Journal of International Scientific Publication:
Materials, Methods & Technologies, Volume 4, Part 1

EFFECT OF SOIL FERTILITY AND DIRECT NITROGEN FERTILIZATION ON THE DURUM WHEAT VARIETIES IN THE CONDITIONS OF CENTRAL SOUTHERN BULGARIA

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Abstract

The purpose of this study was to investigate the influence of nitrogen fertilization on the productivity and seed characteristics of four Bulgarian durum wheat varieties and various parameters of soil fertility, caused by the fertilization of the predecessor cotton in the crop-rotation. The research was carried out on the test field of the Cotton and Durum Wheat Research Institute, Chirpan, Bulgaria in cotton-durum wheat crop-rotation under non-irrigated conditions. In a three-factor experiment with N rates - 0, 60, 120 and 180 kg/ha for durum wheat on three backgrounds, formed by fertilization of cotton predecessor with 0, 80 and 160 kg/ha, was traced the N influence on the crop yield and physical properties of four durum wheat varieties: Zagorka, Progres, Beloslava and Vuzhod. The yield plot for the previous cotton fertilization was 200 m^2 and for the direct N fertilization - 10 m^2.

The received crop yield was significantly influenced by the fertilization. Average for the period the varieties yield ranged from 5165 kg/ha (Progress) to 5370 kg/ha (Vuzhod). Direct fertilization with N_{180} on a moderate background formed yield of 5810 kg/ha average for the varieties, followed by N_{120} - 5797 kg/ha. Fertilization with high N rates, here N_{180}, in poor soil lead to 5628 kg/ha yield, i.e. the high N rate does not compensate the N insufficiency in the soil. The influence of the tested factors was very well demonstrated. Previous N fertilization influences the crop yield with 12.8 %, direct N fertilization- 26.8 %, while their interaction- 8.7 %, i.e. 48.3 % of the formed yield was caused by the N fertilization. The variety's influence is 1.02 %.

From the physical properties of grain the vitreousness was significantly influenced by N rates and soil N fertility and at fertilization with $N_{60\text{-}180}$ it increased with 28.2-78.8 %. The 1000 kernel weight was from 45.5 g (Beloslava) to 56.8 g (Progress). The effect of direct N nutrition was stronger than previous fertilization.

Key words: *durum wheat, variety, nitrogen, yield, test weight, 1000 kernel weight, virtuousness.*

1. INTRODUCTION

Durum wheat (*Tr. Durum Desf.*) takes up approximately 8 % of the world's wheat production. In the last years Bulgaria has increased its grain growing from this crop and has increased the consumption of durum wheat products. The biology of durum wheat and the need to increase the productivity require application of optimal fertilization rates complied with the region and field specifics.

Most research on wheat fertilization refers mainly to common wheat and only a limited number of them are on durum wheat, though not to the present-day most widespread intensive varieties.

In the last two decades the Bulgarian varieties have given comparatively stable yield and good quality parameters in the various agroecological regions of both Northern and Southern Bulgaria. Due to a

number of biological peculiarities such as a slower rate of development in spring, weak reaction to the shortened autumn day, etc. the durum wheat endures later sowing, and for that reason is successfully grown in crop-rotation with cotton.

The productivity and quality of field crops, including durum wheat, varies to a wide range in dependence of a number of factors: agroecological conditions, genetic potential of the cultivar, crop-rotation, soil fertility, applied fertilization, cultivation technology, etc. (Delchev, 2005; Koleva-Lizama and Panayotova, 2002; Lalev et al., 2000; López-Bellido, 2001; Panayotova, 1996, 1998, 1998 b; Saldzhiev, 2002; Panayotova and Genov, 2005;). Weather conditions in the years and applied fertilizers exert great influence on the grain yield of durum wheat (Delchev, 2003; Ricciardi, 2001). In order to obtain normal durum wheat yield are necessary a number of conditions, which directly or indirectly influence the growth and development in different vegetation periods. The differences between the biological requirements of the plants at a certain stage of their development and the conditions they are grown under, give rise to unfavourable stress situations.

The need to protect the environment has largely influenced the agricultural policy measures taken by the European Union. Stability over different weather conditions is a desirable characteristic of the cultivars. The application of such agrotechnical methods and varieties that would guarantee high levels and stability of the economic parameters under different environmental conditions is of importance for breeding and production. Durum wheat genotypes must be adapted for a wide range of environmental stress. Maintaining or improving the soil fertility has a high priority in agriculture and is closely connected with soil properties. Optimizing the mineral nutrition is one of the most important conventions for a favorable growth and production of the plants, for ensuring their need of nutrient elements, for increasing the soil richness. The fertilization of durum wheat grown after cotton should be complied with the fact that a significant part of the nitrogen for cotton, is not utilized by it, but remains in the soil. The two cultures are successfully developed in crop-rotation and when fertilized actively participate in the nutrient utilization (Panayotova, 1999).

A number of studies (Ghabri and Boubakri, 1998; Panayotova and Dechev, 2002; 2003; Panayotova and Yanev, 2001; Pacucci et al., 2004) establish fertilization efficiency for varieties with different genetic endowments in different soil fertility. Panayotova (2001) appoints a genotype specific in relation with grain yield depending on the nutrition level. It is generally acknowledged that the varieties vary in their responsiveness to nitrogen accumulation in the vegetative parts.

Panayotova and Dechev (2004) established, that to form 100 кg grain from durum wheat under fertilization rate of $N_{60\text{-}180}$ some 30.5-43.7 кg N are utilized. An optimal yield is formed under fertilization rate of $N_{10\text{-}14}$, but as having high breeding and agronomical value in regard with a simultaneous assessment for yield and stability in years of different meteorological conditions stands out N_{90}, average for the tested genotypes **(**Panayotova and Dechev, 1997). Nitrogen fertilization will continue to be the main factor for high productivity. The main requirement for high yield, combined with good grain quality is for the plants to receive an optimal amount of nitrogen during vegetation (Schillingb et al., 2003).

The effect of 1 kg N is high under fertilization with $N_{6\text{-}12}$ (13.6-17.3 kg grain) and gets lower with increasing the nitrogen rate. (Panayotova and Kostadinova, 2004). Often the high fertilization rates lead to obtaining negative results and lead to increase of the economic losses in production.

Many studies have been conducted to examine the effects of N fertilizers and preceding crops on cereal grain yield. Some authors (Bauer, A. et al., 1987; Kostadinova and Tomov, 2003) reported that the increasing N rate and rich soil fertility enhanced the content of grain protein and N in the straw. The responsiveness of different cultivars to N accumulated in the vegetative plant parts was

established (May et al., 2008; Panayotova, 1998a). According to Schulthess et al. (1993) the N content in the grain correlated significantly with the environment conditions.

Stability of grain is an interesting feature of today's durum wheat breeding programmes, due to the high annual variation in both grain yield and quality. Breeding cultivars of high productivity and stability is the main breeding goal. Genotypic differences in nutrient utilization have been documented in wheat (Mohammadi and Amri, 2009; Panayotova et al., 2006). These differences have been attributed to both differences in the acquisition and the efficiency of use of nutrients between cultivars (Inthapanya et al., 2000). Rharrabti et al. (2003) described the genotype × environment (G×E) interaction, defined stable durum wheat genotypes in relation to the seven quality parameters and demonstrated that the varieties vary in their requirements to the environment

From practical standpoint stability statistics and genotype performance (yield) need to be integrated. Genotype x environment interaction (GEI) continues to be a challenging issue among plant breeding, genetics and production agronomists who conduct crop performance trials across diverse environments.

The extrapolation of variant method to characterize the stability of agronomic treatments instead of genotypes seems to be practical application in separating the response of treatments depending on environment.

Due to lack of in-depth studies in Bulgaria on nitrogen fertilization of new durum wheat varieties with different parameters of the Leached vertisols soil type in cotton-durum wheat crop-rotation we conducted this study.

2. MATERIALS AND METHODS

The experiment was established in 2006-2008 at the field of the Cotton and Durum Wheat Research Institute, Chirpan, Bulgaria under rainfed conditions. The cropping pattern is winter durum wheat (*Tr. durum Desf.*) – cotton, double cropping system in a two-year rotation. In a three-factor field trial with N rates - 0, 60, 120 and 180 kg/ha for durum wheat on three backgrounds (conditionally specified as poor, moderately and high), formed by fertilization of cotton predecessor with 0, 80 and 160 kg/ha, was traced the nitrogen influence on the crop yield with four durum wheat varieties: Zagorka, Progres, Beloslava and Vuzhod. Split-split-plot design with four replicates was used. The yield plot for the previous cotton fertilization was 200 m^2 (main plots) and for the direct fertilization - 10 m^2. The unfertilized Zagorka variety was accepted for control.

Nitrogen rates for cotton as ammonium nitrate were broadcast preplant by hand and incorporated, and P_2O as triple superphosphate (P_{80} for all plots) was applied after wheat harvest and incorporated at ploughing.

The nitrogen for durum wheat plots was applied two times: one third - at sowing, and the rest as a top dressing at the end of wheat tillering stage.

The seeds were sown on October 25-30, and for each genotype the sowing rate was 400 germinated seeds per m^2. Weeds were controlled between the tillering and shoot elongation stages with herbicides. The harvest with plot combine occurred on July10-15. Site-specific agronomic practices for cotton and durum wheat were applied.

Analyses were made on grain yield (kg/ha), test weight (kg/hl), 1000 kernel weight (g) and virtuousness (%).The test weight was determined with libra, 1000 kernel weight – by weighting two samples with 500 kernels, total virtuousness – by cutting with pharinotom of Heinsdorf.

Soil samples from two replications were collected before durum wheat seeding and after harvest to a depth of 0.60 m.

The data of each studied parameter was analyzed using the split-plot technique for ANOVA. Information about the GEI and NEI was obtained by analysis of variance on the genotype and N effects from each replication and environment (year).

Information about the individual effect and interaction between the genotypes, previous and direct nitrogen fertilization was obtained by analysis of variance. Varieties with the respective direct nitrogen fertilization were analyzed by means of hierarchical cluster analysis for the period.

The cluster analysis for yield was used to obtain dendrogram for grouping of genotypes under moderate soil supply, which is most often seen in production, according to the environment and nitrogen nutrition.

3. RESULTS AND DISCUSSION

Table 1 shows the weather data recorded during the growing season 2006-2008 in relation to the 81-year average. In the durum wheat vegetation period (months X-VI) in terms of temperature sum 2007 was very warm (2813ºC), 2006 and 2008 were moderately warm. As for rainfall supply 2007 was very dry (304.9 mm/m^2), 2006 was moderately dry, and 2008 was wet (531 mm/m^2). From comparing the meteorological conditions in the years of research and those for the long-term period it is seen that there are some fluctuations or both the average monthly temperatures, and regarding the precipitation supply with the deficit being mainly on account of the vegetation precipitation in the most significant stages of the durum wheat development.

The soil type at the Institute region was classified as leached vertisols (FAO), defined by the sandy-clay composition, with high humidity capacity and small water-permeability. The soil has a high-powered humus horizon (70-100 cm), has a compact zone of the profile (united horizon). The analysis before the experiments in 0-30 cm soil layer indicated bulk weight of the arable soil layer – 1.0-1.2 g.cm^{-3} and specific gravity – 2.6-2.7, very high degree of the bases saturation - 93.4-98.8 %. The cation exchange capacity ($T_{8.2}$) was 41.0-46.1 meq/100 g soil, total acidity (exchangeable $H_{8.2}$) was 3.6 meq/100 g soil, no damaging soil acidity and exchangeable aluminum were established. The main soil chemical parameters were measured. The soil in the experimental field was poor to middle provided with mineral N, poorly supplied with available phosphorus and well - with potassium (Table 2). Due to the high humidity capacity the soil is suitable for growing durum wheat, especially in years with lasting drought.

Table 1. Meteorological conditions during the vegetation period (X-VI) of durum wheat, Chirpan

Year	Temperature sum, ºC	Precipitation, mm
2006	2345	384
2007	2813	305
2008	2312	531
1928-2008	2375	440

Table 2. Soil properties in 0-30 cm soil layer of Leached Vertisols, Chirpan

Parameters	Average	Range, from-to
pH	6.1	5.7-6.6
Humus, %	2.25	1.35-2.90
Total N, %	0.10	0.08-0.13
Mineral N, mg/kg	28	22-36
Total phosphorus, %	0.09	0.05-0.11
Available P_2O_5, mg/kg	35	15-52
Available K_2O, mg/kg	240	220-280

The influence of the tested factors was very well demonstrated (Table 3). The results of the analysis of variance showed very significant differences among the direct nitrogen fertilization (N), previous N fertilization (F), environments - in this case year (E), as well as FNI. The mean squares due to years were significant at the 0.001 level of probability. There were no significant effects of the genotype (G) on grain yield, as well as on the FGI and GNI interactions, which shows that during the studied period the varieties have responded one-way to the applied nitrogen levels. The years strongly influence on the grain yield – 7.51 % of the total variation. The detected high FNI ($P < 0.01$) proved strong influence of N rates (8.70 %) on the tested genotypes at created different soil fertility. Previous N fertilization influenced the crop yield with 12.8 %, direct N fertilization appeared as the strongest source of variation - 26.8 %, while their interaction- 8.7 %, i.e. 48.3 % of the formed yield was caused by the N fertilization. The variety's influence is 1.02 %.

The received grain yield changed significantly during the studied years as influenced by fertilization and variety (Table 4). The average yield varied from 487.2 kg/da in 2008 to 577.4 kg/da in 2007, i.e. the meteorological conditions exerted a significant influence. Average for the period the yield by varieties was from 516.5 kg/da with Progress to 537.3 kg/da with Vazhod. By increasing the N level the productivity increased in average for the varieties from 381.5 kg/da (N_0 на poor soil background) and reached 551.5 kg/da (with N_{18} on rich background). For all fertilization rates we see the increase of yield by cultivars as compared with the control, with the differences being well proven by years and for the period. For the period the yield was maximum at fertilization of the Zagorka and Vazhod varieties with N_{18} at moderate background, increased control respectively with 16.0 and 15.8 %.

Table 3.Analysis of variance for grain yield of durum wheat genotypes at nitrogen nutrition, average for 2006-2008

Source of variation	d.f.	Sum of squares	Sum of squares, %	Mean squares	F
Total	143	905408	100.00	-	-
Replications (Years)	2	67960	7.51	33980***	8.58
F - Previous N treatment	2	116216	12.84	58108***	14.66
G - Genotype	3	9244	1.02	3081	0.78
N – Direct N rates	3	242356	26.77	80785***	20.39
F × G	6	5252	0.58	875	0.22
F × N	6	78804	8.70	13134**	3.31
G × N	9	5900	0.65	655	0.16
F × G × N	18	7228	0.80	401	0.10
Error	94	372448	41.14	3962	-

; * - significant at the $P < 0.01$ and 0.001 level of probability, respectively

Table 4. Grain yield for durum wheat genotypes at previous and direct nitrogen fertilization, average for 2006-2008, kg/da

Previous fertilization	N торене на твърда пшеница, kg/da				Average
	N_0	N_{60}	N_{120}	N_{180}	
Variety Zagorka					
N_0	372	472	534	582	490
N_{80}	486	515	578	597	544
N_{160}	523	570	586	567	561
Average for direct fertilization	460	519	566	582	532
Progress					
N_0	383	471	530	543	482
N_{80}	498	551	562	561	543
N_{160}	475	550	551	522	533
Average	452	524	548	542	516
Beloslava					
N_0	383	475	534	573	491
N_{80}	487	556	588	578	552
N_{160}	539	569	572	561	560
Average	470	533	565	571	535
Vazhod					
N_0	388	488	558	553	497
N_{80}	501	528	590	587	560
N_{160}	531	585	579	556	559
Average	473	534	576	565	537

GD (previous N) ***5 %; 1 %; 0.1 % = 25.5; 33.8; 43.6 (***)***

GD (direct N) ***5 %; 1 %; 0.1 % = 29.5; 39.0; 50.4 (***)***

GD (variety) ***5 %; 1 %; 0.1 % = 29.5; 39.0; 50.4 (n.s.)***

GD (interaction) 5 %; 1 %; 0.1 % = 102.0; 135.1; 174.6 (***)

At moderate background average for genotypes direct N_{18} fertilization formed a yield of 581.0 kg/da, followed by fertilization with N_{12}– 579.7 kg/da, but the differences were statistically insignificant. The annual fertilization with high nitrogen rates, in this case N_{18}, in a case of poor soil leads to obtaining 562.8 kg/da grain, i.e. the high N rate does not compensate the shortage of nitrogen in the soil. The reaction of durum wheat to direct nitrogen fertilization was more strongly expressed as compared with the previous nitrogen levels, whereat the effect of either factor is reduced with the increased level of

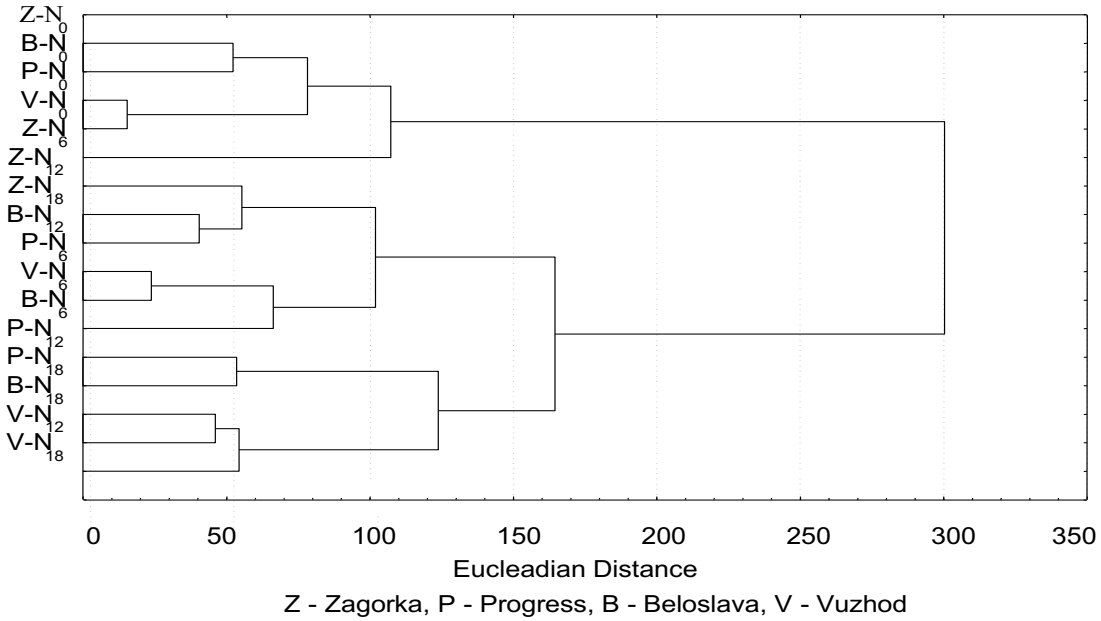
the other one. Nitrogen fertilization with 12 kg/da increased yield and stability for all cultivars. This is the optimal rate for Progress and Beloslava, whereat with Zagorka and Vazhod the yield increased to N_{18}. With the Progress variety was established partial lodging at fertilization with N_{12} and full at N_{18}, which led to the lower yields.

In years with insufficient precipitation during the vegetation period certainty, in late sowing and late germination it is recommended to fertilize with moderate nitrogen rates. A higher yield was formed as compared to durum wheat fertilized with high fertilization rates. The combination of rich nutrition with drought and high temperatures during the critical stages of plant development depressed plants and reduced yield. The influence of precipitation is considerably better expressed than the temperature sum.

Producers who work with similar soil types that fit into the lower yielding environmental mean range, conceivably due to lower average yearly precipitation, distribution, and/or other environmental factors, may benefit limited use of nitrogen fertilizers if the yield is expected to be unfavourable.

The dendrogram of cluster analysis (Fig. 1) showed that the studied variants (genotype × N rate) were clustered in two basic groups. The cluster was distinguished in which went all genotypes without N fertilization and Zagorka × N_6. These variants had the lowest yields and were the most unstable. Including of Zagorka × N_6 here showed that this N level was low for the yield change of this genotype and was not increased its stability.

Fig. 1. Dendrogram of durum wheat varieties yield at N-fertilization 2006-2008



Z - Zagorka, P - Progress, B - Beloslava, V - Vuzhod

In the second cluster were included all variants with N fertilization, collected according to the yield, but in the average results was accumulated and genotypes × N stability. In this cluster the group was dissociated with Zagorka × $N_{12\text{-}18}$ and Beloslava × N_{12}, with the highest stability. These variants were determined as most valuable because possessed high yield potential at different environment

conditions. Progres, Beloslava and Vuzhod with 6 kg N/da were separated in an independent group with good stability.

In the third cluster were variants with higher nitrogen fertilization – 12-18 kg/da, which are economically low effective and yields which most vary in the different years.

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 hL^{-1} or higher (May et al., 2008). From the physical properties in Bulgarian conditions the test weight mean for the 3-year period was very good– from 80.7 to 82.4 kg, i.e. exceeded the requirements of the Bulgarian and international standards (Table 5). However, examining the influence of the various (year with specific conditions, cultivar, previous and direct nitrogen fertilization) were seen significant differences. The year influence was significant – 80.5 % of total variation: the values of test weight were low in 2008 (78.5-81.7 kg), characterized with high moisture supply, while in 2006 and 2007 under the influence of the favourable combination of temperature and precipitation the values were significantly higher – 80.7-84.4 kg. Without fertilization mean for the cultivars during the period was formed grain with very good test weight - 82.08 kg. The values were highest for genotype Zagorka - average 82.1 kg, and lowest for Vazhod – 81.3 kg. The results showed that both the higher soil supply, created by previous fertilization, and the direct nitrogen fertilization, created conditions to reduce the test weight. A high negative correlation (r = -0.944) between direct nitrogen rate and grain test weight was observed. At the same time the regression equation of the dependence (y = 82.204-0.032.N) showed a low value of the regression coefficient.

Table 5. Test weight for durum wheat genotypes at previous and direct nitrogen fertilization, kg/hl, average for 2006-2008

Previous fertilization for cotton	N fertilization, kg				Average for previous fertilization
	N_0	N_6	N_{12}	N_{18}	
Variety Zagorka					
N_0	82.0	82.4	82.4	82.2	82.2
N_8	82.4	82.3	82.1	81.9	82.2
N_{16}	82.0	82.0	81.7	81.6	81.8
Average for direct N	82.1	82.2	82.1	81.9	**82.1**
Progress					
N_0	82.2	82.0	81.7	81.6	81.9
N_8	82.2	82.0	81.4	81.4	81.8
N_{16}	81.7	81.4	81.3	81.1	81.4
Average	82.0	81.8	81.5	81.4	**81.7**
Beloslava					
N_0	82.3	82.1	82.0	81.9	82.1
N_8	82.0	81.8	81.5	81.1	81.6
N_{16}	81.4	81.6	81.1	81.0	81.3
Average	81.9	81.8	81.5	81.3	**81.6**
Vazhod					
N_0	81.8	81.9	81.5	81.5	81.7
N_8	81.6	81.4	81.2	81.1	81.3
N_{16}	81.5	81.0	80.8	80.7	81.0
Average	81.6	81.4	81.2	81.1	**81.3**

Average for the period 1000 kernel weight value was 44.4 to 58.2 g (Table 6) with the values being highest in 2008 – 47.4 to 63.4 g. The meteorological conditions strongly influenced the 1000 kernel weight. Without fertilization average for the cultivars was formed grain with weight of 49.9 g. The direct fertilization with 6 kg N/da on poor to moderate soil supply increased the 1000 kernel weight.

With increasing the N nutrition and with rich soil supply the values lowered but not under the unfertilized durum wheat values. Between the 1000 kernel weight and direct N fertilization existed a high negative correlation (r = -0.930). A tendency was seen for negative interaction with both grain yield (r = - 0.653) and vitreousness (r = -0.734).

Table 6. Influence of previous and direct nitrogen fertilization on the 1000 kernel weight of durum wheat genotypes, average for 2006-2008, g

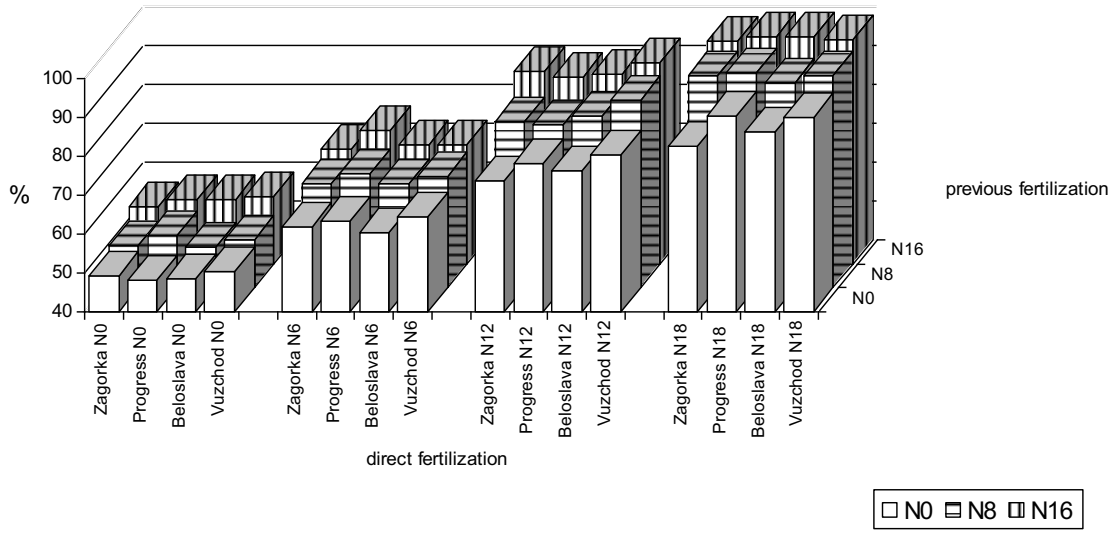
Previous fertilization	N fertilization, kg/da				Average
	N_0	N_6	N_{12}	N_{18}	
Variety Zagorka					
N_0	47.6	49.2	48.0	47.2	48.0
N_8	48.4	48.8	48.6	48.0	48.4
N_{16}	48.6	48.8	47.8	47.0	48.0
Average	48.2	49.0	48.1	47.4	**48.1**
Progress					
N_0	56.2	58.0	58.2	58.0	57.6
N_8	57.6	57.8	56.4	57.6	57.4
N_{16}	56.2	55.8	55.2	54.2	55.4
Average	56.7	57.2	56.6	56.6	**56.8**
Beloslava					
N_0	44.4	44.8	45.4	45.8	45.1
N_8	44.8	45.4	46.2	46.2	45.6
N_{16}	45.6	46.8	45.8	44.8	45.8
Average	44.9	45.7	45.8	45.6	**45.5**
Vazhod					
N_0	51.4	53.0	52.6	52.0	52.2
N_8	53.4	52.6	51.0	50.4	51.8
N_{16}	52.0	51.8	50.4	49.6	51.0
Average	52.3	52.5	51.3	50.7	**51.7**

The dependency with the yield showed that the decisive influence for increasing the yield was not the grain weight, but the higher number of kernels, formed in a spike and the number of spike-bearing stems per 1 plant. The 1000 kernel weight to a great extent depends on the variety and is genetically

endowed – highest for the Progress variety – mean of 56.8 g and going down to 45.5 g for the Beloslava variety.

The total vitreousness mean for the period was 78.3 %, varying from 48.2 to 99.4 % (Fig.2).

Fig. 2. Influence of previous and direct nitrogen fertilization on the grain vitreousness of durum wheat varieties



An exceptionally high vitreousness was formed in 2006 – mean of 82.2 % (69.8-98.3%), when during the maturity stage the weather conditions were mainly dry, with higher than average temperatures. The research emphatically confirms the positive effect of previous and direct nitrogen fertilization, significant at the 0.001 level of probability. The direct N fertilization with 6; 12 and 18 kg/da vitreousness respectively increased with 28.2; 59.6 and 78.8 % compared to the unfertilized under a high correlation coefficient (r = 0.992). Positive changes were found for all years in the period, regardless whether they are wet or dry. Mean for the period the differences by varieties were insignificant with Vazhod having the highest value of 75.9 %.

CONCLUSIONS

The received durum wheat grain yield changed significantly during the studied years - from 487.2 kg/da in 2008 to 577.4 kg/da in 2007. The increasing N rate increased the productivity and reached mean for the cultivars from 381.5 kg/da (N_0 on poor soil background) to 551.5 kg/da (with N_{18} on rich background). The wheat reaction to direct nitrogen fertilization was more clearly expressed in comparison with the one to previous N application, whereat the effect of either of these factors was reduced with the increase of the level of the other.

The Bulgarian varieties of durum wheat formed high yield with very good stability at fertilization with N_{12} at moderate soil supply. Mean for the period by cultivars was formed a yield from 516.5 kg/da for Progress to 537.3 kg/da for Vazhod. A higher breeding and agrotechnical value stood out with Zagorka × N_{12-18} and Beloslava × N_{12}. The Zagorka variety requires nitrogen fertilization over N_6.

In conclusion we can emphasize that the evaluation conducted on yield and stability provides an objective, characteristic of the studied genotypes and applied nitrogen rates in different years can be successfully used in dependence of the breeding and production purposes. The cluster analysis may be used for grouping genotypes according to the environment, including nitrogen nutrition.

With regard to the grain physical properties, the 1000 kernel weight mean for the cultivars was from 45.5 g for Beloslava to 56.8 g for Progress. The high N rates and rich soil supply did not form higher test weight and 1000 kernel weight, regardless of variety or year conditions. The vitreousness was influenced to a greater extent by N fertilization. Under the influence of $N_{6\text{-}18}$ the vitreouslness increased with 28.2-78.8 % compared to the unfertilized.

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