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INFLUENCE OF NPK FERTILIZATION ON GRAIN YIELD AND SOME COMPONENTS OF DURUM WHEAT (*Triticum durum* Desf.)

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Abstract

*The aim of the study was to determine the influence of different levels of mineral fertilizing, individual and combined, on grain yield and some structural elements of productivity. In the field experience for the period 2016-2018 the following mineral fertilization levels were used: N and P - 0, 40, 80, 120 and 160 kg/ha; K - 0 and 80 kg/ha. A maximum increase in the values of the studied parameters was established at the following fertilization rates: number of grains per spike at $N_{160}P_{160}$; grain weight at $N_{80}P_{160}$; length of spike at $N_{160}P_{120}$; spikelets number per spike at N_{120}; plant height at N_{120}. Highest grain yield was reported at $N_{160}P_{80}$. Correlation analysis showed a strong and proven connection between grain yield and the traits surveyed. The strongest correlation connection was between the number of grain per spike and the grain weight (r = 0.789**).*

Key words: *grain yield, NPK fertilizing, triticum durum, yield components*.

INTRODUCTION

Durum wheat is cultivated in our land even before the establishment of the Bulgarian state. The genotype comes from Abyssinia and North Africa (Semkova, 2013). In Bulgaria is transported from Minor Asia and Greece (Lalev et al., 1995.). *Triticum durum* is important raw material for the food industry. It is an important sours of human nutrition and serves as the raw material of numerous food such as couscous (North Africa), pasta (Europe) and bulgur (Middle Eastern) in the alimentation of the world population (Hannachi et al., 2013). Durum wheat (*Triticum turgidum* L. subsp. *durum* (Desf.) Husn.) is cultivated over more than 13 million hectares worldwide and Italy is main European producer with 3.5 milion tons per year (Ferrise et al., 2010).

With the nascency of agriculture the man has begun to apply fertilization as a mean for management of productions. The reutilization is a major factor and indicator for the efficiency of the agricultural production (Nogalskaetal, 2012). Nitrogen is a major nutrient needed to attain optimal grain yield in all environments (Mahjourimajd et al., 2016). Other scientists also have investigated the active influence of the nitrogen fertilizer. (Kostadinova & Panayotova, 2002), have found that its annex has the greatest importance on yield. Studies by Gauer et al., 1992 and Ehdaie and Waines, 2001, also confirms that N is the major nutrient influencing grain yield. On the other hand, to increase crop yield, nitrogen fertilizers have been indiscriminately used, which possesses an immense threat to environment and human health by polluting the air, water and soil (Savci, 2012). Studies of Eichner (1990), Bouman (1994) and Cole et al. (1996) have shown increasing N_2O emissions with an increasing application rate of N fertilizers. The global demand for N has been increasing and was predicted 112 million tons in 2015, indicating the reliance of world food and fiber production on N inputs (FAO). However, adequate food supplies at world level seem difficult to maintain without fertilizer application (Tilman et al., 2002). These preconditions require nitrogen fertilization to be well balanced with the phosphorus and potassium content of the soil and provide the necessary quantities to form the planned yields, including nitrogen losses, in case of leaching (Lalev et al., 1995). Making accurate N fertilizer recommendations can improve fertilizer efficiency, reducing unnecessary input cost to wheat producers (Arregui et al., 2006). The aim of the study was to determine the influence of different levels of mineral fertilizing, individual and combined, on grain yield and some structural elements of productivity of durum wheat cultivar Progress.

MATERIALS AND METHODS

The test was conducted at the Field Crops Institute - Chirpan, Bulgaria (42° 11'58 "N, 25 ° 19'27" E) (Figure 1).

Figure 1. Location of Chirpan, Bulgaria

In 1966 along term field trial was started to conduct, investigating the influence of different levels of mineral fertilization and the rates of nitrogen, phosphorus and potassium fertilizers on the yield and the quality of durum wheat (*Triticum durum* Desf.). The data presented are for the period 2016, 2017 and 2018. The experiment was based on the block method, in four replications, in two-sided rotation cotton - durum wheat. Five normsof nitrogen and phosphorus fertilization were applied (kg/ha) - N_0, N_{40}, N_{80}, N_{120}, N_{160}, P_0, P_{40}, P_{80}, P_{120}, P_{160}, nine combinations of nitrogen-phosphorous fertilization (kg/ha) - $N_{80}P_{40}$, $N_{80}P_{80}$, $N_{80}P_{120}$, $N_{80}P_{160}$, $N_{120}P_{80}$, $N_{120}P_{120}$, $N_{160}P_{80}$, $N_{160}P_{120}$, $N_{160}P_{160}$, and complex application of $N_{120}P_{120}K_{80}$. For control was used $N_0P_0K_0$. The phosphorus and potassium fertilizers were incorporated in the main soil tilling in the autumn, and the nitrogen fertilizer was introduced early in the spring, during the tillering.

The soil of the experimental field of the Field Crops Institute is PellicVertisols (Vp.). The soil is characterized by humidity horizon of 80-115 cm, the structure is crumbly-grained to prismatic in its lower part. In the one-meter layer the humus stock is about 300 t/ha. The soil reaction ranges from pH 6.5-7.4.

The following traits were examined: plant height (cm); number of grains per spike; grain weight (g); spike length (cm); number of spikelets per spike; grain yield (kg/ha).

In the first year, rainfall was higher than the multi-year period (Figure 2). In December the rainfall for the multi-year period was 54.0 mm compared to 2015 (1.3 mm). In June, the rainfall for the multi-year period was 65.4 mm, which was 50.4 mm more than that in 2016. Average temperatures for February (8.1°C), April (14.7°C) and June (22.7°C) were higher than these of the multi-year period, respectively: 2.2°C, 12.2°C and 20.9°C.

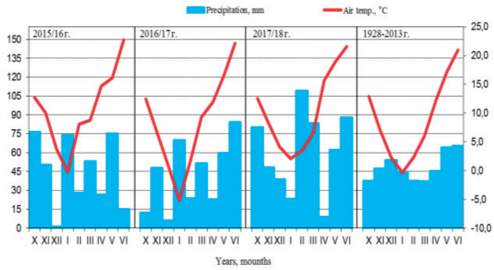

Figure 2. Precipitation and temperature during durum wheat vegetation

In the second year, December had much lower rainfall value (5.9 mm) compared to the multi-year period (54.0 mm). The months of March and June were wet, 14.3 mm and 18.9 mm above the climate norm.Average temperature in January was lower by 4.8°C in comparison to the multi-year period. March and June were warmer, with 3.3°C and 1.2°C, respectively.

In the third year of the study the months of December (with 42.5 mm), February (with 71.3 mm), March (with 46.4 mm) and June (to 22.5 mm) were with higher amounts of rainfall than the climate norm. April was characterized by much lower value (8.7 mm), at average of 45.2 mm for the multi-year period. The average daily temperature was higher than the climate norm: December with 1.9°C, January with 1.7°C and April with 3.5°C.

Analysis of the variance (ANOVA) was applied to establish statistically significant differences (LSD) with the least significant difference of 0.1%. Data correlation was determined with the software Statistica 13.0 (TIBCO, Software, 2018).

Abbreviations:GY - grain yield; NGS - number of grain per spike; GW - grain weight; LS -

length spike; SNPS - spikelets number per spike; PH - plant height.

RESULTS AND DISCUSSIONS

Table 1 presents date of the grain yield (kg/ha), the number of grains per spike and the grain weight (g) averaged over the test period.

Without fertilization, durum wheat achieved an average GY of 1,899 kg/ha. The analysis of dispersion showed that the values of GY with the introduction of P fertilization was not significant compared to the control variant. The tested rates had a negative effect, as a result of which the GY decreased and was lower than the control variant. The lowest GY was obtained at a rate of P_{40} - 1,682 kg/ha, which was 217 kg/ha less than the variant without fertilization. The highest value was obtained with P_{120} - 1,868 kg/ha, which was 31 kg/ha under control variant. In comparison to this study, Grant and Bailey (1998) have reported positive impact of the use of P fertilizers, but with negligible effect, evenin the case of increased norms. François et al. (2009) also have found a higher grain yield under the influence of P, but the difference was not statistically significant.

Table 1. Grain yields (kg/ha), number of grain per spike and grain weight (g) average 2016-2018

Fertilization rates, kg/ha		GY, kg/ha	% St	NGS	% St	GW, g	% St
$N_0P_0K_0$		1,899	100.0	23.5	100.0	1.24	100.0
P_{40}		1,682^{ns}	88.6	30.1***	128.1	2.06***	166.13
P_{80}		1,650^{ns}	86.9	34.8***	148.1	1.95***	157.26
P_{120}		1,868^{ns}	98.4	34.5***	146.8	1.84***	148.39
P_{160}		1,790^{ns}	94.3	36.8***	156.6	1.97***	158.87
N_{40}		2,535*	133.5	35.0***	148.9	2.10***	169.36
N_{80}		3,057***	161.0	36.9***	157.0	2.45***	197.58
N_{120}		3,150***	165.9	40.2***	171.1	2.28***	183.87
N_{160}		3,076***	162.0	**41.6*** **	**177.0**	2.40***	193.55
$N_{80}P_{40}$		3,296***	173.6	36.3***	154.5	2.06***	166.13
$N_{80}P_{80}$		3,294***	170.8	35.1***	149.4	1.91***	154.03
$N_{80}P_{120}$		3,199***	168.5	37.1***	157.9	2.00***	161.29
$N_{80}P_{160}$		3,128***	164.7	39.6***	168.5	**2.47*** **	**199.19**
$N_{120}P_{80}$		3,341***	175.9	38.6***	164.3	2.22***	179.03
$N_{120}P_{120}$		3,344***	176.1	38.4***	163.4	2.26***	182.26
$N_{160}P_{80}$		**3,544*** **	**186.6**	40.9***	174.0	2.40***	193.55
$N_{160}P_{120}$		3,199***	168.5	40.0***	170.2	2.46***	198.39
$N_{160}P_{160}$		3,511***	184.9	42.1***	179.2	2.23***	179.84
$N_{120}P_{120}K_{80}$		3,067***	161.5	40.1***	170.6	2.39***	192.74
Average		2,823	148.7	36.9	157.0	2.14	172.58
LSD	*5%*	*480*	*25.3*	*3.4*	*14.5*	*0.21*	*16.94*
	1%	*642*	*33.8*	*4.6*	*19.6*	*0.28*	*22.58*
	0.1%	*845*	*44.5*	*6.0*	*25.5*	*0.37*	*29.84*

ns: no significant; *, **, ***significant at P = 5%, P = 1% and P = 0.1%

The application of only N fertilizer increased GY. There was a trend for higher values of the trait when the rate was increased to N_{120}. The lowest GY was obtained at rate of N_{40} - 2,535 kg/ha, which was 33.5% above the control. This variant had lowest statistical significant of influence. The remaining three fertilization rates showed slight differences in GY: N_{120} - 3,150 kg/ha, N_{160} - 3,076 kg/haand N_{80} -3,057 kg/ha. Ali et al. (2019) also have found that, with the increasing of the nitrogen rate in the range of 0, 30, 60 and 90 kg N ha, the GY decreased (4.4, 4.5, 4.1 and 4.1 t/ha). Karam et al. (2009) have reported similar results at rate N 100 kg/ha - 3,010 kg/ha, but with increasing of the nitrogen rate to 150 kg/ha, GY was significantly higher than in our study - 3,730 kg/ha.

The combined fertilization with NP in rate of N_{80} led to reduction in GY with increasing of the P rate. The highest value was obtained at the variant with lowest P rate - $N_{80}P_{40}$ - 3,296 kg/ha. The lowest grain yield was reported at the highest P rate - $N_{80}P_{160}$ - 3,128 kg/ha. In a study by Panayotova et al. (2018) the same trend has observed.

The application of $N_{120}P_{80}$ and $N_{120}P_{120}$ led to negligible differences in the values between the two variants. The GY was, respectively 3,341 kg/ha and 3,344 kg/ha. The data obtained were in contradiction with the study of Almaliev et al. (2014), which have found that the combined fertilization of $N_{120}P_{80}$ is most effective. However, both of variants have the highest statistically influence.
The variant $N_{160}P_{80}$ produced the highest grain yield on average of the three years of research - 3,544 kg/ha, which was 86.6% more than the variant without fertilization. With increasing of the fertilizer rate a decrease in the values of the trait was observed. The GY from highest fertilizer rate in the study ($N_{160}P_{160}$) was 3,511 kg/ha. Like a results have reported Dechev and Penov (2009) under similar fertilization rates.
The incorporation of the K fertilizer resulted in reduction of the values of the studied traits. The obtained GY of 3,067 kg/ha was close to that of nitrogen fertilization. This result is contrary to the results of Plana et al. (2008).
According to Garcia et al. (2013) and Slafer et al. (2014) grain number is the main determinant of yield in grain crops.
P fertilization had a positive effect and increased the values in all four rates. However, the largest NGS was obtained when fertilized with P_{120} - 36.8.
Morino et al. (2009) have found that the increasing of the nitrogen rate increases the NGS. As a result of this regularity, the lowest values in our study were reported at a rate of N_{40} - 35.0, and the highest value was at the variant N_{160} - 41.6 or 77.0% greater than the control. Contrary to these results is the study by Álvaro et al. (2008), which have reported a larger NGS (37.7-37.9), obtained atlower fertilization rate (35 kg N/ha).
The value of variant $N_{160}P_{160}$ was with large number of grains (42.1) among of the different combinations. The fallowing variants were with similar values - $N_{80}P_{160}$ - 39.6, $N_{120}P_{80}$ - 38.6 and $N_{120}P_{120}$ - 38.4. The inclusion of K fertilizer had a positive effect on the values of the studied trait. With the application of $N_{120}P_{120}K_{80}$ was reported 40.1 NGS.
Without fertilization, the obtained value of GW was 1.24 g. The application of fertilizer had a positive effect on the GW. However, the highest value of the trait was in the rate of P_{40} - 2.06 g. The increasing of the dosage had the opposite effect and all variants with higher P rate had lower GW. The application of fertilizer had a positive effect on the GW.
Under the influence of N fertilization, the GW increased compared to the variant without fertilization, as the highest value was recorded at the rate of N_{80} - 2.45 g.
Of the combined NP fertilization, the largest increase in GW was observed at a rate of $N_{80}P_{160}$ - 2.47 g, which was 99.19% above the control. However, the differences between $N_{160}P_{120}$ (2.46 g) and N_{80} (2.45 g) were negligible. Considering the other norms, its hould be noted that fertilization with N_{120} (2.28 g) showed higher values than the combined - $N_{120}P_{80}$ (2.22 g), $N_{120}P_{120}$ (2.26 g) and $N_{160}P_{160}$ (2.23 g). In a study by Kolev et al. (2010) authors have reported a higher GW on the same variety at fertilizer rate $N_{120}P_{80}$ (2.45 g), in the conditions of Central South Bulgaria. Fertilizing with $N_{120}P_{120}K_{80}$ showed a GW of 2.39 g.
The value of LS at P_{40} was not statistically proven, this variant remains with the lowest value - 6.1 cm - 17.3% compared to the control (Table 2). The longest spike was obtained for the variant $N_{160}P_{120}$ (8.3 cm), but the difference between variants N_{160} (8.2 cm), N_{120} (8.1 cm) and $N_{160}P_{160}$ (8.1 cm) was small. When the K fertilizer ($N_{120}P_{120}K_{80}$) was included, the trait values decrease - 8.0 cm.
The NSPS averaged over the test period ranged between 16.8 ($N_0P_0K_0$) and 21.7 (N_{120}). The obtained valuesfor N_{12}exceeds the se of the variant without fertilization with 29.2%. The application of 120 kg/ha N showed better results than high nitrogen and phosphorus levels, although with some differences. Combined fertilization with $N_{120}P_{120}K_{80}$ increased the value with 23.8% compared to the control NSPS (20.8).
The difference between the untreated control and the separately applying of P_{40}, P_{80} and P_{120} on PH averaged over the test period was not statistically proven. The rate of 160 kg/ha P showed little significant influence.
N fertilization showed a high, significant effect on PH. The values for the N_{120} rate were close to these of the combined fertilization $N_{160}P_{120}$ - 102.0 and 102.8 cm, respectively.

N fertilization increased the values of the trait to a greater extend in comparison with P fertilization. The highest NSPS was obtained for N_{120} - 21.7. This variant had the highest average trait of the three years of the study. The highest increase over the control was by 29.2%. At the higher N_{160} rate, the NSPS decreased - 20.7.

Table 2. Leight spike (cm), spiklets number per spike and plant height (cm) average 2016-2018

Fertilization rates, kg/da		LS (cm)	% St	NSPS	% St	PH (cm)	% St
$N_0P_0K_0$		5.2	100.0	16.8	100.0	74.9	100.0
P_{40}		6.1 ns	117.3	18.7*	111.3	83.5 ns	111.5
P_{80}		6.5*	125.0	19.7**	117.3	85.2 ns	113.8
P_{120}		6.6*	126.9	19.6**	116.7	85.2 ns	113.8
P_{160}		6.7*	128.9	20.0***	119.1	86.9*	114.8
N_{40}		7.1**	136.5	20.4***	121.4	95.1***	127.0
N_{80}		7.7***	148.1	20.4***	122.0	100.7***	134.5
N_{120}		8.1***	155.8	**21.7*****	**129.2**	102.0***	136.2
N_{160}		8.2***	157.7	20.7***	123.2	100.4***	134.1
$N_{80}P_{40}$		7.5***	144.2	20.5***	122.0	101.4***	135.4
$N_{80}P_{80}$		7.2**	138.5	19.8***	117.9	101.4***	135.4
$N_{80}P_{120}$		7.5***	144.2	20.7***	123.2	99.9***	133.4
$N_{80}P_{160}$		7.7***	148.1	21.0***	125.0	97.3***	129.9
$N_{120}P_{80}$		7.9***	151.9	20.3***	120.8	**104.4*****	**139.4**
$N_{120}P_{120}$		7.7***	148.1	20.4***	121.4	99.4***	132.7
$N_{160}P_{80}$		8.0***	153.9	20.7***	123.2	99.4***	132.7
$N_{160}P_{120}$		**8.3*****	**159.6**	21.2***	126.2	102.8***	137.3
$N_{160}P_{160}$		8.1***	155.8	21.2***	126.2	99.6***	133.0
$N_{120}P_{120}K_{80}$		8.0***	153.9	20.8***	123.8	99.7***	133.1
LSD	*5%*	*1.2*	*23.1*	*10.1*	*10.1*	*10.6*	*14.2*
	1%	*1.6*	*30.8*	*13.7*	*13.7*	*14.2*	*19.0*
	0.1%	*2.2*	*42.3*	*17.9*	*17.9*	*18.7*	*25.0*

ns: no significant; *, **, ***significant at P = 5%, P = 1% and P = 0.1%

The NSPS varied between 19.8 and 21.2 with combined NP fertilization. The highest NSPS was obtained for variants $N_{160}P_{120}$ and $N_{160}P_{160}$. The complex application of $N_{120}P_{120}K_{80}$ increased the NSPS (20.8) with 23.8% in comparison to the variant without fertilization.

Table 3 presents the correlation coefficients between GY and the studied traits. The GY was in a positive and significant correlation with all tested parameters.

The positive correlations of grain yield with most of the traits suggests that improving one or more of the traits as a result of fertilization could result in high grain yield for durum wheat (Tsegaye et al., 2012).

A strong and proven positive relationship was observed between GY and GW (r = 0.727**). The GY was in a well-expressed positive correlation with the NSPS (r = 0.706**).

A strong and significant correlation was also established between GY and NGS (r = 0.706**). Similar results have reported by Moshin et al. (2009) and Kiliç and Yağbasanlar (2010).

Dogan (2009) also have reported a strong correlation relationship between GY and GW. The strongest correlation relationships in analysis were established between the NGS and the GW (r = 0.789**), as well as between the NSPS and PH (r = 0.767**).

Table 3. Correlation coefficients between the surveyed traits

	GY	*NGS*	*GW*	*LS*	*SNPS*	*HP*
GY	1					
NGS	0.706427**	1				
GW	0.726912**	0.789379**	1			
LS	0.317208*	0.384311**	0.142561	1		
SNPS	0.43862**	0.740955**	0.58123**	0.525163**	1	
PH	0.661388**	0.67464**	0.542148**	0.59104**	0.767041**	1

*5%; **1%; n = 57

CONCLUSIONS

Combined fertilization with $N_{120}P_{80}$ has the highest effect on GY - 86.6% in comparison to the control variant.

Under the influence of $N_{160}P_{160}$ the highest NGS was reported by 42.1% more than the variant without fertilization.

The GW showed the highest values in comparison to the control variant at $N_{80}P_{160}$ of 99.2%.

The LS was most influenced by fertilizing with $N_{160}P_{120}$. This variant exceeds control with 59.6%.

SNSP showed the highest values fertilizing with N_{120}. Under this variant was reported 29.2% an increase over the control variant.

The highest plants were measured by fertilizing with $N_{120}P_{80}$ by 39.4% more than the variant without fertilization.

A hight and significant correlation between GY and the indicators surveyed was established. The strongest correlation relations were between the NGS and the GW (r = 0.789**).

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