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Effect of Previous Crop, Mineral Fertilization and Environment on the Characters of Some Wheat Varieties

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Abstract

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A three-year field trial investigated the effect of previous crop, mineral fertilization and year conditions on grain yield, hectoliter weight and 1000-grain weight on 12 T. aestivum L. varieties. The varieties were grown after three previous crops: bean, sunflower and grain maize. Two levels of nutrition regime were investigated in this study. The applied mineral fertilization depended on the type of previous crop: $N_0P_0K_0$ and $N_6P_6K_0$ after bean, and $N_0P_0K_0$ and $N_{10}P_{10}K_0$ after the other predecessors. The factors fertilization and year conditions were decisive for expression of productivity. Mineral fertilization had the highest effect on grain yield. Hectoliter weight was affected mostly by the year conditions and the genotype. The factors variety and environment had the highest effect on the value of 1000-grain weight. The tested varieties had similar values by this index at the two fertilization norms. The role of the previous crop was most evident in grain formation and was insignificant for 1000-grain weight.

Key words: wheat - previous crop - fertilization - year conditions - yield - hectoliter weight - 1000-grain weight

Introduction

The importance of wheat determined the constant interest of researchers to finding methods and means for obtaining higher yields. Long-term investigations have proved that growing of wheat in crop rotation ensures higher and sustainable yields in comparison to unchanged repeated crops (Shtereva et al., 1989). The investigations up to now on various tillages, fertilization, varieties, interruption with different crops and other agro-technical practices have shown that the yields from monocrops and repeated crops are still lower than those obtained in proper crop rotation (Mitova, 1996). Besides fertilization efficiency, the different previous crops affect the soil nutrition regime and thence the amount and quality of the obtained produce (Nankova et al., 1995).

Fertilization is a significant and dynamic part of the crop growing technology. Its effect on wheat productivity depends to a great extend on the level of soil fertility and the fertilizer combinations used (Gospodinov, 1981). Ivanov et al. (1983) point out that fertilization should not be considered a universal compensatory element but should be applied in harmonious combination with the other agro-technical practices under the specific agro-ecological conditions.

Productivity of cereals is rather changeable and depends on the specific growing conditions (Delibaltova and Ivanova, 2006). According to the investigations of Kolev (1998) and Penchev et al. (2005), the meteorological conditions during the individual years have the highest effect on the growth, development and yield of wheat. The varieties, regardless of the growing conditions, differ by absolute and hectoliter weight of grain (Dekov, 1989; Nankova and Penchev, 2006). These characters are significantly affected by the meteorological and soil conditions, while the agro-technical practices and their level have various effects on them (Filipov and Mangova, 1992).

The aim of this study was to establish the effect of the previous crop, mineral fertilization and year conditions on grain yield, hectoliter weight and absolute weight of grain in new wheat varieties.

Material and Methods

The investigation was carried out during 2004-2006 at the trial field of DAI - General Toshevo on slightly leached chernozem (Luvic Phaeozem - FAO). The trial was designed by the split plot method in four replications, the size of the trial area being 22.5 m^2. Twelve wheat varieties were subjected to investigation: Sadovo 1 (standard), Aglika, Iveta, Bolyarka, Milena, Slaveya, Enola, Kristy, Pryaspa, Todora, Karat and Pobeda (standard). The varieties were grown after three predecessors: bean, sunflower and grain maize. Two levels of nutrition regime were studied. The applied mineral fertilization depended on the type of previous crop:

i) After bean - $N_0P_0K_0$ and $N_6P_6K_0$

ii) After sunflower - $N_0P_0K_0$ and $N_{10}P_{10}K_0$

iii) After grain maize - $N_0P_0K_0$ and $N_{10}P_{10}K_0$

Soil tillage included single disking (10-12 cm) after harvesting of the previous crop, and double disking after the main fertilization. Phosphorus and 1/3 of nitrogen were applied before main soil tillage. The remaining amount from the nitrogen norm was applied before the beginning of permanent spring vegetation. Triple super phosphate and ammonia nitrate were used. Sowing was completed within the agrotechnical term optimal for this region at sowing norm 500 germinating seeds/m^2. Control of weeds, diseases and pests was done with suitable pesticides when necessary. Harvesting was done at full maturity.

During the years of investigation, the sums and distribution of vegetation rainfalls and temperature dynamics differed both between themselves and in comparison to the long-term values. The spring-and-summer period of 2004 was meteorologically specific. It was characterized with extreme draughts in April (2.2 mm) and high precipitation sums during May, June and July. During the autumn of the second year of the investigation (2004/2005) there was a long period of clear, sunny and warm weather. The last year of the investigation (2005/2006) was characterized with a comparatively warm autumn with temperatures close to the mean values for this region and abundant rainfalls after sowing

Table 1

Distribution of rainfalls during the investigated period

Year / Month	2004	A	2005	B	2006	C	1951-2005
X – III	275.3	+ 82,0	300.9	+ 107,6	244.2	+ 50,9	193.3
IV – V	95.9	- 29,6	71.9	- 53,6	129.9	+ 4,4	125.5
VI - VII	155.8	+ 39,9	146.8	+ 30,9	93	- 22,9	115.9

A - Differences between 2004 and 1951-2005

B - Differences between 2005 and 1951-2005

C - Differences between 2006 and 1951-2005

(55.8 mm in November) (Table 1). Most significant were the rainfalls during autumn (at stages germination and tillering) and during the critical spring period. The mean annual precipitation sums during October-March, which formed the autumn and winter moisture reserve in soil, were higher during the period of investigation in comparison to the mean long-term values. During April-March, when plants were at stages booting and heading, the mean annual precipitation sum in 2004 and 2005 was lower than the mean long-term value, and in 2006 this sum was higher with 4.4 mm. During June-July, when wheat was at stage grain filling-maturation, the mean annual precipitation sum in 2004 and 2005 was higher than the mean long-term value, and in 2006 this sum was lower with 22.9 mm.

Results

The results from the multifactor analysis of variances showed the independent effect of the investigated factors, as well as their interaction (Table 2). Fertilization had the highest independent effect on grain yield (F=3904.9), followed by year conditions (F=690). Less expressed was the combined interaction of the factors variety x fertilization and variety x previous crop x year (2.2 and 1.6, respectively). The combined effect of the four factors for grain formation was not statistically significant ($F=1.2^{NS}$).

Hectoliter weight was most affected by the independent action of year conditions (F=13576.9), followed by variety (F=1803.9), and least affected by the type of previous crop (F=245.9). The combined interaction between the individual groups of factors was statistically significant.

Thousand seed weight was most strongly affected by the variety (F=612.9), and least affected by the type of previous crop (F=59.6). The fertilization level and the year also had strong effect on grain size. The combined interaction previous crop x fertilization (F=2.9) was weak and insignificant, and the interaction between the four investigated factors was statistically significant (F=7.6).

The type of predecessor was most important for grain yield, while 1000-grain weight was least dependent of it. The investigated factors had maximum values after predecessor bean, and lowest - after grain maize (Table 3). Sunflower occupied an intermediate position. Variation was significant in yield formation after the individual predecessors and insignificant in

Table 2

Variances of the interactions between factors and effect on grain yield, kg. ha^{-1}

Indices / Source of variation	df	Grain yield, kg.ha^{-1}		Hectoliter weight, kg		1000-grain weight, g	
		F	Sig	F	Sig	F	Sig
A Variety	11	24.4	,000	1803.9	,000	612.9	,000
B Predecessor	2	560.2	,000	245.9	,000	59.6	,000
C Fertilization	1	3904.9	,000	696.5	,000	142.5	,000
D Year	2	690	,000	13576.9	,000	187	,000
AxB	22	2.5	,000	10.3	,000	4.9	,000
AxC	11	2.2	,014	57.9	,000	18.4	,000
BxC	2	111.7	,000	30.4	,000	2.9	,055
AxD	22	5.3	,000	213.7	,000	37.8	,000
BxD	4	27.7	,000	172.9	,000	32.2	,000
CxD	2	74.2	,000	656.8	,000	158.3	,000
AxBxC	22	2.2	,002	15.3	,000	4.2	,000
AxBxD	44	1.6	,018	10	,000	7.3	,000
AxCxD	22	2.9	,000	37.9	,000	12.6	,000
BxCxD	4	14.7	,000	30.4	,000	10.7	,000
AxBxCxD	44	1.2	,182	13.5	,000	7.6	,000

Table 3

Effect of predecessor on the investigated factors

Character / Factor	Yield, kg.ha^{-1}		Hectoliter weight, kg		1000-grain weight, g	
Predecessor	$\bar{x}$	t	$\bar{x}$	t	$\bar{x}$	t
Bean	5632.3 ± 8.7	64.60 ***	78.31 ± 0.15	532.66 ***	48.34 ± 0.26	183.93 ***
Sunflower	5186.3 ± 10.5	49.18 ***	78.13 ± 0.15	509.35 ***	47.97 ± 0.26	182.36 ***
Grain maize	4436.0 ± 11	40.40 ***	77.91 ± 0.14	551.24 ***	47.48 ± 0.28	167.53 ***

hectoliter and absolute weight of grain. The differences between the previous crops were significant in all three investigated characters.

The factor fertilization had the highest effect on the grain yield value. Most significant differences were obtained between the variants without mineral fertilization and the variants with fertilization in yield formation (Table 4). This factor had a weak

Table 4
Effect of fertilization on the investigated factors

Character / Factor	Yield, kg.ha^{-1}		Hectoliter weight, kg		1000-grain weight, g	
Fertilization	$\bar{x}$	t	$\bar{x}$	t	$\bar{x}$	t
Zero (without fertilization)	4163.2 ± 6.55	63.60 ***	77.90 ± 0.13	621.64 ***	48.31 ± 0.2	236.38 ***
According to predecessor	6006.5 ± 6.1	98.39 ***	78.30 ± 0.11	685.28 ***	47.55 ± 0.23	202.87 ***

Table 5
Effect of the year on the investigated factors

Character / Factor	Yield, kg.ha^{-1}		Hectoliter weight, kg		1000-grain weight, g	
Year	$\bar{x}$	t	$\bar{x}$	t	$\bar{x}$	t
2004	4459.2 ± 7.71	57.84 ***	77.59 ± 0.09	890.86 ***	48.64 ± 0.22	217.54 ***
2005	5001.9 ± 10.14	49.32 ***	76.97 ± 0.11	723.87 ***	48.03 ± 0.29	163.82 ***
2006	5793.5 ± 11.56	50.12 ***	79.78 ± 0.13	626.43 ***	47.13 ± 0.28	169.65 ***

effect on hectoliter weight, and 1000-grain weight was with higher mean values in the variants without fertilization. The differences between the two fertilization norms were significant for all three investigated characters.

The factor year conditions had a significant effect on hectoliter weight and absolute weight of grain (Table 5). Maximum grain yields were obtained in 2006. During this year the varieties had the highest values of hectoliter weight, as well, while 1000 seed weight was highest in 2004. The differences in the meteorological conditions of the year were significant for all three characters.

Discussion

Yields obtained under filed conditions are a sum index determined by the genetic production potential, the level of agrotechical practices used and the combination of meteorological conditions during vegetation (Ivanov et al., 1991).

Depending on the meteorological conditions during the individual years, the response of common winter wheat varies according to the type of previous crop and fertilization norm and different grain yields are obtained as a result (Dimitrova-Doneva, 2005).

Under the conditions of this trial, grain yield from the varieties depended to the highest degree on the fertilization norm, and was least dependent on the type of previous crop (Figure 1A). Predecessor has a significant effect on yield (Ostapenko and Nilovskaya, 1994). The differences between the individual predecessors were most evident in the variants without mineral fertilization. In the variants with fertilization, the differentiation between the individual genotypes increased and the differences between the previous crops bean and sunflower decreased. Greatest differences in the productivity of the varieties were established after previous crop bean. After sunflower and grain maize the differences in the grain yields between the varieties decreased. The year conditions also differentiated the investigated varieties by the obtained grain yields. The variation analysis of grain yield revealed a significantly high genotype x environment interaction (Tsenov et al., 2006). In the variants without mineral fertilization the differences by individual years were not so distinct, while in the variants with applied fertilization this distinction was very clear. At both fertilization norms highest yields were obtained in harvest year 2006, and lowest - in 2004.

This investigation confirmed the literary data that hectoliter weight was more affected by the meteorological conditions in comparison to the other factors (Figure 1B). Significant differences according to the previous crop were not established between the tested genotypes. Hectoliter weight changed within the range 76-80 kg. The varieties grown after bean had higher hectoliter weight, although the differences with the varieties grown after sunflower were not very big; the values of the varieties grown after grain maize were lowest. The investigated varieties had significantly higher hectoliter weight in 2006 as compared to 2004 and 2005, the latter two years being with similar values. Depending on the year conditions, this index varied within a wider range from 74 to 82 kg, and the established great differences were due to the factor variety. Similar results have been obtained by Tsenov et al. (2004).

1000-grain weight is a factor directly related to productivity. Garmashov et al. (1993) have established that mineral fertilization with lower nitrogen norms had the highest positive effect on 1000-grain weight, while the higher nitrogen norms reduced this character. According to the data, the type of previous crop affected grain size formation (Figure 1C). After predecessor grain maize all genotypes had lowest values of this index, and after predecessor bean - highest. In the variants without mineral fertilization the varieties sown after bean and sunflower had similar and higher values of this index in comparison to the varieties sown after grain maize. In the variants with fertilization, the genotypes grown after bean formed grains with high absolute weight, and those grown after sunflower and grain maize had similar and lower values of this index.

According to Todorova et al. (2001, 2005) the regularities in the effect of nitrogen, phosphorus and potassium on 1000-grain weight were not unidirectional. The authors point out the definite positive effect of nitrogen-phosphorus and nitrogen-potassium fertilization (as compared to the check) on this index, phosphorus-potassium fertilization having significantly higher effect by the above two types of fertilization. In this study the investigated varieties had higher absolute weight in the variants without fertilization.

1000-grain weight varied significantly by years. In the variants without mineral fertilization the values of this index were very close during the individual years, while in the variants with fertilization differences were established in the character between the varieties during the years of investigation. The greater part of the genotypes had highest 1000-grain weight in 2004 and lowest - in 2006.

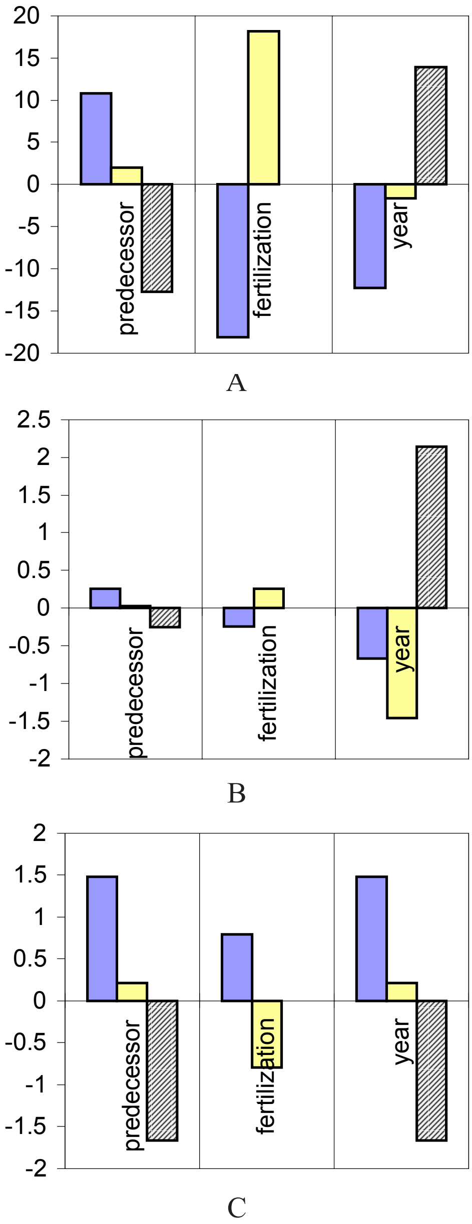

Fig. 1. Effect of previous crop, fertilization and year on: A – Grain yield; B – Hectoliter weight; C – 1000-grain weight

The ordinate is the level of each investigated factor, in % from the mean group value

Conclusions

The level of mineral fertilization and the meteorological conditions were the decisive factors for the expression of grain productivity. The fertilization had the highest effect on the formation of the economic part of the grain yield.

Hectoliter weight was most affected by the year conditions and the type of the genotype.

The variety and the environment had the highest effect on the value of 1000-grain weight. At both fertilization norms the tested varieties had similar values of this index.

The role of the previous crop was most evident in grain yield formation and was little significant for 1000-grain weight.

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