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INFLUENCE OF LEAF FERTILIZERS ON THE CHEMICAL COMPOSITION OF THE GRAIN OF SOLID DURUM

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Abstract

During the 2014-2016 period, in the experimental field of the Department of Plant Growth at Agricultural University of Plovdiv were carried out field experiments. The aim of the study was to investigate the influence of foliar fertilizers on the chemical composition of the grain of durum wheat varieties Predel and Elbrus. The plants were treated in the tillering, jointing and heading phases of growth with Megafol (300 ml/da) and Megafol-protein (300 ml/da). The results were compared with an untreated control. The experiments were based on a predecessor chickpea on the block method in four replications with a plot size of 15 m^2.
As a result of the experiments, the use of Megafol-protein had the most significant effect on the crude protein content of the Predel grain when it was applied in the tillering phase and the Elbrus grain when applied in the heading phase. The use of Megafol had a significant positive effect on the gluten content of the Elbrus variety only after application in the jointing phase.

Key words: *gain chemical content, durum wheat, leaf fertilizers.*

INTRODUCTION

The factors of the environment have an enormous influence on the processes of the plants, the formation of the yield and its quality. The protein content of wheat grains also varies strongly (from 9 to 24%) depending on the growing conditions. The role of nutrition and the importance of individual elements in plant life are primarily determined by the fact that the nutrients entering the plant cells are compounded by important organic compounds. Nitrogen in plants is quickly converted to amino acids, which are the starting compounds for the synthesis of proteins, nucleic acids, alkaloids and others.
The use of foliar fertilizers during vegetation can greatly influence the formation of yields and the quality of the grain obtained. There is much work to do in this direction. For example, the application of leaf fertilizers during jointing phase has been found to increase grain yield for durum wheat: 9.1% for Lactofol O and 9% for Devifert M + M due to their positive influence on the structural elements of the yield and the mass per 1000 grains (Delchev, 2000). The Ramil Stimulator, applied alone or in combination with complex foliar fertilizers, increases the protein content, wet and dry gluten, as compared to Tritimil and its combinations (Delchev, 2004). Applied through vegetation, leaf microbes provide a better diet for wheat. The combined spring feed with Vouxal Microplant (100 ml / da) + Kodice (250 ml/da) contributes to obtaining the highest number of grains in class and a larger grain mass - 63% higher than untreated crops. The application of leaf fertilizers during the period of intense growth increases the protein content, the raw fats, the carbohydrate compounds (starch) and the cellulose. The amount of crude protein is highest (17.4%) when applying the mineral fertilizers Vouxal and Kodice - 14.4% higher protein content than in the wheat, once fertilized with ammonium nitrate at 30 kg/da (Stoyanova, 2010). The combination of the Microelements for cereals with Amalgerol Premium leads to an increase in yield (by 59.4 kg/da) and increases the resistance of durum wheat to unfavorable climatic conditions (Delchev, Stoyanova, 2013).
The purpose of this study was to investigate the effects of two foliar fertilizers (Megafol and Megafol-protein) and the time of their application on grain quality and yields of two varieties of durum wheat in the conditions of the Plovdiv region.

MATERIALS AND METHODS

The experiments were carried out in the experimental field of the Department of Plant Growth at the Agricultural University of Plovdiv in the period 2014-2016. The effects of the Megafol (300 ml/da) and Megafol-protein (300 ml/da) were studied. The influence of the fertilizers was compared to control plants that were not treated. The experiments were based on a predecessor chickpea on the block method in four replicates with a plot size of 15 m^2. The sowing of durum wheat is carried out in the optimal time from 20th of October to 10th of November with a sowing rate of 500 seeds/m^2 and mineral fertilization with 12 kg/da nitrogen and 8 kg/da phosphorus. All phosphorus fertilizer was imported prior to sowing together with 1/3 of the nitrogen fertilizer. The rest of nitrogen fertilizer was imported as spring feed. All units of the established technology for growing durum wheat were followed.

The foliar treatment preparations used contain valuable plant growth stimulating ingredients. Megafol contains amino acids and a complex of biologically active substances (sugar beet extract, algae extract, and organic ingredients required for growth). Megafol-protein also contains a complex of biologically active substances that activate the genes involved in protein synthesis (GEA 166).

The following grain parameters were determined: wet and dry gluten yield (by weight), fiber, crude fat (by residual method), nitrogen content and crude protein (Kjeldahl), carbohydrate substances (by the residual method).

RESULTS AND DISCUSSIONS

Table 1 shows the occurrence of phenophases in the tested varieties.

The duration of the period from sowing to germination is determined by the amount of precipitation before sowing, but is mainly limited by the air temperature, with the higher average air temperature guaranteeing the faster and joint growth of wheat. Prior to sowing of durum wheat on 10th November 2014, soil moisture reserves increased, which combined with the higher temperature compared to the multiannual period of time created good conditions for the germination of the plants. Higher temperatures in mid-November and falling precipitations contributed to the normal germination phase at the end of the month. The germination of plants is followed by abundant rainfall in the first ten days of December - 32.3 mm more than the multiannual period of time. In the early stages of development no significant differences were observed between the two tested varieties (Table 1). The Elbrus variety enters one to two days earlier, respectively, in phase of germination and third leaf compared to Predel variety. Predel variety entered the phase of 3rd leaf on 17.12.2014, and Elbrus variety on 15.12.2014. Gradually, with decreases in temperatures in December, the growth processes of durum wheat also subsided. In January, rainfall was 23.6 mm less, and in February and March it was 44.6 and 100.0 mm higher than the norm for the multiannual period. These two months were also characterized by higher average monthly temperatures of 3.10°C and 3.70°C (versus -0.4°C for January and 2.2°C for February on average over a thirty year period), but the plants are in hibernation. In the second ten days of March, with temperatures rising, the plants entered the tillering phase. The tillering phase of Elbrus variety is on 26th March 2015, and in the Predel variety it is three to four days later on 30th March 2015. The precipitation in April was 27.0 mm less than the norm, and this had a retaining effect on the growth of durum wheat. Temperatures for the same period were within the normal range for the month, and a shooting up phase occurred on 20.04.2015 for Elbrus variety and three days later on 23.04.2015 for Predel variety.

The rainfall in May and June was 12.5 mm and 15.7 mm less than the norm, respectively, while the average monthly temperature in May and June was higher than the norm, which led to an accelerated development of durum wheat. The stages of filling and ripening of the grain occurred under favourable rainfall conditions. The ear formation phase of Elbrus variety took place on 15.05.2015, while on 18.05.2015 for Predel variety. Full maturity for durum wheat was recorded on 01.07.2015 and on 03.07.2015 respectively for Elbrus and Predel varieties. Harvest of durum wheat was carried out on 09.07.2015.

Table 1. Phenological phases of the durum wheat varieties tested

Development phases	2014-2015	
	Predel	Elbrus
Sowing	10.11	10.11
Germination	26.11	25.11
3rd leaf	17.12	15.12
Tillering	30.03	26.03
Shooting up	23.04	20.04
Ear formation phase	18.05	15.05
Full maturity	03.07	1.07

Table 2. Duration, temperature sum, and precipitation during interfacial periods

Year	Interfacial periods	Number of days		∑ *t* active, (°C)		*t* average, (°C)		The amount of rainfal, mm/m^2	
		Predel	Elbrus	Predel	Elbrus	Predel	Elbrus	Predel	Elbrus
2014 - 2015	Sowing - germination	17	16	144.0	144.0	8.47	9.0	48.7	48.7
	Germination – 3rd leaf	22	21	77.3	77.3	3.51	3.68	78.8	78.7
	3rd leaf - tillering	104	102	394.6	345.4	3.79	3.38	246	239.3
	Tillering - shooting up	25	26	297.6	311.6	11.90	11.98	13.6	20.3
	Shooting up - ear formation phase	26	26	451.0	420.5	16.17	17.34	66.0	64.7
	Ear formation - ripening	47	48	976.2	993.1	20.77	20.68	87.3	79.5

The data in Table 2 on the characteristics of the interphase periods shows similar numbers of days, the sum of the active and average t°C for both varieties. The germination of the plants takes place for 16 and 17 days at an equal sum of active temperature of t°C - 144°C for Predel and Elbrus varieties and at average temperatures of 8.47-9.0°C with an equal amount of precipitation for the period - 48.7 mm. The interphase period "germination - third leaf" runs for 21 and 22 days also at the same temperature sums of 77.3°C, with average temperature for the period 3.5-3.7°C, and precipitation quantity with close values 78.7-78.8 mm for both varieties. The longest period is the period of the
3rd leaf - tillering, i.e. 102 days for Elbrus and 104 days for Predel variety, the sum of the active temperatures for Predel variety being greater than that of Elbrus variety, respectively 394,6°C and 345,4°C. The average t°C for the period of Elbrus variety is 3.38°C, and for Predel variety is 3.79°C, and the precipitation quantity is 239.3 mm and 246.0 mm, respectively. The interphase period of tillering - shooting up occurs in shorter time in Predel variety, 25 days, and in Elbrus variety for 26 days. The sums of active temperatures are slightly different - 297.6°C for Predel and 311.6°C for Elbrus. Average temperatures are close to 12.0°C, and the amount of rainfall in Elbrus variety is greater, 20.3 mm, versus that of Predel, 13.6 mm.

The same is the duration of the interphase period tillering - ear formation equalling to 26 days for both varieties. It occurs at sum of the active temperature of 451.0°C and precipitation quantity of 66.0 mm for Predel variety, the values of which are greater than those of the Elbrus, namely 420.5°C, and 64.7 mm. The value of the average t°C for Elbrus variety period is 17.34°C, being higher than that of Predel variety for the same period - 16.17°C. "Ear formation - ripening" takes place for 48 days for Elbrus variety, and 47 days for Predel variety. The sum of the active temperatures is greater for Elbrus variety 993.1°C, compared with the Predel variety, 976.2°C, while the average temperature for the period and the amount of precipitations are higher for Predel, 20.77°C and 87.3 mm, compared to the Elbrus variety, 20.68°C and 79.5 mm.

In the second experimental year, the sowing of durum wheat was carried out on 21th October 2015. This year, the soil moisture reserves due to fallen rainfall combined with the higher temperature compared to the multiannual period, create good conditions for the germination of the plants.

Higher temperatures at the end of October and the amount of fallen rainfall contributed to the normal germination phase at the end of the month. In the early stages of development no significant differences were observed between the two tested varieties.

Elbrus variety enters one day earlier, respectively, in phase germination and third leaf compared to Predel variety (Table 3).

Table 3. Phenological phases of the durum wheat varieties tested

Development phases	2015-2016	
	Predel	Elbrus
Sowing	21.10	21.10
Germination	31.10	30.10
3rd leaf	18.11	17.11
Tillering	09.03	07.03
Shooting up	15.04	13.04
Ear formation phase	12.05	09.05
Full maturity	02.07	01.07

Predel variety enters 3rd leaf phase on 18.11.2015, while Elbrus variety on 17.11.2015. Plants enter the beginning of the tillering phase on 20.11.2015.

Gradually, with the fall in temperatures in December, the growth processes of durum wheat subside. In January, the amount of precipitation was more, and in February and March and April less than the multiannual period norm. These four months were also characterized by higher average monthly temperatures. The occurrence of the tillering phase of Elbrus variety is on 07.03.2016, while in Predel variety it is two days later on 09.03.2016. Temperatures and precipitation in April were higher compared to a multiannual period of time and shooting up phase occurred on 13.04.2016 for Elbrus variety and two days later on 15.04.2016 for Predel variety.

The phases of filling and ripening of the grain took place in favourable rainfall conditions and optimal temperatures in May and June. The shooting up phase occurred on 13 April 2016 for Elbrus variety, and two days later on 15 April 2016, for Predel variety.

Ear formation phase of Elbrus variety took place on 09.05.2016, while for Predel variety on 12.05.2016. Full maturity for durum wheat was reported on 01.07.2016 and on 02.07.2016 respectively for Elbrus and Predel varieties. Harvest of durum wheat was carried out on 11.07.2016.

In conclusion, it can be said that Elbrus variety in both years of research is developing faster and entering the different stages of development earlier than Predel variety.

Varieties that can complete the vegetation more quickly are advantageous in avoiding later the summer heat and could be an indication of a good adaptability of Elbrus variety for growing in the Plovdiv region.

According to Gandee et al. (1997), a longer vegetation period means higher yields unless grain filling occurs in a time of extreme drought. Others, Giordani et al. (1989) found that at high temperature and water deficiency, factors that are known to accelerate the phenophase development, less number of days are required for going through the respective phenophase.

According to the same author (1989), the longer duration of grain formation time is reflected in a larger number of grains. Plants are most sensitive to the impact of unfavourable factors in the ear formation phase when the processes of gametogenesis are completed and pollen and ova are formed.

Table 4. Duration, temperature sum, and precipitation during interfacial periods

Year	Interfacial periods	Number of days		$\sum$ *t* active, (°C)		*t* average, (°C)		The amount of rainfal, mm/m²	
		Predel	Elbrus	Predel	Elbrus	Predel	Elbrus	Predel	Elbrus
2015 - 2016	Sowing - germination	11	10	100.8	92.1	9.16	9.21	39.6	39.6
	Germination – 3rd leaf	19	19	215.5	216.0	11.34	11.36	0	0
	3rd leaf - tillering	114	113	628.9	618.5	5.51	5.47	139.4	135.9
	Tillering - shooting up	38	38	397.6	402.4	10.46	10.58	45.7	48.5
	Shooting up - ear formation phase	28	27	414,0	396.6	14.78	14.68	41.9	38.7
	Ear formation - ripening	51	54	1117	1168	21.91	21.62	103.9	97.7

The germination of plants in the second year occurs for 10 and 11 days with sum of the active temperature t°C, 100.8°C for Predel variety and 92.1°C for Elbrus, and at average temperatures of 9.16-9.21°C with the same amount of precipitation for the period - 39.6 mm (Table 4). The interphase period “germination - 3rd leaf” occurs for 19 days for both varieties also at close temperature sums of 215.5-216.0°C, average temperature for the period 11.34-11.36°C, and the same precipitation amount 0.0 mm. The longest is the period “3rd leaf - tillering, consisting of 113 days for Elbrus and 114 days for Predel, the sum of the active temperatures for Predel variety - 628.9°C being greater than that of Elbrus variety - 618.5°C. The average t°C for the period of Elbrus is 5.47°C, while for Predel variety, 5.51°C, and the precipitation quantity, 135.9 mm and 139.4 mm, respectively. The interphase period “tillering - shooting up” takes place for 38 days in both varieties of durum wheat. The sums of active temperatures are slightly different - 397.6°C for Predel and 402.4°C for Elbrus.

The average temperatures are close to 11.0°C, while the amount of rainfall for Elbrus variety is 48.5 mm being higher than that of Predel - 45.7 mm. The interphase period “shooting up - ear formation” occurs for 27-28 days. It occurs at sum of the active temperature, 414.0°C, and rainfall quantity, 41.9 mm for Predel variety, the values of which are higher than those of Elbrus, 396.6°C and 38.7 mm, respectively. The value of the average t°C for the period for Elbrus variety is 14.68°C being lower than that of Predel variety for the same period - 14.78°C. “Ear formation - ripening” takes place for 54 days for Elbrus variety, and 51 for Predel variety. The sum of the active temperatures is higher for Elbrus variety, 1168°C, versus that of Predel variety, 1117°C, while the average temperature for the period and the precipitation quantity are higher for Predel, 21.91°C and 103.9 mm, versus Elbrus variety, 21.62°C and 97.7 mm, respectively.

Soil climatic conditions are an important factor for grain quality in cereals. Plant feeding, however, in the form of soil fertilizer application or use of leaf fertilizers can compensate for adverse abiotic factors and strongly affect the chemical composition of the grain and increase its quality.

The Table 5 presents the results of the surveyed indicators, which are expressed as a percentage and represent an average of three repetitions for the two consecutive years. From the analysis of grain chemistry, it has been found that application of Megafol-protein results in an increase in the crude protein content of the Predel grain. This was observed in the three phases of development, with the increase being most pronounced after the foliar fertilizer application (14% crude protein) compared to the control (12.5%). These results were in positive correlation with the nitrogen content

(2.5%) and gluten (wet - 31.2% and dry - 14.7%) during the tillering phase treatment. Elevated crude fat content of the Predel variety was also observed as a result of the use of Megafol-protein, the highest value being reported after treatment in the heading phase (3.6%).

In the Elbrus variety, the application of Megafol-protein in the heading phase only leads to an increase in the nitrogen content (2.4%) and protein (13.8%). Its application in the remaining phases does not result in significant differences in these indicators. The application of Megafol during the tillering and jointing phases in the Elbrus variety leads to an increase in the gluten content (27.8% - tillering, 26.1% - jointing). The crude fat content of the Elbrus variety was increased after administration of Megafol-protein in the tillering phase (3.1%) and jointing (2%), while using Megafol - only in the heading phase (2.3%).

Another indicator that is affected by application of leaf fertilizers is the content of carbohydrate substances (in particular starch accumulation). The carbohydrates and protein content are in reverse correlation. The highest content of carbohydrate substances was recorded in the variants with the lowest protein content, and this was observed in both tested varieties and the two tested products.

Table 5. Chemical composition of the grain of two varieties of durum wheat (Predel and Elbrus) treated with leaf fertilizers (Megafol and Megafol-protein) at different stages of their development

Variety	Variants	% WGY	% DGY	% N	% Crude protein	% Carbohydrates	% Fibre	% Crude fats
Predel	$A_1B_1C_0$	29,5	13,1	2,2	12,5	84,1	1,0	2,4
	$A_1B_1C_1$	24,2	11,5	2,4	13,4	82,3	3,1	1,2
	$A_1B_1C_2$	**31,2**	**14,7**	**2,5**	**14,0**	82,0	1,4	**2,6**
	$A_1B_2C_0$	28,1	12,1	2,3	12,9	82,1	3,1	1,9
	$A_1B_2C_1$	23,8	10,1	2,3	13,0	81,6	3,1	2,3
	$A_1B_2C_2$	**32,0**	**14,3**	**2,4**	**13,6**	81,7	1,4	**3,3**
	$A_1B_3C_0$	23,4	10,7	2,2	12,7	84,6	1,5	1,2
	$A_1B_3C_1$	23,6	10,9	2,2	12,4	82,4	1,7	3,5
	$A_1B_3C_2$	**27,2**	**12,4**	**2,3**	**13,2**	78,3	4,9	**3,6**
Elbrus	$A_2B_1C_0$	25,5	12,7	2,1	12,0	85,1	1,2	1,8
	$A_2B_1C_1$	**27,8**	**13,3**	2,1	11,7	**85,7**	1,3	1,3
	$A_2B_1C_2$	26,6	12,1	2,1	11,8	82,0	3,1	**3,1**
	$A_2B_2C_0$	22,7	10,1	2,1	12,1	83,0	3,6	1,4
	$A_2B_2C_1$	**26,1**	**12,7**	2,1	12,2	**85,4**	1,4	1,1
	$A_2B_2C_2$	19,6	8,8	2,1	11,7	83,9	2,4	**2,0**
	$A_2B_3C_0$	28,9	15,4	2,0	11,4	**84,8**	2,3	1,5
	$A_2B_3C_1$	19,4	8,9	2,2	12,5	83,0	2,2	**2,3**
	$A_2B_3C_2$	27,5	12,5	**2,4**	**13,8**	82,7	1,7	1,8

Legend: Factor A (variety) - A_1 - Predel, A_2 - Elbrus; factor B (development phases used for the treatment) - B_1 - tillering, B_2 - jointing, B_3 - heading; Factor C (leaf fertilizer) – C_0 - control (untreated), C_1 - Megafol 300 ml / ha, C_2 - Megafol protein 300 ml / ha. % WGY - percentage of wet gluten yield, % DGY - yield of dry gluten.

Regarding the fiber content, no clear relationship was found between the type of leaf fertilizer, the application phase and the variety. Similarly to our results, were the findings of other authors worked with wheat (Delchev et al., 2004; Blandino et al., 2015; Smith et al., 2005). For example, late leaf nourishment (in flowering phase) with nitrogen-containing fertilizers increases the grain protein content of durum wheat and bread wheat (Blandino et al., 2015).

Synthesis of protein is a complex and multi-step process requiring a lot of energy that is provided by solar radiation. A large amount of water is required to form carbohydrates, causing water deficiency to disturb the synthesis of carbohydrates. In cereals, there is a reverse relationship between the amount of protein and starch: with increased protein content in the grain, the amount of starch decreases and vice versa. In order to improve the quality of cereals, the nitrogen fertilizers are also important (Delchev, 2000). Nitrogen feed fertilization by spring increases not only yield but also improves grain quality. Of great importance for the quality are the nitrogen-containing complex fertilizers applied in the late stages of development - for example, during the period of jointing, heading and flowering (Delchev, 2010). The nitrogen introduced in these terms is used by the plant, not for the growth of the vegetative organs, but it reaches the reproductive organs, increases the concentration of nitrogen in them and during the period of grain development and growth, the protein synthesis processes are much more intense (Delfine et al., 2005; Stoyanova, 2010). In leaf fertilizers, nitrogen uptake faster into plants and transported into seeds, creating excellent conditions for intense protein synthesis. This can be used with great effect in unfavorable climatic conditions to increase yields and improve quality. In excessively humid years, when conditions are created to produce grains with degraded properties (low protein and high starch content), it is advisable to use nitrogen containing fertilizers (soil or leaf applied) even in the late stages of plant growth. In very dry years, when plants need to be grown under irrigation conditions to increase yields and quality, additional fertilization may also be used.

CONCLUSION

The use of leaf fertilizers containing nitrogen and/or amino acids increases the quality of wheat of Predel and Elbrus varieties. The phase in which fertilizers are applied is essential. In this study, we found that the use of Megafol-protein had the most significant effect on the crude protein content of the Predel grain when applied in the tillering phase, and in the Elbrus grain when applied in the heading phase. The use of Megafol has a significant positive effect on the gluten content of the Elbrus variety only after application in the jointing phase.

REFERENCES

Blandino, M., Vaccino, P., Reyneri, A. (2015). Late-Season Nitrogen Increases Improver Common and Durum Wheat Quality. *Agronomy Journal*, *107*(2), 680–690.

Delchev, G. (2000). Exploration of the timing of import of certain complex foliar fertilizers in durum wheat. *Plant Growth Sciences,* BG, *37*(9), 738–742.

Delchev, G., Ivanova, I., Nenkova, D. (2004). Study of some combinations of growth regulators and complex foliar fertilizers in durum wheat. *Plant Growth Sciences, XLI*(6), 552–555.

Delchev, G. (2010). Grain yield and quality of durum wheat when treated with some complex and organic foliar fertilizers. *Soil Science, Agrochemistry and Ecology, XLIV*(3), 46–51.

Delchev, G., and Stoyanova, A. (2013). Changes in the sowing properties of durum wheat seed in the use of leaf fertilizers, stimulants and antitranspirants. *Plant studies, III*(6), 215–216.

Delfine, S., Tognetti, R., Desiderio, E., Alvino, A. (2005). Effect of foliar application of N and humic acids on growth and yield of durum wheat. *Agron. Sustain. Dev*., *25*, 183–191.

Gandee, C.M., Davies, W.P., Goodind, M.J. (1997). Interactions between nitrogen and growth regulator on wheat and spelt. *Aspects of Applied Biology*, *50*, 219–224.

Giordani, G., Baldoni, G., Rapparini, L. (1989). Influenza di trattamenti fitoregulatori su varieta di frumento duro. *Informatore Agrario*, *45*(15), 115–118.

Giordani, G., Rapparint, L. (1989). Influenza della concimacione azotata e dei trattamenti fitoregulatori su varieta di frumento tenero e duro. *Informatore Agrario*, *45*(16), 83–90.

Smith, G.H., Chaney, K., Murray, Ch., Le, M.S. (2015). The Effect of Organo-Mineral Fertilizer Applications on the Yield of Winter Wheat, Spring Barley, Forage Maize and Grass Cut for Silage. *Journal of Environmental Protection*, *6*, 103–109.

Stoyanova, A. (2010). Foliar fertilizers and wheat grain quality. *Agriculture Plus*, *5*, 33–35.