreated control in the

three tested phenophases of the development of durum wheat of Elbrus variety, respectively 37.8 pcs. during tillering, 37.2 pcs. during shooting up, and 34.9 during ear formation, which allows us to point out that the use of the organo-mineral products Megafol and Megafol Protein has a positive effect on the number of grains in durum wheat of Elbrus variety.

Grain mass in the ear

Another very important indicator of the productive capacity of the variety and the amount of yield is the mass of grains in the ear. Both meteorological conditions and various agro-technical activities play an important role in the period of grain formation.

Table 2 summarizes the data obtained from the implementation of this experiment for this indicator. Regarding the first factor investigated, i.e. organo-mineral fertilizers, the greatest grain mass was reported when applying the ograno-mineral product Megafol during tillering phase, namely - 2.039 g. A tendency to increase the mass of grains in the ear is also observed in the treatment of plants in phenophase of shooting up - 1.839 g. The least increase in the grain mass in the ear was reported when applying Megafol in the ear-formation phase, which was 1.657g.

High values of the indicator were also reported in the second organo-mineral fertilizer tested - Megafol Protein. The largest mass of grains was reported in phenophase of tillering - 1.851 g, followed by phenophase of shooting up 1.718 g, and in ear formation - 1.657 g. The values of the control crops for this indicator are the lowest in all three phenophases tested, which shows the positive effect of the two organo-mineral products Megafol and Megafol Protein on the grain mass of durum wheat, with the highest results reported when treated with Megafol and Megafol Protein during the phases of tillering of the durum wheat of Elbrus variety.

Grain yield

Grain yield is the most important and accurate criteria for the effect of agri-environmental, organizational and technological factors. Thus, the application of organo-mineral products together with the introduction of new higher-yielding varieties, and technologies of durum wheat cultivation are some of the most effective factors in intensifying grain production and meeting consumer needs. To produce bigger quantities of and high quality grain is unthinkable without optimizing the varietal composition, sowing density, fertilization, diseases, pest and weed control, harvesting, storage and processing of durum wheat.

The results of the experiment carried out to determine the influence of the studied factors are shown in Table 3.

Table 3.Grain yield, t/ha

Phases of growth	Organo-mineral products	2015	2016	2017	Average	%
Tillering	Control	3.101	3.332	3.951	3.461	100.0
	Megafol	3.961	3.630	4.429	4.007	115.7
	Megafol protein	3.491	3.589	4.083	3.721	107.5
Shooting-up	Control	3.420	3.500	4.008	3.643	100.0
	Megafol	3.756	3.935	4.215	3.969	108.9
	Megafol protein	3.491	3.683	4.031	3.735	102.5
Ear formation	Control	3.385	3.415	3.972	3.591	100.0
	Megafol	3.542	3.621	4.055	3.739	104.1
	Megafol protein	3.465	3.493	3.996	3.651	101.7
		A B A x B	A B A x B	A B A x B		
GD 5%		0.02 2.53 3.91	0.13 2.21 3.15	0.09 3.51 4.65		

The highest yield of grain, on average for the study period 2015-2017 was obtained with the variant of Elbrus durum wheat treated with the organo-mineral product Megafol in phenophase of tillering - 3.940 t/ha or with 0.479 t/ha more (13.8%) than the untreated control. By years, the increase in yield is in the range of 0.298 t/ha in 2016 to 0.86 t/ha in 2015. Next is the variant of applying the product Megafol in phenophase of shooting up of the durum wheat from 0.207 t/ha in 2017 to 0.435 t/ha in 2016 or

an average over the study period of 0.326 t/ha more than the untreated control.

The grain yield in the case of treatment with the organo-mineral product Megafol Protein is less than that of the Megafol-treated variants, with the best result being reported in phenophase of tillering, from 0.132 t/ha in 2017 to 0.390 t/ha in 2015, with average result for the three-year experimental period being 0.260 t/ha. The control crops achieved the lowest yield results.

The use of the organo-mineral products Megafol and Megafol Protein during the phenophase of ear-formation does not lead to any significant positive changes in the grain yield obtained.

From the data obtained from the conducted experiment we can say that higher yield is achieved with the organo-mineral product Megafol, applied in phenophase of tillering and phenophase of shooting up of durum wheat. The organo-mineral product Megafol Protein produces lower results than Megafol, with the highest yield being observed when applied during the phenophase of tillering of the Elbrus variety.

CONCLUSIONS

The organo-mineral products tested have positively affected the productivity of Elbrus durum wheat.

The highest grain yield was obtained in the period of 2014-2017 by treating with the organo-mineral product Megafol in phenophase of tillering. On average for the experimental period for Elbrus durum wheat, the yield reported was 3.940 t/ha, or with 0.479 t/ha more (13.8%) than the control crops. Next is the variant of applying the product Megafol in phenophase of shooting up of durum wheat, the yield being averagely for three years with 0.326 t/ha more than the untreated control.

The grain yield achieved with the use of the organo-mineral product Megafol Protein was smaller than the variant treated with Megafol, with the best result being achieved in phenophase of tillering, averagely for the experimental period 3.721 or with 0.260 t/ha (7.5%) more than control.

The use of the organo-mineral products Megafol and Megafol Protein during the phenophase of ear formation did not lead to significant positive changes in the grain yield obtained.

The new organo-mineral products helped to increase the number of tillers, number of ear-bearing stems, number of spikelets in an ear, number of grains and grain mass of one plant.

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