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GENETIC AND PHENOTYPIC VARIABILITY OF YIELD COMPONENTS IN WHEAT (*TRITICUM AESTIVUM* L.)

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Abstract

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Variability, heritability and components of variance for number of grains per spike and grain weight per spike have been studied in 10 winter wheat varieties from different selection centers (Arsenal, KG-56, Gruza, Mironovskaya 808, Norin 10, Rana Niska, Spartanka, Sterna, Osjecanka, and Szegedi 765). The experiment was performed in randomized block design in three replications on the experimental field of Small Grains Research Centre, Kragujevac in three years.

Average estimated values for number of grains per spike and grain weight per spike differed significantly among years and among varieties. The highest average value for number of grains per spike had Szegedi 765 variety ($\bar{x}$ = 75.1) and the lowest value was found in Spartanka ($\bar{x}$ = 56.0). During investigated period the highest average value for grain weight per spike was determined in Gruza ($\bar{x}$ = 2.9 g), and the lowest value in Norin 10 ($\bar{x}$ = 2.0 g). The average variation coefficient for number of grains per spike was 17.4%, and for grain weight per spike was 21.4%. The lowest variability for number of grains per spike and grain weight per spike was established in Sterna variety (V = 13.0%; 16.2%, respectively) and the highest in Norin 10 variety (V = 21.6%; 25.1%, respectively). Obtained heritability value in broad sense for number of grains per spike was about 60%, and for grain weight per spike about 40%. Statistical analysis of variance established highly significant differences in mean values for number of grains per spike and grain weight per spike. Phenotypic analysis of variance indicated that ecological factors had higher impact on the expression of number of grains per spike and grain weight per spike than genetic factors.

Key words: Grain weight per spike, heritability, number of grains per spike, variability, variety, wheat

Introduction

Wheat breeding programs have been directed towards such factors as grain yield and quality. The successful process of wheat breeding is based on the knowledge of characteristics of genotypes, environment and its interaction. The ideal cultivar for high grain yield or for any other desirable traits needs to express genetic potential with low value of variance in different environmental factors of growing. Understanding

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causes of genotypic-environment interaction helps to establish breeding objectives, identify ideal test conditions and formulate recommendations for areas of optimal cultivar adaptation (Panayotov, 2000; Weikai and Hunt, 2001). The presence of genotype-environment interaction complicates selection of superior genotypes and understanding of environmental and genotypic causes of significant genotype-environment interaction is important in all stages of plant breeding (Dhungana et al., 2007).

Characteristics such as number and weight of grains per spike were positively correlated with grain yield. These characteristics play an important role in increasing yield potential. The grain yield of wheat is variable trait that depends on numerous yield components and environmental factors (Kraljevic-Balalic et al., 1995). Variability of yield components is less studied than the yield. Investigation of variability and components of phenotypic variance for number of grains per spike and grain weight per spike are very important for the cultivar creation. This two traits are quantitative characters, and learning about the influence of genetic and environmental variability in genetically different wheat cultivars to be necessary for good selection of parents in breeding programs. The knowledge of genetic association between grain yield and its components would improve the efficiency of breeding programs by identifying appropriate indices for selecting wheat varieties (Evans and Fischer, 1999). Yield performance continues to be of importance in wheat breeding, trough it will be necessary to improve traits involved in yield stability if further yield increases are to be achieved (Bedo et al., 2005).

The aim of this paper was to study components of phenotypic variability for number of grains per spike and grain weight per spike in genetically divergent wheat varieties, which can be used as parent cultivars in breeding programs for improvement grain yield and quality of wheat.

Materials and Methods

Variability, heritability and components of variance for number of grains/spike and grain weight/spike have been studied in 10 winter wheat varieties originated from different selection centers (Arsenal, KG-56, Gruza, Mironovskaya 808, Norin 10, Rana Niska, Spartanka, Sterna, Osjecanka, and Szegedi 765). Studies were conducted on the experimental field of the Center for Small Grains in Kragujevac during three growing seasons (2004-2006). The experiment was conducted by randomized block design with three replications. The seeds were sown in 1 m long rows, with 20 cm space between the rows and 10 cm distance between each seed in a row (rare sowing). The experiment was performed with rare sowing so that varieties could express their maximal genetic potential for tillering and other components. The fields were prepared with standard production practices. For the analysis of yield components 60 plants of each cultivar in full stage of maturity were used in three repetitions (20 plants per repetition). The number and weight of grains per spike were calculated by standard methods as the average of 60 plants.

The following parameters were computed: the average value ($\bar{x}$); the variance (σ^2); standard deviation (σ) and the coefficient of variation (V) as an index of relative variability of the trait. Difference between mean values was tested by LSD test (Hadzivukovic, 1991). All parameters of variability were calculated for each variety and year separately and then presented as average values.

The heritability in a broad sense, as a ratio of genetic/phenotypic variance, was calculated according to the formula $h^2 = \sigma^2 g / \sigma^2 f \times 100$. The analysis of variance was performed according to a random block design with two factors in three repetitions. Components of variance calculation was based on the results of analysis of variance: $\sigma^2 g$ - genetic; $\sigma^2 gl$ - interaction; $\sigma^2 E$ - environment; $\sigma^2 f$ - phenotypic), according to the Falconer (1981).

Results

Number of grains per spike

Grain number per spike is one of important yield components, which directly affect genetic yield potential. The results for number of grains per spike are

presented in Table 1. According to the results, number of grains per spike depended significantly of genetic and environmental factors. Significant differences between years indicated that this trait depended on the environmental conditions during the year of growing. Variability between varieties was lower than between investigated growing seasons. In this research, average value for this property is varied in the range of 56.0 to 75.1 grains per spike. The highest average value for number of grains/spike was observed in Szegedi 765 variety ($\bar{x}$ = 75.1). This variety showed high variability of this property with a coefficient of variation of V = 15.8%. The lowest value number of grains/spike was found in Spartanka ($\bar{x}$ = 56.0), with a coefficient of variation of V = 16.6%.

High variability of the number of grains per spike was found in all investigated varieties. Results showed the average coefficient of variation of 17.4% (Table 1). The coefficient of variation was high and varied in the range from 13.0% to 21.6%. The lowest variability of the number of grains/spike was found in Sterna variety (V = 13.0%), and the highest in Norin 10 variety (V = 21.6%). The number of grains per spike is a quantitative trait whose expression depends on a large number of genes that are strongly influenced by environmental factors that cause high variability, as confirmed by this research.

Analysis of variance for the number of grains per spike is shown in Table 2. The analysis of phenotypic variance established highly significant F values for varieties, years and their interaction. Most of the total phenotypic variance belongs to the year (48.71%), less interaction (28.88%), and the smallest belonged to genetic factors (15.48%). These results show high dependence of grain numbers on environmental factors. This is confirmed by value of heritability in a broad sense for this yield component (hI = 59.82%).

Grain weight per spike

Average values and variability of the grain weight per spike are shown in Table 1.

The grain weight per spike is very variable trait, because it depends on grain number and grain chemical composition. This trait is very important yield components, which directly influence to harvest index and yield. This yield component is very variable and its expression depends highly on the environmental factors. Examined varieties reacted differently to environmental changes during particular years. Average grain weight per spike in all analyzed varieties was 2.6 g, ranging from 2.0 g (Norin 10) to 2.9 g (Gruza).

The lowest variability for number of grain weight per spike was established in Sterna variety (16.2%) and the highest in Norin 10 variety (25.1%).

Table 1

Average values and variability of the number of grains/spike and grain weight/spike

Variety	Number of grains per spike			Grain weight per spike, g		
	x ± S`x	σ	V, %	x ± S`x	σ	V, %
Arsenal	64.1 ± 1.39	10.84	16.8	2.6 ± 0.07	0.51	19.5
KG-56	60.6 ± 1.43	11.11	18.4	2.7 ± 0.07	0.55	20.1
Gruza	69.7 ± 1.74	13.44	19.6	2.9 ± 0.05	0.69	24.5
Mironovskaya 808	61.2 ± 1.22	9.46	15.3	2.6 ± 0.07	0.52	20.6
Norin 10	58.5 ± 1.62	12.51	21.6	2.0 ± 0.04	0.52	25.1
Rana Niska	60.9 ± 1.59	12.31	20.3	2.5 ± 0.08	0.62	24.9
Spartanka	56.0 ± 1.16	8.99	16.6	2.5 ± 0.06	0.49	20.0
Sterna	60.3 ± 1.01	7.82	13.0	2.5 ± 0.05	0.40	16.2
Osjecanka	59.8 ± 1.24	9.55	16.6	2.4 ± 0.06	0.47	20.0
Szegedi 765	75.1 ± 1.53	11.82	15.8	2.8 ± 0.08	0.63	22.6
Average	60.8 ± 1.39	10.78	17.4	2.6 ± 0.06	0.54	21.4

Table 2
Components of phenotypic variance for the number of grains/spike in wheat

Source	d.f.	Mean square	F	Components of variance		LSD	
				σ^2	%	0.01	0.05
Variety	9	295.20	33.56**	19.62	15.48	3 163	4 543
Year	2	1971.16	224.13**	61.75	48.71	3 295	7 600
Variety x year	18	118.63	13.49**	36.61	28.88	5 087	6 970
Error	60	8.79	-	8.79	6.93	-	-
Total	89	-	-	126.77	100.00	-	-
V = 4.74%							
h^2 = 59.82%							

High variability and significant differences for grain weight per spike in different varieties were established by analysis of variance (Table 3). The analysis of phenotypic variance showed differences in average grain weight per spike between different cultivars, experimental years and their interactions. The highest percentage of the total phenotypic variability was assigned to interactions (51.18%), less to experimental year (18.82%), and only 12.35% varieties. This suggests that environmental factors in this study played major role in the expression of grain weight per spike. This is confirmed by low heritability in a broad sense for this property, whose value amounted to hI = 39.62%.

Discussion

Component analysis of the number of grains per spike and grain weight per spike of examined varieties showed significant differences among genotypes, experimental years and their interactions. Variability among genotypes and experimental years indicated genetic distance between investigated varieties and differences of environmental factors during growing period. Success in breeding depends on genetic and phenotypic variability that influence expression of individual genotypes. Genotype and environment interactions are important sources of variation in crop breeding programs (Mohammadi and Amri, 2009). Accordingly, varieties with low yield variability components are stable and have higher potential for grain yield. Wheat yield is highly complex trait resulting from the effect of genotype and environment throughout the life cycle of the plant. Therefore, yield components such as number and weight of grains per spike, are

Table 3
Components of phenotypic variance for grain weight/spike in wheat

Source	d.f.	Mean square	F	Components of variance		LSD	
				σ^2	%	0.01	0.05
Variety	9	0.48	17.45**	0.021	12.35	0.253	0.175
Year	2	1.24	45.37**	0.032	18.82	0.421	0.182
Variety x year	18	0.29	10.53**	0.087	51.18	0.386	0.282
Error	60	0.03	-	0.030	17.65	-	-
Total	89	-	-	0.170	100.00	-	-
V = 6.48%							
h^2 = 39.62%							

strongly influenced by environmental factors. These are quantitative traits whose expression depends on large number of genes that are strongly influenced by environmental factors that cause high variability, as confirmed by this research.

The number and weight of grains per spike is the last component of wheat yields, which depend on the development of many components in the earlier stages of ontogenesis. The number of grains per spike depends on number of spikelets per spike and on the number of flowers per spikelets, and finally on successful fertilization in flowers. Therefore, the number of grains is very variable property, as confirmed in this research. Investigated varieties showed high variability in the number of grains per spike and grain weight per spike. This research is in agreement with previously published papers (Borojevic and Williams, 1982; Petrovic et al., 1993; Kraljevic-Balalic et al., 1995; Mladenov, 1996; Roncevic et al., 1998; Zecevic et al., 1998; Tajammal et al., 2003; Ali et al., 2008), which also found high variability in yield components of wheat.

The number and weight of grains per spike directly affect the other spike properties and grain yield (Sabo et al., 2002). The same authors established the lowest influence of location, genotype and its interaction on grain weight/spike. Investigated traits showed high variability and highly depended to environmental factors, what agree with previous investigations (Bilgin et al., 2008; Dagustu, 2008).

Weight of kernels per spike is variable component because it depends on the number of grains and chemical composition of grain. The results for variability of grain weight per spike obtained in this study are in accordance to those reported by Roncevic et al. (1998). Zecevic and Knezevic (1998) also reported a significant effect of environmental factors for grain weight per spike expression.

The results of this study indicate highly significant F values for genotype, growing years and their interactions for number and weight of grains per spike indicating substantial genetic diversity among the genotypes and variation among environments. The analyzed wheat cultivars showed significant phenotypic and genotypic variability for investigated yield components. High variability of number of grains per spike and grain weight per spike depended on investigated cultivars and years. These two yield components are in positive correlation with other and directly influence to wheat yield (Sabo et al., 2002; Zecevic et al., 2004; Leilah and Al-Khateeb, 2005; Munir et al., 2007; Yucel et al., 2009).

Heritability in a broad sense for investigated yield components was medium for both investigated yield components, which indicated that grain number per spike and grain weight per spike depended highly to environmental factors. Low values of heritability for grain number per spike and grain weight per spike have been obtained in some studies that were conducted previously (Mladenov, 1992; Mladenovic, 1995; Petrovic et al., 1993; Aycicek and Yildirim, 2006).

High heritability in a broad sense for grain number per spike (Zecevic et al., 1998) and for grain weight per spike (Zecevic and Knezevic, 1998) established in our previous investigations. The results of these studies have pointed to high variability of yield components and their high dependence on environmental factors that significantly influence breeding success and stability of wheat yields.

Conclusions

Investigated yield components depended highly by growing seasons and analyzed varieties. Average values for number of grains per spike varied from 56.0 to 75.1, and for grain weight per spike varied from 2.0 g to 2.9 g. In this investigation established high variability of wheat yield components. Heritability in broad sense for number of grains per spike was about 60%, and for grain weight per spike about 40%. Statistical analysis of variance established highly significant differences in mean values for number of grains per spike and grain weight per spike. Phenotypic analysis of variance indicated that ecological factors had higher impact on the expression of number of grains per spike and grain weight per spike than genetic factors.

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