

RESPONSE OF DURUM WHEAT (TRITICUM DURUM DESF.) CULTIVAR PROGRESS TO FOLIAR FEEDING

Galia D. Panayotova¹, Violeta Z. Bozhanova², Svetla S. Kostadinova³,

Neli K. Valkova², Mladen Almaliev³

1 - Faculty of Agriculture, Trakia University, 6000 St. Zagora, Bulgaria

2 - Field Crops Institute, 6200 Chirpan, Bulgaria

3 – Faculty of Agronomy, Agrarian University, 4000 Plovdiv, Bulgaria

Abstract

During the period 2008-2010 the response of durum wheat cultivar Progress, grown on Pellic Vertisols at the field of the Field Crops Institute, Chirpan, Bulgaria, to foliar feeding was studied. The new organic, systematic and complex fertilizers - Icyactive, Icyamin, Start-up, Fertileader Alfa, Fertileader BPK and Fertileader Vital 954 were tested. Fertilizers were applied twice during tillering - beginning of stem elongation, alone and in combination with N120 fertilization.

The results showed that the products influenced the durum wheat growth, productivity and grain quality. Additional grain yield after foliar application ranged from 122 to 430 kg.ha⁻¹, which is 4.4-15.4 % above the control. Differences were stronger after a combination of foliar spraying and N fertilization - yields were in excess of 53.7-54.1 % and reached 4.30 t.ha⁻¹ after fertilization with Icyactive + N120. The test weight of the grain was in the range of 79.70-80.23 kg/hl and was formed mainly under influence of the weather conditions. The 1000 kernel weight reached 57.7 g after Fertileader Vital 954 - 3 l/ha, which is 2.5 % above control. Vitreousness increased with 36.4-43.9 %, content of crude protein - with 22.0-30.7 % and wet gluten – with 17.9-25.7 % compared to control. From agronomic point of view liquid fertilizers can be successfully used for foliar feeding of durum wheat. Icyactive - 1 l/ha, Fertileader Alfa - 3 l/ha and Start-up - 3 l/ha manifested a very good effect.

Key words: durum wheat, foliar feeding, nitrogen, yield, quality.

1. INTRODUCTION

Balanced nutrition with nitrogen, phosphorus and potassium and microelements is a prerequisite for achieving good plant quality and yield. The application of fertilizers in modern agriculture is related to requirements for adequate nutrition of different crops and varieties. The use of nutrients and reduce nutrients loss can be improved significantly by foliar application (Kostadinova, 2011). Balanced nutrition plays a significant role in increasing crop production and its quality and presents an essential component of nutrient management.

Recently, in agriculture more and more widely are being used new fertilizer formulations for spraying during vegetation at certain ratios to the needs of different crops. According to published results from a number of authors foliar application improves vegetative growth and plant development, has a stimulating effect on flowering and increases crop yield (Gramatikov, 2005; Gramatikov and Koteva, 2004; Masheva et al., 2012; Nenov et al., 2004; Valchev and Masheva, 2012).

It has been observed that foliar fertilizer application methods ensure the availability of nutrients to crops for obtaining higher yield (Alaru et al., 2003). Cereals are very responsive to application of liquid and suspension fertilizers during vegetation (Arif et al., 2006; Bazitov et al., 2011, Bazitov et al., 2013; Nankova et al., 2004). According to Ahmed et al. (2011), Yaseen et al. (2011) and others, foliar application of micronutrients together with NPK fertilizers increased the yield of wheat grain, the structural elements and net revenue. Foliar application of micronutrients is effective in supplying crops with micronutrients in critical periods of their growth (Kostadinova, 2011a). According to Stoyanova (2008) and Stoyanova and Petkova (2010) foliar feeding supplements soil fertilization and leads to complete valuable nutrition of wheat. Fertilization with liquid fertilizers, including and Fertileader, can compensate for nitrogen loss by washing in early spring application and increased grain yield of wheat.

According to Bosev et al. (2012) different treatment combinations between Magnisal 6 and NH_4NO_3 (17.5% N) applied by foliar spraying significantly affected almost all agronomic characteristics, but plant height and kernel weight per spike in cultivar Olga were not significantly changed by the use of foliar fertilizers.

Bazitov (2013) reported that reduction of nitrogen and potassium rate by half the optimum and replacement of phosphoric norm with Laktofol 0 decreased the yield with 11.5% in comparison with the optimum rate. Replacement of nitrogen and potassium norm with Laktofol 0 and reduction half of phosphorus rate reduces the yield by an average of 20.4%.

Providing an adequate nutrient rate to suit the durum wheat requirements is an important prerequisite for increasing productivity and quality (Delfine et al., 2005; Kostadinova et al., 2011; Panayotova, 2010; Panayotova et al., 2006). Eckhoff (2001) reported that N fertilization during vegetation increased the yield of durum wheat, even after high levels of preplant applied N fertilization, and top dressed N increased protein of all studied varieties, but too much preplant N reduced test weights to levels not acceptable for U.S. No 1 durum. Panayotova and Dechev (2004) reported that nitrogen fertilization increased N accumulation and use in durum wheat.

Delchev (2000, 2005a) also reported that foliar feeding, combined with nitrogen weed control, increased yield and it was highest after complex foliar fertilizers treatment during the stem elongation stage. The increase in yield was due to the positive change in the structural elements of the yield and the weight of 1000 grains. The foliar treatments during the ear emergence and milk development stages had a weak effect on the yield, but increased grain quality (Delchev, 2009).

The objective of this study was to establish the efficiency of liquid fertilizers on the development, yield and grain quality of the Bulgarian durum wheat (*Triticum durum* Desf.) cultivar Progress grown on Pellic Vertisols at the Field Crops Institute, Chirpan, Bulgaria.

2. MATERIALS AND METHODS

The research was carried out on the test field of the Institute of Field Crops, Chirpan, Bulgaria under rainfed conditions during the period of 2008-2010 in cotton-winter durum wheat (*Tr. durum* Desf.) rotation. The experimental setup was randomised block design in four replications. The yield plot size was 10 m². The unfertilized Progress variety was accepted for control.

The liquid fertilizers Icyactive, Icyamin, Start-up, Fertileader Alfa, Fertileader BPK and Fertileader Vital 954 were tested. The fertilizers Icyactive, Icyamin and Start-up contain low molecular carboxylic acids and free amino acids that promote better absorption of water and nutrients (according to the producer Carbotecnia SL, Spain). Icyactive is an inorganic liquid mixture containing 1 % Zn and 1 % Mn solution. Icyamin is formulated with 13.2 % total organic matter, 5 % total N, 5 % P_2O_5 , 1 % Zn, 1 % Mg and 13.2 % free amino acids. Inorganic fertilizer Start-up is formulated with carboxylic acids of low molecular weight and contains 7 % N and 17 % P_2O_5 .

The liquid products FERTILEADER (developed by the Roullier Group in cooperation with the University of Florence) contains a patented complex SEACTIV® (acid extracted from a seaweed from the Fucaceae family), plant acids, glycine betaine. The following were tested: Alfa - containing 6.5 % N; 12.6 % P_2O_5 ; 4.2 % B; BPK - with 6.2 % P_2O_5 ; 12.6 % K_2O ; 1.03 % B; Vital 954 - containing 9 % N, 5 % P_2O_5 , 4 % K_2O and micronutrients B, Cu, Fe, Mn, Mo, Zn.

Fertilizers were applied as two-fold foliar feeding during tillering-beginning of stem elongation in doses for each product as recommended by the producer - 1 or 3 l/ha in 300 l of water/ha, alone and in combination with soil N_{120} fertilization. The results were compared to a water control and a standard N fertilization as ammonium nitrate (34 % N) at a rate of 120 kg/ha. One third of the nitrogen was broadcast pre-sowing by hand, and the rest 2/3 - as early spring top dressing at the end of the wheat tillering stage - beginning to stem elongation (Feekes stage 4-5).

The seeds were sown on October 25-30, with a sowing density of 550 seeds per m². Weeds were controlled between the tillering and shoot elongation stages with herbicides. There were no pathogens and pests above the threshold of harm during the durum wheat vegetation period in the three growing years and chemical spraying was not carried out. The harvest with plot combine Wintersteiger occurred on July 10-15.

The grain yield (kg/ha), test weight (kg/hl), 1000 kernel weight (g), vitreousness (%), crude protein (%) and gluten (%) were determined on the harvested grain. The test weight was determined by hectoliter, 1000 kernel

weight – by weighting two samples of 500 kernels, total vitreousness – by cutting with pharintom of Heinsdorf, the content of crude protein - by Kjeldahl standard method after combustion with sulfuric acid and derived according to: Protein, % = N (% DM) x 5.7; and wet gluten - with Gluten washing apparatus.

The data of studied parameters was statistically analysed according to the analysis of variance (ANOVA) and LSD test for evaluation of significant differences.

In regard with the meteorological conditions the studied years were characterized by higher temperatures in the autumn-winter period, unevenly distributed precipitation and they were not particularly favorable to the optimal development, growth and productivity of the durum wheat (Table 1). Temperature sums total for the vegetation period of durum wheat (X-VI) in 2008, 2009 and 2010 exceeded the average amount (2375°C) with 103, 419 and 238°C, respectively. With respect to rainfall for the vegetation period in 2008 and 2010 the amount of rainfall was respectively 90 and 75 mm/m² more, and in 2009 with 210 mm/m² less than average (442 mm/m²).

The soil in the field was Pellic Vertisols (FAO). It was with high humidity capacity and small water-permeability, defined by the sand-clay composition. The test field was with bulk weight of the plough soil layer - 1.2 g/m³ and specific gravity - 2.45. The sorbcium capacity was 35-50 mequ/100 g soil (Table 2). The soil was of slightly acid to neutral soil reaction, with total C content of 0.89-1.38 %, total N – average 0.110 %, poor to middle supplied with mineral nitrogen, low supplied with available phosphates and well provided with available potassium.

Table 1. Meteorological conditions during vegetation period of durum wheat, 2008-2010

Period	Temperature sum, °C			Rainfall, mm/m ²		
	X-II	III-VI	X-VI	X-II	III-VI	X-VI
2008	734	1744	2478	322	210	532
2009	1011	1783	2794	137	95	232
2010	879	1734	2613	311	206	517
1928-2010	705	1670	2375	238	203	442

Table 2. Agrochemical properties of the Eutric Vertisols in the region of the Field Crops Institute, Chirpan, 0-60 cm

Depth (cm)	pH	Total C (%)	Mineral N (mg/kg soil)	Available forms (mg/100 g)	
				P ₂ O ₅	K ₂ O
0-10	5.5 - 5.8	1.18 - 1.27	15 - 18	0.3 - 0.5	32 - 38
10-20	5.5 - 5.8	1.21 - 1.38	20 - 25	0.5 - 1.4	25 - 35
20-40	5.8 - 6.5	1.12 - 1.30	23 - 25	2.5 - 3.0	19 - 28
40-60	6.0 - 6.5	0.89 - 0.98	20 - 22	2.0 - 3.2	15 - 26
Average	5.5 - 6.5	0.89 - 1.38	15 - 25	0.5 - 3.2	15 - 38

3. RESULTS AND DISCUSSION

The combination of temperature and rainfall was the main regulatory factor for the phenological development of durum wheat plants (Table 3). During the period of research an insignificant delay was observed in the plant development – the tillering occurred in February, the stem elongation – at the beginning of April. Temperatures below -14°C in February 2010 caused partial freezing of the crops and lower grain yield. The highest temperatures and drought in May 2010 hindered the obtaining of record yield. The abundant rainfall in June 2008 led to lodging of the durum wheat and deteriorated the grain appearance. Year 2010 was favorable for the durum wheat development and obtaining a good yield, but it was very unfavorable to the grain quality due to the July rainfalls (114.4 mm/m²). Overall durum wheat riping was reported in the period July 5-13.

The influence of the tested factors was very well demonstrated (Table 4). The results of the analysis of variance showed very significant differences among the foliar fertilizers (F), N fertilization (N), environments - in this case year (Y), as well as NYI and FNYI. The mean squares due to foliar feeding, nitrogen fertilization and year were significant at the 0.001 level of probability. There were no significant effects of interactions FNI и FYI on grain yield, which shows that during the studied period the effect of foliar fertilizers responded one-way to the applied nitrogen levels.

Nitrogen fertilization appeared as the strongest source of variation - 45.31 % of the total impact of factors. The years also had a strong influence on the grain yield - 41.20 % of the total variation, while foliar application had 1.09 % influence, proven in $P \leq 0.001$. That high interaction NYI ($P \leq 0.001$) showed the strong influence of N fertilization (5.73 %) on grain yield in years with different temperature and precipitation probability

Table 3. Phenological stages in durum wheat development, 2008-2010

Stage	2008	2009	2010
Emergence	10. XI	15. XII	25. X
Tillering	25. XII	25. II	10. II
Stem elongation	01. IV	03. IV	22. IV
Ear emergence	15. V	18. V	12. V
Flowering	22. V	28. V	24. V
Maturity	10. VII	05. VII	13. VII

Table 4. Analysis of variance for grain yield of durum wheat cultivar Progress at foliar feeding, 2008-2010

Source of variation	df	SQ	η (%)	MS	Fisher's-tests
Total	191	1 656 528	100.00	-	-
Replications	3	6 060	0.37	2 020*	3.8
Variants	47	1 576 144	95.15	33 535***	63.6
F - foliar feeding	7	18 040	1.09	2 577***	4.9
N - $\pm$ N fertilization	1	750 500	45.31	750 500***	1423.8
Y – Year	2	682 436	41.20	341 218***	647.3
F x N	7	3 256	0.19	465 n.s	0.9
F x Y	14	10 116	0.61	722 n.s	1.4
N x Y	2	94 904	5.73	47 452***	90.0
F x N x Y	14	16 892	1.02	1 206**	2.3
Error	141	74 324	4.48	527 n.s	

*, **, *** - significant at the $P \leq 0.05$, 0.01 and 0.001 level of probability, respectively

The assessment of average grain yield of durum wheat cultivar Progress grown from 2008 to 2010 showed that all levels of foliar feeding increased the grain yield. Additional realized average grain yield was from 0.122 to 0.430 t.ha⁻¹, which is from 4.4 (Icyactive) to 15.4 % (Fertileader Alfa) above control under the influence of alone two-fold application of liquid fertilizers (Table 5). The average grain yield without fertilization was 2.791 t.ha⁻¹. The differences after combining foliar spraying and nitrogen fertilization were stronger, and then yields

exceeded water control with 53.7 to 54.1 %. After combined foliar and N fertilization the grain yield exceeded the standard N_{120} fertilization with 0.187-0.198 t.ha⁻¹ and for the same period reached 4.30 t.ha⁻¹ (Icyactive + N_{120}).

Grain yield of durum wheat was significantly different in the three harvest years. In 2008 the yield was lowest - an average of 2.881 t.ha⁻¹. The high temperatures during the spring-summer period were the main reason for that. In 2009 the sum of the temperatures in the spring-summer period was high and the amount of rainfall - lowest, but they were during the formation of fruiting organs where yields were highest and reached an average of 4.054 t.ha⁻¹.

Table 5. Grain yield (t.ha⁻¹) of durum wheat cultivar Progress after foliar feeding, average for 2008-2010

Treatment	Year			Average		
	2008	2009	2010	t.ha ⁻¹	%	Additional yield (t.ha ⁻¹)
Water check	2.13	3.54	2.70	2.791	100.0	-
N_{120} – St	3.86	4.49	3.97	4.104	147.0	1.313
Icyactive – 1 l/ha	2.16	3.74	2.84	2.913	104.4	0.122
Icyactive – 1 l/ha + N_{120}	4.01	4.78	4.03	4.302	154.1	1.511
Icyamin – 3 l/ha	2.27	3.76	2.94	2.989	107.1	0.198
Icyamin – 3 l/ha + N_{120}	4.05	4.89	3.93	4.291	153.7	1.500
Icyactive+Icyamin-1l/ha+3l/ha	2.27	3.89	3.02	3.062	109.7	0.271
Start-up – 3 l/ha	2.31	3.72	3.06	3.034	108.7	0.243
Start-up – 3 l/ha + N_{120}	3.99	4.78	4.12	4.295	153.9	1.504
Fertileader Alfa – 3 l/ha	2.96	3.54	3.16	3.221	115.4	0.430
Fertileader BPK – 3 l/ha	2.26	3.62	3.24	3.039	108.9	0.248
Fertileader Vital 954 - 3 l/ha	2.30	3.90	3.44	3.215	115.2	0.424
Average	2.881	4.054	3.371	3.435	-	-

LSD (foliar feeding x N x year) 0.05; 0.01; 0.001 = 320.9; 423.9; 545.6

LSD (foliar feeding) 0.05; 0.01; 0.001 = 131.0; 173.1; 222.7

LSD (N fertilization) 0.05; 0.01; 0.001 = 65.5; 86.5; 111.4

LSD (year) 0.05; 0.01; 0.001 = 80.2; 106.0; 136.4

LSD (foliar feeding x N) 0.05; 0.01; 0.001 = 185.3; 244.7; 315.0

LSD (foliar feeding x year) 0.05; 0.01; 0.001 = 226.9; 299.7; 385.8

LSD (N fertilization x year) 0.05; 0.01; 0.001 = 113.5; 149.9; 192.9

The productivity increased as a result of the positive influence of foliar and soil nutritions on the structural components of yield. For the studied period the spike length, spikelets per spike, kernels per spike and grain weight per spike increased with the increase of nutrition. The results showed that the decisive influence for increasing the yield was not the grain weight, but the higher number of kernels in a spike and the number of spike-bearing stems per 1 plant. The structural elements of yield increased to a lesser extent in foliar feeding compared to nitrogen fertilization. The structural elements variation was stronger over the year conditions.

From an environmental viewpoint, additional foliar feeding can be successfully combined with nitrogen fertilization in rates of 120 kg/ha, whereat the grain productivity increases. Under the influence of the applied foliar and soil fertilization no negative influence was found in the durum wheat development and productivity.

Delchev (2005, 2006) also reported that foliar fertilizations increased photosynthetic activity and productivity of durum wheat.

The application of foliar fertilizers stimulated the durum wheat growth processes (Table 6). Under the influence of foliar and nitrogen fertilization plant height at the end of vegetation significantly increased with 25.4 % over the water control (86.8 cm) and reached the highest value of 108.8 cm under Icyamin + N₁₂₀. The height of the plants after liquid fertilizers without N application exceeded the control average for the period by 7.2-12.0 %. In 2009 the plants were characterized by a low height in maturity – an average of 93.2 cm, while in the remaining two years the mean values were 100.1 and 101.8 cm, respectively. In 2010 the height reached a maximum value - 112.3 cm under tested Start-up application together with N₁₂₀.

From the physical properties of grain, test weight is an indirect classification parameter, normally in direct correlation with flour output, a criterion for the healthy state of durum wheat. It is desirable that the test weight is over 78 kg.h⁻¹. In western Canada, grain samples of top grade (No. 1) Canada Western Amber Durum wheat must contain at least 80 % hard vitreous kernels and have a test weight of 80 kg.h⁻¹ or higher (May et al., 2008).

Average for the 3-year period, the test weight without fertilization was 79.70 kg (Table 7). The test weight values under the influence of the tested fertilizers were good – an average of 80.04 kg and ranged from 79.97 to 80.23 kg, i.e. exceeded the requirements of the standard. It is formed mainly under the influence of weather conditions without proven influence of applied N and foliar fertilizers, with significant differences in years. Under the influence of the favorable combination of temperature and precipitation the values were highest in 2008 - an average of 81.62 kg, and lowest in 2010 - 78.48 kg, under the influence of heavy rainfall in June.

Table 6. Effect of fertilization on height of plants in maturity (cm), 2008-2010

Treatment	Year			Average	
	2008	2009	2010	cm	%
Water check	82.0	79.4	99.0	86.78	100.0
N ₁₂₀ - St	100.2	105.5	112.0	105.88	122.01
Icyactive - 1 l/ha	101.2	83.9	98.4	94.50	108.90
Icyactive - 1 l/ha + N ₁₂₀	103.0	109.8	109.2	107.30	123.65
Icyamin - 3 l/ha	104.8	87.7	97.4	96.65	111.37
Icyamin - 3 l/ha + N ₁₂₀	105.8	111.4	109.3	108.82	125.40
Icyactive+Icyamin-1+3 l/ha	102.2	88.5	95.5	95.38	109.91
Start-up - 3 l/ha	99.9	85.2	94.6	93.25	107.46
Start-up - 3 l/ha + N ₁₂₀	102.0	108.8	112.3	107.72	124.13
Fertileader Alfa - 3 l/ha	100.5	91.6	99.6	97.23	112.04
Fertileader BPK - 3 l/ha	100.8	82.4	97.5	93.58	107.84
Fertileader Vital 954- 3 l/ha	98.5	83.8	96.8	93.03	107.20
Average	100.1	93.2	101.8	98.35	-
LSD (foliar feeding x N x year) 0.05, 0.01, 0.001 = 11.6; 16.4; 19.5					

Table 7. Test weight for durum wheat grain at fertilization (kg.h⁻¹), average for 2008-2010

Treatment	Year			Average	
	2008	2009	2010	kg	%
Water check	81.1	79.8	78.2	79.70	100.00
N ₁₂₀ - St	81.9	79.5	79.2	80.20	100.63

Icyactive - 1 l/ha	81.5	80.3	78.2	80.00	100.38
Icyactive - 1 l/ha + N ₁₂₀	81.8	79.8	78.6	80.07	100.46
Icyamin - 3 l/ha	81.5	80.8	78.4	80.23	100.67
Icyamin - 3 l/ha + N ₁₂₀	82.1	79.9	78.1	80.03	100.42
Icyactive+Icyamin-1+3 l/ha	81.6	80.5	77.8	79.97	100.33
Start-up - 3 l/ha	81.7	80.0	78.3	80.00	100.38
Start-up - 3 l/ha + N ₁₂₀	81.5	79.7	78.8	80.00	100.38
Fertileader Alfa - 3 l/ha	81.8	80.0	78.4	80.07	100.46
Fertileader BPK - 3 l/ha	81.9	80.2	78.2	80.10	100.50
Fertileader Vital 954 - 3 l/ha	81.1	79.9	79.5	80.17	100.58
Average	81.62	80.03	78.48	80.04	-
LSD 0.05	1.02	0.89	0.76	0.94	

Grains of the durum wheat cultivar Progress during the same period were distinguished by high 1000 kernel weight - an average of 56.34 g (Table 8). After two-fold foliar feeding the 1000 kernel weight increased and reached 57.7 g after fertilization with Fertileader Vital 954, with 2.5 % over the control (56.3 g), but decreased after N fertilization due to higher number of kernels in a spike. The weather conditions greatly affected the 1000 kernel weight. The values in 2009 were very high, ranging from 59.8 to 62.1g, and in 2010 they were 50.4-55.0g.

Vitreousness is a parameter reflecting the grain structure with a proven impact on the yield and partial size of the meal, the extent of starch damage, ash and protein content and stability of yellow pigments.

Table 8. Effect of fertilizers on the 1000 kernel weight of durum wheat grain (g), 2008-2010

Treatment	Year			Average	
	2008	2009	2010	g	%
Water check	56.9	61.4	50.6	56.30	100.0
N ₁₂₀ - St	53.9	60.3	53.0	55.70	98.9
Icyactive - 1 l/ha	54.8	61.3	51.4	55.84	99.2
Icyactive - 1 l/ha + N ₁₂₀	54.0	60.7	53.0	55.91	99.3
Icyamin - 3 l/ha	57.9	62.2	50.4	56.83	100.9
Icyamin - 3 l/ha + N ₁₂₀	54.2	60.2	54.8	56.43	100.2
Icyactive+Icyamin-1+3 l/ha	55.4	61.5	51.1	55.99	99.4
Start-up - 3 l/ha	57.2	62.1	51.1	56.77	100.8
Start-up - 3 l/ha + N ₁₂₀	54.5	59.8	53.3	55.87	99.2
Fertileader Alfa - 3 l/ha	55.5	60.7	52.5	56.23	99.9
Fertileader BPK - 3 l/ha	56.0	61.6	52.0	56.53	100.4
Fertileader Vital 954 - 3 l/ha	56.7	61.4	55.0	57.71	102.5
Average	55.6	61.1	52.4	56.34	-
LSD 0.05	1.48	1.90	1.12	1.21	

The yellow berry grains are generally with lower protein content. High-quality durum wheat has more than 75-80 % vitreousness. The total average vitreousness in the period varied from 56.0 to 80.6 % (Table 9). Higher vitreousness was formed in 2008 - 64.8-86.3 %, when during the maturity stage the weather conditions were dry, with temperatures higher than average. Positive changes were found in all the years in the period, regardless whether they were wet or dry. Studies strongly supported the positive influence of nitrogen fertilization, proven that at $P \leq 0.01$. At N_{120} vitreousness increased with 36.4 % to 43.9 % compared to water control. Positive development was found in all years of the period, whether they were provided with enough rainfall or dry. Average for the period under the influence of foliar feeding the values were low and vitreousness was highest under Start-up - 63.8%, with 13.9 points compared to the unfertilized.

The technological parameters were strongly influenced by the N and foliar application (Table 9). The contents of protein and gluten were important indicators for quality of the grain intended for pasta products. The crude protein, wet and dry gluten in grain, average for the period for the grain of check, were 12.7%, 25.7% and 9.5%, respectively. The fertilization with liquid fertilizers was an additional factor for stabilizing the technological properties of durum wheat grain. The protein and wet gluten content increased with 1.5-8.7 % and 0.8-4.5 % after foliar fertilizers, and with 22.0-30.7 % and 17.9-25.7 % over the check under nitrogen and foliar application. The data confirmed that nitrogen fertilization was decisive for the protein content. Start-up at doze 3 l/ha had a better positive effect in terms of quality of the grain of the tested liquid fertilizers.

Values changed significantly under the influence of conditions over the years, but were not very high, due to rainfall in June and July, which worsened the grain quality. In 2010 the wet gluten values were significantly lower - 22.4-29.1 % while in 2008 and 2009 were in the range 24.8-34.4 %.

Table 9. Influence of fertilizers on the quality properties of durum wheat grain,
average for 2008-2010

Treatment	Vitreousness (%)	Crude protein (%)	Wet gluten (%)
Water check	56.0	12.7	25.7
N_{120} – St	76.4	15.5	30.3
Icyactive - 1 l/ha	58.6	12.9	25.9
Icyactive - 1 l/ha + N_{120}	79.4	15.8	31.4
Icyamin - 3 l/ha	59.8	13.1	25.9
Icyamin - 3 l/ha + N_{120}	80.6	16.4	31.9
Icyactive+Icyamin-1+3 l/ha	61.2	13.6	26.9
Start-up - 3 l/ha	63.8	13.8	26.9
Start-up - 3 l/ha + N_{120}	80.2	16.6	32.3
Fertileader Alfa - 3 l/ha	56.2	13.4	26.3
Fertileader BPK - 3 l/ha	57.4	13.2	26.2
Fertileader Vital 954- 3 l/ha	62.8	13.5	26.7
LSD 0.05	7.1	1.12	4.07
LSD 0.01	9.7	1.54	5.37
LSD 0.001	12.7	2.14	6.90

4. CONCLUSIONS

Under foliar feeding the average grain yield increased with 4.4 to 15.4 % over the check. The yields exceeded the check with 53.7 to 54.1 % after combined foliar spraying and nitrogen fertilization and reached 4.30 t.ha⁻¹ at Icyactive + N₁₂₀.

Under the influence of foliar and nitrogen fertilization, the plant height at the end of the vegetation exceeded with 25.4 % compared to the water check and the test weight which ranged from 79.97 to 80.23 kg.hL⁻¹. The 1000 kernel weight reached 57.7 g after Fertileader Vital 954, 2.5 % over the control, but decreased after N fertilization due to a higher number of kernels in a spike. Vitreousness increased with 36.4-43.9 % compared to check, the crude protein content - with 22.0-30.7 % and wet gluten - with 17.9-25.7 % over the water control.

The data showed that the two-fold foliar feeding improved growth, yield and grain quality of durum wheat and was effective agronomic activities. The liquid fertilizers can be successfully used for durum wheat feeding. A very good effect was manifested by Icyactive, Fertileader Alfa and Start-up.

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