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NUMBER OF GRAINS PER SPIKE OF WHEAT USING DIFFERENT WAYS OF SEED PROTECTION

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ABSTRACT

The research was conducted in field conditions with seven different treatments of seed protection and three winter wheat varieties. The varieties PKB-Christina, Pobeda and Vizija were different according to tillering type, stem height, leaf position, duration of vegetation, genetic potential for grain yield and quality. The micro trial was set up during 2004-2006, using split-plot system with four variants of chemical protection, plus electronic protection of plasma electrons, with positive and negative control. The way of seed protection significantly influenced grain weight per spike. The variety Vizija had significantly less number of grains per spike (39.0) than the varieties Pobeda (39.5) and PKB-Christina (41.4). By comparing grain number per spike from the aspect of applied protection, highly significant difference was proven between control (38.7) and variants being treated with diviconazole and tebuconazole + triazoxine. Highly significant difference was determined between variants treated by fungicides carboxin + tiran and control, then between diviconazole and tebuconazole + triazoxin (41.7) and +c/+control. Fungicide difeconazole showed some influence upon grain number per spike, but that difference was not statistically significant. Plasma electrons treatment was at the level of controls. A highly significant interaction was determined between variety * year * treatment.

Key words: wheat, variety, grain number per spike, fungicide.

INTRODUCTION

Grain number per spike, as one of the yield components, depends on the development of many components in the earlier stages of ontogenesis. Considering the fact there is a hyper production of primordia in every stage of development, grain number and grain weight can be affected by agronomic practices, mineral nutrition or irrigation. If there were adverse conditions for the development of spikelet number, some compensation can be made by creating favourable conditions for fertilization of as much flowers per spikelet/ spike as possible.

It can be expected that grain number per spike will be in correlation with the parameters whose activity declines after coming into ear period. Therefore, a selection according to these parameters, for a higher photosynthetic activity, is at the same time a selection according to larger number of grains per spike. A higher productivity of new varieties can be attributed to the effect of special genes for grain number per spike, which is shown in the grain yield difference between the varieties with the same *Rht* genes (Borojević, 1990). Cilyke et al. (1979) determined that grain number per spike depends on environmental conditions during the year, nutrition, generations of offspring, as well as genetic control. It was determined that the way of seed protection is a factor that significantly influences grain yield (Protić et al., 2011a). New varieties have been emerging over the last decades. These varieties differ not only in morpho-physiological traits, but also in grain number per spike. Therefore, the objective of the paper was to determine the effect of different ways of seed protection on grain number per spike, an important grain yield component of three different winter wheat genotypes.

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MATERIAL AND METHODS

Three winter wheat varieties (Pobeda, Vizija and PKB-Christina), which are different according to tillering type, stem height, leaf position, duration of vegetation, genetic potential for grain yield and quality, were used in this trial.

The experiment was set up in trial field of "Tamis" Institute in Pančevo (2003/2004 - 2005/2006) using split-plot system, four replications, including five variants of chemical protection plus plasma electron protection, with positive and negative control. The size of elementary plot was 5 m^2 (1 x 5 m). Mechanical sowing was done in mid-October.

Sowing density was 600 germinating kernels/m^2 and row spacing was 10 cm. Seed was previously artificially inoculated with teleutospores *Tilletia tritici* (1 g/kg of seed). After that, seed was treated with the following active substances: difeconazole (30 g/l), diviconazole (20 g/l), combination of carboxin (200 g/l) and tiran (200 g/l), combination of tebuconazole (20 g/l) and triazoxin (20 g/l). The fifth variant was plasma electrons seed protection, which was done at Schmidt Seeger AG, Beilngries, Germany.

The sample size for counting number of grain per spikes was 30 spikes in the stage of full maturity. Data were processed statistically using analysis of variance by MSTAT - C program, Michigan State University, Version 1. Year, variety and ways of seed protection were taken as factors in the analysis. The results were shown as triennial average.

RESULTS AND DISCUSSION

Number of grains per spike is an important component of yield. Change in number of grains per spike drastically influences the final yield. In this research, the largest grain number per spike had the variety PKB-Christina (41.4), then the variety Pobeda (39.5) and Vizija had the smallest grain number per spike (39.0). Differences are statistically highly significant (Table 2). The analysis of variance determined highly significant difference between the years when the experiment was conducted, which is often seen in this region (Tables 1 and 2).

Table 1. Analysis of variance of the research results on grain number per spike in wheat varieties and different ways of protection of seed artificially inoculated with *Tilletia tritici*

Source of variance	Degrees of freedom	Sum of squares	Mean square	F value	Significance
Repetition	3	89.567	29.856	1.9770	
Variety (V)	2	267.643	133.821	8.8613	**
Error	6	90.611	15.102		
Year (Y)	2	10388.024	5194.012	268.9594	**
V x Y	4	779.476	194.869	10.0908	**
Treatment (T)	6	613.690	102.282	5.2964	**
V x T	12	1295.690	107.974	5.5912	**
Y x T	12	2233.476	186.123	9.6379	**
V x Y x T	24	1435.857	59.827	3.0980	**
Error	180	3476.071	19.312		
Total	251	20670.107			

By comparing grain number per spike from the aspect of applied protection, highly significant difference was proven between control (38.7) and variants treated with fungicides diviconazole and tebuconazole + triazoxine (41.7). Then, highly significant differences were determined between variants treated by fungicide carboxin + tiran and control, as well as between diviconazole and tebuconazole + triazoxin (41.7) and +c/+control. Fungicide difeconazole showed some influence upon grain number per spike, but that difference was not statistically significant. Plasma electrons treatment was at the level of controls (Tables 1 and 2). In the years of the research, PKB-Christina had the largest grain number per spike (from 29.9 to 50.5), whilst Vizija had the smallest one (from 30.8 to 46.0). This effect was highly significant (Tables 1 and 2). Grain number per spike of the variety PKB-Christina ranged from 34.9 (plasma electrons treatment) to 45.3 (diviconazole treatment).

Grain number of the variety Pobeda ranged from 35.7 (diviconazole treatment) to 42.3 (tebuconazole + triazoxin 18.0 treatment), while grain number per spike of the variety Vizija ranged from 36.4 (plasma electrons treatment) to 44.2 (diviconazole treatment). Differences were highly significant (Tables 1 and 2).

Table 2. Grain number per spike of wheat varieties and different ways of protection of seed artificially inoculated with *Tilletia tritici* (2003/2004 and 2005/2006 year)

Year (Y)	Way of protection (T)	Variety (V)			YT $\bar{x}$	Y $\bar{x}$
		PKB-Christina	Pobeda	Vizija		
2004	Difeconazole	34.2	30.5	34.7	33.2	31.3
	Diviconazole	33.2	31.5	36.2	33.7	
	Carboxine + Tiran	36.0	33.0	36.7	35.2	
	Tebuconazole + Triazoxine	40.2	43.2	30.2	37.9	
	+C/+ Control	24.2	29.0	21.7	25.0	
	Control	26.7	33.5	31.2	30.5	
	Plasma electrons	14.7	30.7	24.7	23.4	
	YV $\bar{x}$	29.9	33.1	30.8		
2005	Difeconazole	39.0	42.0	38.2	39.7	41.9
	Diviconazole	46.7	38.2	46.0	43.7	
	Carboxine + Tiran	46.0	44.0	37.7	42.6	
	Tebuconazole + Triazoxine	46.7	45.7	40.7	44.4	
	+C/+ Control	46.0	40.0	42.0	42.7	
	Control	41.2	40.7	38.5	40.2	
	Plasma electrons	40.0	43.0	37.7	40.2	
	YV $\bar{x}$	43.7	42.0	40.1		
2006	Difeconazole	49.0	37.7	48.0	44.9	46.6
	Diviconazole	56.0	37.2	50.2	47.8	
	Carboxine + Tiran	51.2	49.0	37.7	46.0	
	Tebuconazole + Triazoxine	42.0	38.0	48.0	42.7	
	+C/+ Control	57.0	47.7	49.0	51.2	
	Control	48.2	46.2	42.0	45.5	
	Plasma electrons	50.0	47.7	46.7	48.2	
	YV $\bar{x}$	50.5	43.4	46.0	T $\bar{x}$	
TV $\bar{x}$	Difeconazole	40.7	36.7	40.3	39.3	39.9
	Diviconazole	45.3	35.7	44.2	41.7	
	Carboxine + Tiran	44.4	42.0	37.4	41.3	
	Tebuconazole + Triazoxine	43.0	42.3	39.7	41.7	
	+C/+ Control	42.4	38.9	37.6	39.6	
	Control	38.7	40.1	37.2	38.7	
	Plasma electrons	34.9	40.5	36.4	37.3	
	V $\bar{x}$	41.4	39.5	39.0		

Level of significance

		V	Y	T	VY	VT	YT	VYT
LSD	5%	1.47	1.34	2.04	2.32	3.54	3.54	6.13
	1%	2.22	1.76	2.70	3.06	4.67	4.67	8.09

A highly significant interaction was determined between variety * year * treatment (Table 1).

The research of Šćepanović (1979) showed that grain number per spike is the primary yield component, which depends on hereditary components of a certain variety, number of flowers formed per spike, climate factors during the flowering and fertilisation stage, that is the temperature and humidity during the eight and ninth stage of organogenesis and the level of nitrogen nutrition from the third stage of organogenesis. In this author's research, sowing time and the level of nitrogen nutrition were determined to affect significantly grain number per spike.

According to Borojević (1963), grain number per spike is a hereditary character of a variety that shows a large phenotypic variability. Under less favourable conditions and a too dense stands, the coefficient of variation of grain number per spike is two times higher than under the conditions when plants have enough nitrogen nutrition and good space allocation.

Grain number per spike increases with more intensively nitrogen nutrition up to 150 and 180 kg/ha in the conditions of Vojvodina (Drezgić et al., 1975; Šćepanović, 1979). At density of 550 plants/m^2, nitrogen increases most the grain number per spike, which is very important because grain number per spike accounts for 71.4 % of total yield increase (Kostić, 1966).

Kalasnik and Molin (1974), Ali-Zade (1981), Knežević and Kraljević-Balalić (1993), Dimitrijević and Kraljević-Balalić (1992) in their research estimated the inheritance of grain number per spike, with the advent of super dominance and epistasis.

The analysis of variance showed significant genotype by environment interaction, where all agronomical explainable variance was brought out by the first PCA. This result is in accordance to results obtained by Perlaki (2004). The variety Evropa 90 had the smallest GE interaction, having mean value of grain number per spike higher than overall mean. The variety Pobeda expressed better reaction in more favourable growing conditions, with the average somewhat higher than overall mean. The variety NSR-5 appeared to be better adapted to less favourable conditions keeping its average at the level of overall mean (Petrović et al., 2009).

Organic matter production and spike weight directly depend on grain number per spike and grain weight per spike. Grain number per spike depends on a spikelet number, flower number per spike, the success of pollination and the success of the early organogenetic stages of flowers (Kraljević-Balalić, 1978).

Protić et al. (2007) found that, according to the way of protection, grain yield ranged from 7.19 t/ha at control to 7.56 t/ha with difenoconazole protection.

Results obtained by Protić et al. (2011a) demonstrate a significant impact of different ways of seed protection on test weight in three winter wheat varieties. Highly significant differences were found between control and fungicide treated variants.

By comparing the yields from the aspect of applied protection, highly significant difference was proven between control and variants treated with diviconazole, difeconazole, carboxine + tiran and tebuconazole + triazoxine. Highly significant difference in grain yield was established between the years when research was carried out, as well as for variety * year interaction (Protić et al., 2011b).

CONCLUSIONS

The way of seed protection is a factor that significantly influenced grain number per spike.

The variety Vizija had less grain number per spike (39.0) than the varieties Pobeda (39.5) and PKB-Christina (41.4), the difference being highly significant. By comparing grain number per spike from the aspect of applied protection, highly significant differences were proven between control (38.7) and variants treated with diviconazole and tebuconazole + triazoxine.

Highly significant differences were determined between variants treated by fungicides carboxin + tiran and control, as well as between diviconazole and tebuconazole + triazoxin (41.7) and +c/+control. Fungicide difeconazole showed some influence upon grain number per spike, but that difference was not statistically significant. Plasma electrons treatment was at the level of controls.

A highly significant effect was determined for the interaction between variety * year * treatment.

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