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GENETIC AND PHENOTYPIC VARIABILITY OF LENGTH OF SPIKE IN BREAD WHEAT GROWN UNDER DIFFERENT RATE OF NITROGEN NUTRITION

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Abstract

Variability of length of spike was studied in four wheat genotypes: G-3052, G-3625, G-3004 and G-3617, grown over two years under four nitrogen nutrition treatments: 0, 30, 60 and 90kg N ha^{-1}. The experiment was set up as a randomised block design in four replications. Differences in average values of length of spike among tested cultivars were determined in both years and under all variant of nitrogen fertilization. On average, for all genotypes, length of spike increased with increasing nitrogen rate in both years, it mean that phenotypic variability of length of spike was affected by nitrogen nutrition. In average for all cultivars length of spike was higher in the first year than in second year of experiment. The wheat genotypes G-3617 expressed highest length of spike (9.24cm) in average in the first experimental year while the wheat G-3625 had the least lowest (7.74cm) in average second experimental year. Spike length expression also highly depended to genetic factors (38.97%), but on this trait expression the environmental factors had higher influence (56.99%).

Keywords: *wheat, variability, spike length, nitrogen nutrition*.

Introduction

The wheat morphological traits have impact to yield values that are influenced by genetic factor, environments and interaction genotype/environment have influence to efficiency of absorption and accumulation of nutrient (Agoston and Pepo, 2005). Spike is the organ of wheat where produced grains. Also, spike is active in photosynthesis after heading and contribute to grain filling, especially under drought conditions. Increasing of genetic potential of grain yield is possible achieve through increasing of size and capacity of spike (Knezevic et al., 2012). The long and fertile spike is one of the most important and promising direction in improvement of grain yield of wheat (Zečević et al., 2008; Knezevic et al., 2014). The difference in response of genotypes towards heterosis studied by Inamullah et al. (2006) and reported positive mid parent heterosis, while Singh et al. (2004) have recorded a negative heterosis for spike length in wheat genotypes (Khan & Ali, 2011). However, the spike traits development respond to different environmental factors, soil fertility, precipitation, temperature mineral nutrition (Petrović et al. 2008). The optimizing nutrition by nitrogen application (dose and time) is important for improvement of efficiency of N absorption during the phase of organogenesis and grain filling in wheat to achieve high yield (Bedo et al., 2005; Bertheloot et al., 2008). However, differences in nitrogen uptake have been found between varieties (Kovacevic et al. 2006; Paunovic et al., 2007) which are adapted in variable environments. The seeding rates and N level, the stage of plants at time of N application has an important effect on yield components as well development of spike traits length of spike, number of spikelet's per spike, number of florets per spikelet and efficiency of pollination and seed developing in florets grain mass as well as other yield components (Knezevic et al.,

2007; Iqbal et al., 2012; Kondić et al., 2012). Spike length had positive relationship with number of spikelets per spike at both genotypic and phenotypic levels. It was positively correlated with number of grains per spike at genotypic level (Akram et al., 2008). Genetic potential of wheat yield represents yield of a wheat genotypes grown in environments which is adapted, with nutrients and water regime, as well as with biotic stresses (pests, diseases, weeds) effectively controlled (Miflin, 2000; Drezner et al., 2006; Shehzad et al., 2012).
The aim of this paper was to evaluate the effect of increasing rates of N, applied during the growing season on length of spike in genetically divergent wheat genotypes.

Materials and methods

The four winter wheat selected lines (G-3052, G-3625, G-3004 and G-3617) were tested in two year experiment was performed in randomized block design on $5m^2$ plots and 4 replications under different rate of mineral nutrition (control N_0=0, N_1=30, N_2=60 and N_3=90 kg ha^{-1}). The length of spike in full stage of maturity of 80 plants (20 plants per replication) were used for analysis. The average value (x) the variance (σ^2), and analysis of variance was computed. 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). The significant differences among the average values were estimated according to least significant difference (LSD) Hadživuković (1991) .

Climatic conditions during growing seasons

During two years experiment values of temperature and precipitation were different. Those values were compared to average values of previous ten years (table 1). In the first year the average temperatures (8.3 ^oC) were similar to average of ten years period (8.5 ^oC) and in second (11.0 ^oC) were in avereage slightly higher than in first year and ten year period. In the first year 2005/06 the amount of precipitation (533.7mm) was higher than in second 2006/07 (369.9mm) year as wel than during ten year period (417.8mm). Amounts of precipitation in the first year are was more suitable than in second year and without big differences between minimum and maximal values per munth, as in second year (in April – 3.6mm and in May 118mm).

Table 1. Monthly and mean temperatures and monthly and cumulative precipitation

Tem& Precpt	Period	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Xm	Total
^0C	2005/06	11.5	5.6	3.3	-1.7	1.5	5.5	12.7	16.4	19.7	8.3	74.4
^0C	2006/07	13.3	7.6	3.5	6.1	6.3	9.1	12.1	18.2	22.8	11.0	99.0
^0C	1990/2000	11.8	6.4	1.7	-0.1	2.6	5.9	11.6	16.4	20.4	8.5	76.7
(mm)	2005/06	49.0	54.8	47.1	27.9	38.1	116	86.3	29.6	84.8	59.3	533.7
(mm)	2006/07	16.7	13.7	51.9	45.3	32.1	62.9	3.6	118	25.3	41.1	369.9
(mm)	1990/2000	61.0	44.3	44.6	30.0	29.9	33.2	52.9	52.6	69.3	46.4	417.8

Results and discussion

The varying of length of spike and of investigated wheat genotypes in dependence on genotype, nutrition variant, year of experiment was determined (table 2). In average, the line G-3617 expressed the highest length of spike (9.24cm) in the first year, and 8.46cm in the second year of experiment, while wheat G-3625 in average had the least length of spike (8.08cm) in the first year and 7.41cm in the second year of investigation. According to variant of N nutrition all wheat cultivars in both year of investigation in average had the highest length of spike (9.26cm) in the first year and (8.34cm) in second year of experiment by application the highest dose of nitrogen (90 kg ha^{-1}) and the lowest on the control variant (without nitrogen nutrition) 8.13cm in the first year and 7.34cm in the second year. In average the highest length of spike was found for wheat G-3617 (9.86cm) in the first year and 9.15cm in second year of experiment by application the highest dose of nitrogen (90 kg ha^{-1}) while the least length of spike expressed wheat G-3625 on control variant (without N fertilizer) 7.79cm in the first year and 6.93cm in the second year of experiment.

The significant differences among the investigated wheat genotypes were established for the expressed average values of length of spike. Also, were significantly different among the investigated wheat genotypes. Also, the values of length spike of analysed genotypes were significant different between first and second experimental years, as well between nutrition variant, which indicates that the weather conditions in the first vegetation period were more favourable and enabled more efficient nitrogen exploitation from soil, as well that the 90kg ha^{-1} had the highest influence to increase length of spike. However, all wheat genotypes in both year and in average expressed higher values of length of spike in dependence of increasing rate of N application. This indicates that the effect of nitrogen on the investigated characteristic depends on applied N doses.

Table 2. Average values of analyzed length of spike of winter wheat genotypes

Year	2005/06					2006/07					Two-years average
Cultivar	Nitrogen (kg ha^{-1})					Nitrogen (kg ha^{-1})					
	0	30	60	90	x	0	30	60	90	x	
G-3052	**7.90**	**8.36**	**8.64**	**8.96**	**8.46b**	**7.06**	**7.43**	**7.76**	**8.08**	**7.58d**	**8.02**
G-3625	**7.79**	**8.05**	**8.10**	**8.36**	**8.08c**	**6.93**	**7.40**	**7.62**	**7.70**	**7.41e**	**7.74**
G-3004	**8.45**	**8.90**	**9.56**	**9.85**	**9.19a**	**7.62**	**7.85**	**8.25**	**8.45**	**8.04c**	**8,62**
G-3617	**8.38**	**9.12**	**9.60**	**9.86**	**9.24a**	**7.75**	**8.25**	**8.70**	**9.15**	**8.46f**	**8.85**
Average per N rate variant	**8.13**	**8.61**	**8.98**	**9.26**	**8.74**	**7.34**	**7.73**	**8.08**	**8.34**	**7.87**	**8.31**

The investigation of morphological traits in wheat grown under different dose of nitrogen nutrition (Ali et al., 2011) showed that all the nitrogen treatments significantly influenced to the value of spike length of wheat which found the maximum spike length was (11.30cm) in case of 130 kg N ha^{-1} followed by (10.71 cm) in case of N_1 where 80 kg N ha^{-1} was applied which is statistically different in comparison to recorded value of spike length (10.00cm) on variant N_3 (180 kg N ha^{-1}). Treatment N_0 (without nitrogen application) produced minimum spike length of 10.13 cm. Similar results for effect of nitrogen application are reported in investigation of Ali et al., 2000; Asif et al., 2009; Iqbal et al., 2010).

Different value of spike length among different wheat of genotypes are effected more by genotype than by relationships to the geographic origin of cultivars (Dotlačil et al., 2003). Also, the sensitivity of length of spike under environmental variation noticed (Zečević et al., 2008) and represent important components of wheat yield.

Among morphological characters, there is a lower positive correlation between spike length and plant height (r=0.34), grain protein content of cultivars (r=0.55), TGW (r=0.28) and grain weight per spike (r=0.21). Significant but low contribution to the spike productivity was noted for time to heading (4% of variability) and spike length (1%). The increase of spike productivity was facilitated by the increase of harvest index (23% and more) due to stem shortening (33%). It seems that spike length was influenced by breeding much less (Dotlačil et al., 2003).

According to phenotypic variance analysis, the spike length expression also highly depended to genetic factors (38.97%), but on this trait expression environmental factors had higher influence (56.99%) Table 3. The investigated trait highly depended to genetic and environmental factors. These results are in agreement with previous reported by Zečević et al.

(2004a). The spike length is yield components which highly positively correlated to number of spikelets per spike (Zečević et al., 2004b; Akram et al., 2008). Likewise, the spike length has strong indirect influence through number of spikelets per spike on grain weight per plant (Zečević et al., 2004b).

Table 3. Components of phenotypic variance for length of spike (cm) of wheat

Source of variance	Degree of freedom (DF)	Mean square (MS)	F-test	Components of variance		LSD	
				σ^2	%	0.01	0.05
Repetitions (R)	3	0.001	0.180	-	-		
Genotypes (G)	3	2.094	436.269**	0.251	38.97	0.2065	0.1125
Years (Y)	1	5.951	1248.199**	0.367	56.99	0.071	0.052
Interaction (GxY)	3	0.087	18.252**	0.021	3.26	0.292	0.1591
Error	21	0.005	-	0.005	0.78		
Total	31	-	-	0.644	100.00		

The analysis of variance reveals significant differences in length of spike among genotypes and N application rates in both years (Table 3).

The direct effect of spike length on grain yield was negative in dryland condition and positive in supplemen tal irrigation condition (Ahmadizadeh et, al. 2011; Mohammadi et al., 2012) . Regardless of sowing date, year and water regime, yield per spike had a positive phenotypic correlation with spike length (Zeeshan et al., 2014). Analysis of variance showed highly significant differences among genotypes (G) for length of spike. Differences between investigated years (Y), interactions (GxY) were also high significant for this investigated trait.

Conclusions

In this investigation were determined differences among wheat genotypes according to values of length of spike and high influence of mineral N nutrition to the expression of this trait. The application of mineral fertilizers in variants N_3 (90 kg ha^{-1}) showed the highest values of length of spike of winter wheat in comparison with other variants of mineral nutrition. The highest values of length of spike (9.24cm) in G-3617 expressed in the first experimental year while the least (7.74cm) in wheat G-3625 had in second experimental year. Nitrogen application had significant effect on length of spike. By analysis of variance, it was established that analyzed yield component significantly dependeds to genotypes and investigated years, and increasing quantity of N. In the expression of value of length of spike the impact of genetic factors is (38.97%) and impact of environmental factors was higher (56.99%). Interactions between genotypes, applied nitrogen doses and years were also highly significant, which means that new genotypes are positive reacted on nitrogen applying

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