STUDY OF SOME SPIKE CHARACTERISTICS IN WHEAT (*TRITICUM AESTIVUM* L.)

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ABSTRACT
In this paper was analyzed genetic and phenotypic variability of the spike length and number of spikelets per spike. Ten winter wheat cultivars (Arsenal, KG-56, Gruza, Mironovskaya 808, Norin 10, Rana Niska, Spartanka, Sterna, Osjecanka, and Szegedi 765) originated from different selection centers and countries were selected for this study. Investigated spike characteristics depended highly by growing seasons and analyzed varieties. Average values for spike length varied from 8.1 cm to 14.5 cm, and for number of spikelets per spike varied from 20.4 to 25.8. The highest average value for spike length was observed in Mironovskaya 808 variety (14.5cm). This variety showed the lowest variability of this property with a coefficient of variation of V = 7.7%. The lowest value of spike length was found in Rana Niska (8.1cm), with a coefficient of variation of V = 14.2%. Heritability in broad sense for spike length was about 98%, and for number of spikelets per spike about 75%. Statistical analysis of variance established highly significant differences in mean values for spike length and number of spikelets per spike. Phenotypic analysis of variance indicated that ecological factors had higher impact on the expression of number of spikelets per spike, but genetic factors had higher impact on the expression of spike length.

Keywords: wheat, cultivar, spike length, number of spikelets/spike, variability

INTRODUCTION

The main objective of wheat breeding is to improve yield and related parameters by selecting and improving yield components including spike characteristics like, spike length, spikelets per spike, grains per spike, spike weight. Any improvement of spike characteristics through selection and breeding would help improve the per plant productivity (IQBAL AND KHAN, 2006). A successful selection depends upon the information on the genetic variability and association of morpho-agronomic traits with grain yield (ALI ET AL., 2008). Grain yield is under big influence of spike properties, and interdependence and correlation between spike length and spikelet number per spike (MARTINCIC ET AL., 1996). All spikelet florets are not fertile and the number of fertile florets depends significantly of genotype and ecological factors (SABO ET AL., 2002). The apical and basal spikelets are often sterile, and in each spikelet the third floret (counting from the base) is often sterile and the fourth floret usually sterile. Apart from these differences, the spikelets and florets are indistinguishable at maturity (STEWART, 1950). The characters as spike length and number of spikelets per spike are in positive correlation with grain yield, and have played a great role in increasing the yield potential.

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. Little information is available as to the nature and

importance of interaction between genotype and environment in determining grain yield in wheat.
The grain yield of wheat is variable trait that depends on numerous yield components and environmental factors (KRALJEVIC-BALALIC ET AL., 1995). The genotype-environment interaction presence complicate selection of superior genotypes. Understanding of environmental and genotypic causes of significant genotype-environment interaction is important in all stages of plant breeding (WEIKAI AND HUNT, 2001; DHUNGANA ET AL., 2007).
This work was conducted to study the variability of spike characteristics in genetically divergent wheat cultivars that can be used as parent cultivars in breeding programs to improve grain yield in wheat.

MATERIAL AND METHOD

Ten winter wheat cultivars (Arsenal, KG-56, Gruza, Mironovskaya 808, Norin 10, Rana Niska, Spartanka, Sterna, Osjecanka, and Szegedi 765) originated from different selection centers and countries were selected for this study. The investigation was performed in field experiment during three years. The experiment was conducted in a randomized complete block design with three replications. The seeds were sown in 1 m long rows, with 0.20 m space between the rows and 0.10 m distance between each seed in a row. For analysis of spike length and number of spikelets/spike were used 60 plants in full maturity stage (20 plants per replication).
The following parameters were computed: the average value ($\bar{x}$), the standard deviation (σ), the variance (σ^2), the coefficient of variation (V) as an index of relative variability of the trait, and analysis of variance. The significant differences between the average values were estimated by LSD-test values (HADZIVUKOVIC, 1991). The analysis of variance was performed according to a random block system with two factors, allowing the calculation of the components of variance (σ^2_g-genetic, σ^2_{gl}-interaction; σ^2_E-environment; σ^2_f-phenotypic), FALCONER (1981).

RESULTS AND DISCUSSION

Spike length

Variability of spike length is controlled by high number of genes which expression highly influenced by environment. Spike length has influence on grain yield through number of spikelets per spike. High spike length increases photosynthetic active area and become important source and acceptor of assimilates and has influence to plant production (DENCIC, 1990; DENCIC AND BOROJEVIC, 1992; BOROJEVIC ET AL., 1994; ZECEVIC ET AL., 2008).
The results for spike length are presented in *Table 1.* According to the results, spike length 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 higher than between investigated growing seasons, what indicated that divergent genetic material was investigated. In this research, average value for this property is varied in the range from 8.1 cm to 14.5 cm. The highest average value for

spike length was observed in Mironovskaya 808 variety ($\bar{x}$ = 14.5cm). This variety showed the lowest variability of this property with a coefficient of variation of V = 7.7%. The lowest value of spike length was found in Rana Niska ($\bar{x}$ = 8.1cm), with a coefficient of variation of V = 14.2%.

High variability of spike length was found in all investigated varieties. Results showed that average variation coefficient for this trait was 10.3% (*Table 1.*). The coefficient of variation was high and varied in the range from 7.7% to 14.2%. The lowest variability of this trait was found in Mironovskaya 808 (V = 7.7%), and the highest in Rana Niska variety (V = 14.2%). The spike length 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.

Table 1. Average values and variability of spike length and number of spikelets/spike

Variety	Spike length (cm)			Number of spikelets/spike		
	$\bar{x} \pm S\bar{x}$	σ	V (%)	$\bar{x} \pm S\bar{x}$	σ	V (%)
Arsenal	10.9 ± 0.13	1.01	9.3	23.1 ± 0.31	2.39	10.3
KG-56	10.7 ± 0.11	0.85	8.0	24.0 ± 0.26	1.97	8.2
Gruza	10.4 ± 0.19	1.47	14.1	23.0 ± 0.26	1.99	8.6
Mironovskaya 808	14.5 ±0.14	1.12	7.7	25.8 ± 0.21	1.63	6.3
Norin 10	8.4 ± 0.11	0.80	9.6	22.0 ± 0.36	2.72	12.4
Rana Niska	8.1 ± 0.15	1.15	14.2	20.4 ± 0.29	2.24	11.0
Spartanka	9.8 ± 0.13	0.99	10.1	22.2 ± 0.33	2.59	11.7
Sterna	10.9 ± 0.16	1.26	11.6	23.1 ± 0.36	2.81	12.2
Osjecanka	8.4 ± 0.11	0.85	10.1	22.1 ± 0.30	2.35	10.6
Szegedi 765	9.2 ± 0.10	0.77	8.4	22.6 ± 0.28	2.15	9.5
Average	10.1 ± 0.13	1.03	10.3	22.8 ± 0.30	2.28	10.1

Analysis of variance for spike length 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 varieties (81.76%), less to year (12.06%), and the smallest belonged to interactions (5.01%). These results show high dependence of spike length on genetic factors. This is confirmed by value of heritability in a broad sense for this yield component (h^2 =97.85%). These results agree with previous investigated by ULAH ET AL. (2011), who established that genotypic coefficient of variation was high for spike length, but phenotypic coefficient of variation was higher for spikelets/spike which reflect the influence of environment on trait expression.

In this investigation established significant positive correlation among spike length and number of spikelets per spike (r=0.710), what agree with previous investigations (ZECEVIC ET AL., 2004; MOAYEDI ET AL., 2010).

Table 2. Components of phenotypic variance for spike length

Source	d.f.	Mean square	F	Components of variance		LSD	
				σ^2	%	0.05	0.01
Replication	2	0.048	0.921	-	-	-	-
Variety	9	33.494	646.397**	3.641	81.76	0.243	0.349
Year	2	16.843	325.062**	0.537	12.06	0.253	0.584
Variety x year	18	0.721	13.912**	0.223	5.01	0.391	0.536
Error	58	0.052	-	0.052	1.17	-	-
Total	89	-	-	4.453	100	-	-
h^2 = 97.85 % Correlation coefficient between spike lent and number of spikelets/spike (r=0.710)							

Number of spikelets per spike

Investigation of the number of spikelets per spike is important because this spike component directly influence the grain number and grain mass per spike in wheat. In previous research (ZECEVIC ET AL., 2004; ZECEVIC ET AL., 2009; ÁLVARO ET AL., 2008; BILGIN ET AL., 2008) established a significant positive correlation between the number of spikelets per spike and other spike components (spike length, number of grains and grain weight per spike) which directly influence the grain yield of wheat cultivars.

Average values and variability for number of spikelets per spike are shown in *Table 1*. The number of spikelets/spike is very variable trait, because it depends on spike length and spike density. This trait is very important yield components, which directly influence to grain number 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 number of spikelets/spike in all analyzed varieties was 22.8, ranging from 20.4 (Rana Niska) to 25.8 (Mironovskaya 808). The lowest variability for number of spikelets/spike was established in Mironovskaya 808 (6.3%) and the highest in Norin 10 variety (12.4%).

High variability and significant differences for number of spikelets per spike in different varieties were established by analysis of variance (*Table 3*). The analysis of phenotypic variance showed differences in average number of spikelets per spike between different cultivars, experimental years and their interactions. The highest percentage of the total phenotypic variability was assigned to year (44.89%), less to varieties (25.98%) and interactions (25.41%). This suggests that environmental factors in this study played major role in the expression of number of spikelets/spike. This is confirmed by heritability in a broad sense for this property, whose value amounted to h^2 =74.54%. The significant environment component for spikelets/spike indicates that this trait was strongly persuaded by the environment (IQBAL AND CHOWDHARY, 2000; SABO ET AL., 2002; ALI ET AL., 2008; BILGIN ET AL., 2008; NAZEER ET AL., 2011; ULAH ET AL., 2011).

Table 3. Components of phenotypic variance for number of spikelets/spike

Source	d.f.	Mean square	F	Components of variance		LSD	
				σ^2	%	0.05	0.01
Replication	2	0.818	4.9916	-	-	-	-
Variety	9	13.832	84.3633**	1.145	25.98	0.432	0.620
Year	2	62.883	383.8393**	1.979	44.89	0.450	1.038
Variety x year	18	3.524	21.4941**	1.120	25.41	0.695	0.952
Error	58	0.164	-	0.164	3.72	-	-
Total	89	-	-	4.408	100	-	-
h^2 = 74.54 %							

CONCLUSIONS

Investigated spike characteristics depended highly by analyzed varieties and growing seasons. Average values for spike length varied from 8.1 cm to 14.5 cm, and for number of spikelets per spike varied from 20.4 to 25.8. In this investigation established high variability of investigated spike components. Heritability in broad sense for spike length was about 98%, and for number of spikelets per spike about 75%. Statistical analysis of variance established highly significant differences in mean values for spike length and number of spikelets per spike. Phenotypic analysis of variance indicated that ecological factors had higher impact on the expression of number of spikelets per spike, but genetic factors had higher impact on the expression of spike length.

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