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Genetic and Phenotypic Variability of Grain Mass per Spike in Wheat under Different Dose of Nitrogen Nutrition

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Abstract

Variability of grain mass per spike was investigated in four wheat genotypes: G-3052, G-3625, G-3004 and G-3617, grown under application of four nitrogen nutrition treatments: 0, 30, 60 and 90kg N ha^{-1} in field experiment during two years. The experiment was designed by randomised block system on plot 5m^{2} in four replications. Obtained results indicate differences in average values of grain mass per spike among tested cultivars were determined in both years and under all variant of nitrogen fertilization. In average for all cultivars grain mass per spike was higher in the first year than in second year of experiment. In average the highest grain mass per spike expressed the wheat genotypes G-3625 in the first year (2.85g) as well as in the second experimental year (2.35g) while the least value of grain mass in the first year had G-3617 (2.20g) and in the second year G-3004 (1.94g). On average, for all genotypes, grain mass per spike increased by increasing nitrogen rate in both years, it mean that variability of grain mass per spike was affected by nitrogen nutrition. The genetic components of variance showed that environmental factor (61.49%) had the higher influence than genetic factor (19.26%) on the expression the grain mass per spike.

Keywords: wheat, spike, grain mass, variability, nitrogen.

Introduction

Wheat is one of the most important cereal plant species. That is the reason why is developed intensive breeding program in the world. Breeders developed a large number of wheat cultivars and step by step improved many desirable traits. The most of developed wheat cultivars were created by using crossing method and selection of progenies which carry desired traits (Khan et al., 2013). By breeding increased grain yield, improved resistance to disease and optimized morphological traits and grain protein composition (Sabaghnia et al., 2014). For increasing grain mass spike^{-1} the important role have morphological and anatomical structure of plants and their organs (Kondić et al., 2012).

Differences among developed wheat cultivars influenced by genetic and environmental factors as well as by interaction genotype/environment (Knezevic et al., 2007). For developing new wheat cultivars with desirable traits is necessary apply knowledge of the physiology of different traits (Tiwari, 2007). For distinguishing impact of genetic and environmental responses is possible by growing under defined conditions which can be reproducible. The wheat cultivation spreading on the large areas under applying scientific farming measures. Among these measures the very important is intensive fertilization to achieve large yields and high protein concentrations (Zecevic et al., 2004; Bedo et al., 2005). The optimizing time and dose of nutrition by nitrogen is important for improvement of efficiency of N absorption during the phase of organogenesis and grain filling in wheat to achieve high yield (Bertheloot et al., 2008). The differences in nitrogen absorption among cultivars are effected by variable environments (Kovacevic et al. 2006). The wheat productivity showed a linear response to accumulated N (Asif et al., 2009). 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, efficiency of pollination and seed developing in florets, mass of grain and all other yield components (Iqbal et al., 2012). The number of grains per plant increased linearly with increased N availability whereas grain weights were essentially unaffected (Paunovic et al., 2007). Grain N concentrations and N content varied slightly, with highest values generally at the lower N availability levels (Oscarson, 2000). New aproach in agriculture directed in development of cultivars with low imput of nutrient and high output of yield. Also, important demands on the cultivars used are improvement of technological and nutritional quality (Knezevic et al., 2013; Zecevic et al., 2014). 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). Grain development is determined by the availability of assimilates, the growth potential of the grain and the resistance within the pholem to the movement of assimilates to the grain (Bremner and Rawson, 1978) and affected by environment (Zarejan et al., 2014). Grain mass as component of grain yield depends of the duration time of grain filling which is a component of maturity. Both, grain mass and grain yield are important traits in applied plant breeding and both depend upon the grain filling process (Chanda and Singh, 2010). Genetic controll and optimizing environmental factors (temperature, light, nutrient, water) have influence to efficiency of grain filling and grain mass as well total yield (Agoston and Pepo, 2005; 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 grain mass per spike in genetically divergent wheat genotypes.

Materials and Methods

The four genetically divergent wheat lines (G-3052, G-3625, G-3004 and G-3617) were used for investigation during two year. The 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}). In the full stage of maturity the spike of 80 plants (20 plants per replication) were used for analysis of grain mass per spike. 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

Two experimental years are characterized different regime of temperature and precipitation were different. The values of temperature and precipitation varied per months within years and were different between same period in two experimental years. Obtained average values of those parameters were compared to average values of previous ten years (table 1). The average value of temperatures (8.3 ^{o}C) in the first year were similar to average of ten years period (8.5 ^{o}C) and less than in second (11.0 ^{o}C) experimental year. In the first experimental year 2005/06 the amount of precipitation (533.7mm) that was higher than in second 2006/07 (369.9mm) year and also was the higher than average values of precipitation of 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).

Results and Discussion

The varying of grain mass spike^{-1} in investigated wheat was in dependence on genotype, nutrition variant, year of experiment was determined (table 2). For all genotypes and all variant of N application and two year of investigation the average value of grain mass spike^{-1} was 2.37g. In average of two year, the line G-3625 expressed the highest grain mass spike^{-1} (2.60 g) in the first year, and 2.85g and in the second year of experiment 2.35g. According to all variant of N nutrition all wheat genotypes, in the first year of investigation the average values of grain mass spike^{-1} (2.60g) was the higher than in second experimental year (2.14g). Also, average values of grain mass spike^{-1} on each dose of applied N was higher than in second year on the same variant. In both years and for each genotypes the highest values of grain mass spike^{-1} was on on the variant by application the highest dose of nitrogen (90 kg ha^{-1}), while the least on the control variant (without nitrogen nutrition) table 2. In average the grain mass spike^{-1} was found for wheat G-3617 (2.85g) in the first year and 2.35g in second year of experiment by application the highest dose of nitrogen (90 kg ha^{-1}) while the least grain mass spike^{-1} expressed wheat G-3004 on control variant (without N fertilizer) 1.42g in the first year and 1.32g in the second year of experiment.

Table 1. Average values of temperatures and precipitation (monthly & cumulative values)

Tem& Precpt	Period	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Xm	Total
^{0}C	2005/06	11.5	5.6	3.3	-1.7	1.5	5.5	12.7	16.4	19.7	8.3	74.4
^{0}C	2006/07	13.3	7.6	3.5	6.1	6.3	9.1	12.1	18.2	22.8	11.0	99.0
^{0}C	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

The significant differences among the investigated wheat genotypes were established for the expressed average values of grain mass spike^{-1}. According to values of grain mass spike^{-1} of analysed genotypes were found significant differences between first and secnd experimental year, as well between nutrition variant, which indicates that the weather conditions in the first vegetation period were more favourable and enabled more efficient utilization of nitrogen from soil and its reutilization.

Also, the highest effect on increasing the values of grain mass spike^{-1} expressed applied dose of 90kg ha^{-1} nitrogen. However, all wheat genotypes in both year and in average expressed higher values of grain mass spike^{-1} of analysed genotypes in dependence of increasing rate of N application. This indicates that the effect of nitrogen on the investigated trait depends on applied N doses. The productivity of the plants, based on values of different morphological traits in wheat which are different depends of the nutrient supplay. In generally most of the traits increased in a more or less linear manner with increased N availability (Ali et al., 2011). Even at low N levels, the plants still produced grains, at a lesser number, but with seemingly similar quality (Oscarson, 2000). There was a linear relationship between grain number and N availability.

Table 2. Average values of analyzed grain mass spike^{-1} in 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	**1.50**	**2.42**	**3.07**	**3.60**	**2.65b**	**1.43**	**2.08**	**2.48**	**3.14**	**2.28cd**	**2.46**
G-3625	**1.70**	**2.59**	**3.36**	**3.75**	**2.85a**	**1.44**	**2.20**	**2.54**	**3.22**	**2.35c**	**2.60**
G-3004	**1.42**	**2.67**	**3.14**	**3.65**	**2.72b**	**1.32**	**1.73**	**2.16**	**2.55**	**1.94e**	**2.33**
G-3617	**1.49**	**1.98**	**2.38**	**2.95**	**2.20d**	**1.43**	**1.79**	**2.10**	**2.66**	**2.00e**	**2.10**
Average	**1.53**	**2.42**	**2.99**	**3.49**	**2.60**	**1.40**	**1.95**	**2.32**	**2.89**	**2.14**	**2.37**

Most of the increased productivity at higher N availability could be attributed to an increased number of tillers per plant and, to some extent, by more spikelets spike^{-1} and potentialy more number of grain and grain mass spike^{-1}. So, nitrogen treatments significantly influenced to the value of spike length of wheat which found the maximum spike length was under the highest rate of application of mineral fertilizers (Ali et al., 2011; Knezevic et al., 2014) while growing without N application characterized minimum of spike traits (Asif et al., 2009; Iqbal et al., 2010).
Different value of spike trait among different wheat of genotypes are effected under environmental variation noticed (Zečević et al., 2008) and represent important components of wheat yield. For example increasing drought or salinity decreased indicated growth and yield of two cultivars of wheat (Sadeghi and Emam, 2011). In about 80 countries are in semiarid areas where salinization is a major problem and mainly worst salinity is present in arid and semiarid regions of the world which causes considerable reduction in crop production (Katerji *et al*., 2009).

The increasing of grain mass spike^{-1} in relations with increasing of nitrogen dose nutrition is possible explain by increased availability of N which resulted in increased vegetative and generative production of the plant. There are many individual processes that, integrated, are responsible for increased yield. The main stem have slightly longer stem as well more spikelets and grains which influence to increase in grain production. Its indicate that no single trait responsible for full response but rather a number of processes were integrated in the forming of grain yield. There a lot of research results which indicated different level of correlation among morphological characters (i.e. spike traits) as a components of yield (Akhtar and Chowdhary, 2006; Ahmad et al., 2010; Guendouz et al., 2014; Knezevic et al., 2014; Sabaghnia et al., 2014;

According to phenotypic variance analysis, the grain mass spike^{-1} expression also highly depended to genetic factors (19.26%), but on this trait expression environmental factors had higher influence (61.49%) Table 3. The investigated trait highly depended to genetic and environmental factors. These results are in agreement with previous reported by Zečević et al. (2004). The grain mass spike^{-1} is yield components which highly positively correlated to number of spikelets per spike (Zečević et al., 2004; Akram et al., 2008). Likewise, the grain mass spike^{-1} has strong indirect influence through number of spikelets and grain spike^{-1} on grain weight per plant (Zečević et al., 2004).

The analysis of variance reveals significant differences in grain mass spike^{-1} among genotypes and N application rates in both years (Table 3).

Table 3. Components of phenotypic variance for grain mass spike^{-1} of wheat

Source of variance	*Degree of freedom* (DF)	*Mean square* (MS)	F-test	*Components of variance* σ^2	%	*LSD* 0.05	0.01
Repetitions (R)	3	0.010	6.530	-	-	-	-
Genotypes (G)	3	0.364	241.593**	0.031	19.26	0.0712	0.1306
Years (Y)	1	1.702	1129.744**	0.099	61.49	0.0329	0.0447
Interaction(GxY)	3	0.119	79.013**	0.029	18.01	0.1006	0.1847
Error	21	0.002	-	0.002	1.24	-	-
Total	31	-	-	0.161	100.00	-	-

The direct effect of grain mass spike^{-1} on grain yield was negative in dryland condition and positive in supplemen tal irrigation condition (Ahmadizadeh et, al. 2011) . 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 grain mass spike^{-1}. 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 grain mass spike^{-1} 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 grain mass spike^{-1} of winter wheat in comparison with other variants of mineral nutrition. In average for all variant of nitrogen application, the highest values of grain mass spike^{-1} (2.85g) in G-3625 expressed in the first experimental year while the least (1.94g) in wheat G-3004 had in second experimental year. Nitrogen application had significant effect on grain mass spike^{-1}. By analysis of variance, it was established that analyzed yield component significantly depends to genotypes year conditions and rate of applied N. In the expression of value of grain mass spike^{-1} the impact of genetic factors was (19.26%), environmental factors was higher (61.49%) and impact of interactions genotypes/environment was (18.01%) what indicate nature of genotype reaction on applied rate of nitrogen.

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