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Variability of grain weight per spike of wheat grown in different ecological conditions

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Abstract: Variability of grain weight spike^{-1} was studied in 10 wheat genotypes: Ana Moava, Julija Mono, Gruža, Kruna, Lasta, Balkan, Rodna, NS Rana 2, Partizanka, Pobeda, grown over three experimental years under different environmental factors. The experiment was set up as a randomised block design in three replications. Differences in average values of grain weight spike^{-1} among tested cultivars were determined in all three years. On average, for all genotypes, grain weight spike^{-1} was the highest (2.32g**)** in first experimental year (2005/06) while the least average value (1.95g) was in second experimental year (2006/07). For all investigated wheat cultivars in third experimental year the average value of grain mas spike^{-1} was 2.24g, while total average value for all cultivars and three experimental year was 2.17g. Wheat cultivar Ana Morava had the highest average values of grain weight spike^{-1} in all three experimental years, while the least grain mas spike^{-1} had Balkan (1.81g) in second year Lasta (1.40g) and in third experimental year Partizanka (1.91g). In average Ana Morava had the highest value

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(2.67g) of grain weight spike^{-1}, while the least average value (1.94g) for period of investigation had wheat Balkan cultivar.
Key words: alfalfa wheat, variability, spike, grain weight, environment .

Introduction

Grain weight spike^{-1} together with numerous wheat traits have contribution in forming total grain yield. Among the yield and yield components exist positive or negative correlation what contribute to complexity of determination yield value. So, stem height and length of spike have negative direct influence grain yield (Bhagat et al., 2004; Haq et al., 2010), while tillers per plant (Khan et al., 2010), grain weight spike^{-1} (Ashfaq et al., 2003) have positive direct influence on grain yield, and thousand grain weight (TGW) has a negative direct effect on grain yield while positive indirect effects was observed via number of grains per spike and grain weight per spike (Shoran et al., 2000). Each component of yield is under control of genes and under influence of environmental factors, as well under influence of interaction of genetic and environmental factors. The high temperature shortens grain filling period, and induce early maturity which cause grains shrinking as well low value of grain weight (Khan et al., 2007). For successful breeding is important wide knowledge about characteristics of genotypes and environment as well interaction of genotype/environment (Knezevic et al., 2007). Evaluation of interaction genotype/environment is important in function to help selection of superior genotypes (Dhungana et al., 2007). The areal of wheat plant growing is wide and spread in different climate areas. Due to wheat importance, the main task of breeders is to develop new genotypes with high grain yield potential, enhanced quality traits and high adaptability to environmental conditions. The success of wheat breeding for high grain yield depends of germplasm source for choice the best parent plants for hybridization and producing progenies with inherited characters with economic importance (Zečević et al., 2005; Akcura, 2009; Iftikhar et al., 2013). For achievement desirable combination of traits breeders developed methods for creating new high yield cultivars, based on conduction large number of crossing and testing early generation of progenies. The increasing of grain yield is possible through increasing value of component of yield: spike traits, efficiency of photosynthesis and use of nutrients (Knezevic et al., 2012). The increasing

capacity of spike traits respond to environmental factors, as well temperature values, precipitation, nutrition (Petrović et al. 2008). Spike productivity is in direct correlation with the number of grain and grain weight spike^{-1}. The grain weight spike^{-1} is in positive connection with weight of spike as well total grain yield (Okuyama, 2005). Also, breeding of wheat on improved capacity of morphological and anatomical structure of plant and organs have contribution to increasing grain weight spike^{-1} in selected cultivars (Kondić et al., 2012).

The aim of this study was to evaluate the variability of grain weight spike^{-1} in genetically divergent wheat cultivars grown in different environmental conditions, and identification of cultivars as a suitable parent in wheat breeding programs to improve grain yield.

Materials and methods

The variability of grain weight per spike was studied in 10 winter wheat cultivars selected in two different Serbian wheat breeding centers (Novi Sad and Kragujevac). For this investigation used cultivars: Ana Moava, Julija Mono, Gruža, Kruna, Lasta, Balkan, Rodna, NS Rana 2, Partizanka, Pobeda. The investigation carried out during three experimental years (2005/6-2007/8). The experiment was performed in randomized block design in three replication in field conditions. The seeds of wheat cultivars were sown at the distance of 0.05m in rows of 1m length. The space between rows was 0.2m. For analysis of grain weight per spike were used 60 plants in full maturity stage (20 plants per replication). After analysis were computed: the average value (x); the variance (σ^2). The significant differences between the average values were estimated by F-test values.

Climatic conditions during growing seasons

For the better understanding of variability of analyzed trait the environmental condition (temperature and precipitation) were presented for three years of experiment during vegetative period of wheat plant (Table 1). Average temperatures were similar during first (8.3 ^{o}C) and third (8.05 ^{o}C) investigated years, which also were similar according to the long-term period (8.5 ^{o}C). In 2006/07, average temperature (11.0 ^{o}C) was higher than in the 2005/06 and 2007/08 years as well as in the long-term period. Mainly differences were in the winter period when plants were in hibernation that did not significant influenced on plant growing. Sums of precipitation were higher in 2005/06 (533.7 mm) than in other two experimental years: 2006/07 (369.9 mm), 2007/08 (430.7mm) and

long-term period (417.8 mm). Precipitations in 2006/07 vegetative period were the lowest (369.9mm). This amount of precipitation was the lower for 115.9 mm than in long-term period, for 163.8mm than in 2005/06, and for 60.8 than in 2007/08 year. In May 2006/07 precipitations were higher four time in relation to 2005/06 year and long-term period, and nine time higher than in 2007/08 (13.1mm) but in April 2006/07 was only 3.6 mm, when was drought period which negatively influenced on plant growing.

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

Month	Temperature ^{o}C				Precipitation (mm)			
	2005/06	2006/07	2007/08	1990-2000	2005/06	2006/07	2007/08	1990-2000
October	11.5	13.3	10.9	11.83	49.0	16.7	69.1	61.02
November	5.6	7.6	4.5	6.4	54.8	13.7	110.4	44.29
December	3.3	3.5	0.4	1.71	47.1	51.9	28.1	44.65
January	-1.7	6.1	2.5	-0.1	27.9	45.3	37.7	30.04
February	1.5	6.3	4.4	2.62	38.1	32.1	13.0	29.87
March	5.5	9.1	8.0	5.99	116.1	62.9	61.5	33.21
April	12.7	12.1	12.6	11.6	86.3	3.6	30.1	52.88
May	16.4	18.2	17.4	16.37	29.6	118.4	13.1	52.57
June	19.7	22.8	21.8	20.37	84.8	25.3	67.7	69.28
Average	**8.3**	**11.0**	**8.05**	**8.5**	59.3	41.1	47.9	46.4
Total	74.4	99.0	72.5	76.7	**533.7**	**369.9**	**430.7**	**417.8**

Results and Discussion

In this study of grain weight spike^{-1} were found significant differences among cultivars in all three year of experiment. In the first year of study the grain weight spike^{-1} was the least in wheat cultivar Balkan (1.81g) and the highest in cultivar Ana Morava (2.80g), in second year the least grain weight spike^{-1} was in wheat cultivar Lasta (1.40g) and the highest in Ana Morava (2.25g), while in the third experimental year the least grain weight spike^{-1} was established in wheat cultivar Partizanka (1.91g) and the highest in Ana Morava (2.96g) table 2.

In average for all three year of investigation, the least value was found in cultivar Balkan (1.94g) and the highest value of grain weight spike^{-1} was found in cultivar Ana Morava (2.67g) table 2.

The average value of grain weight spike^{-1} for all cultivars in the first year was 2.32g, in the second year was 1.95g while in the third experimental year was 2.24g. These values are significantly different (tab.2).

The results obtained in this investigation of ten wheat cultivars showed significant differences in the average values of grain weight spike^{-1} per year that indicates on diversity of examined cultivars. Variability of grain weight spike^{-1} depended on investigated genotypes and year as well. These findings are in agreement with previous study (Knezevic et al., 2010).

In investigation of 15 wheat cultivars the average values of grain weight spike^{-1} variate from 1.43g in Inqilab-91 cultivar to 2.33g in Wattan cultivar (Ashfaq et al., 2003).

Similar results for variability grain weight spike^{-1} in study of another wheat cultivars, under different dose of nitrogen nutrition, established (Knezevic et al. 2012). Grain weight as component of grain yield determined by genetic and environmental factors (temperature, light, nutrient, water), Agoston and Pepo (2005) and depends from duration of filling time and efficiency of utilization and translocation of nutrient from vegetative to reproductive par of plant (Chanda and Singh, 2010; Zareian et al., 2014).

Table 2. Average value of grain weight (g) of anlysed wheat geotypes

Geneotypes	Year			$\overline{X}A$
	2005/06	2006/07	2007/08	
	$\overline{X} \pm S_x$	$\overline{X} \pm S_x$	$\overline{X} \pm S_x$	
Ana Moava	2.80 ± 0.09	2.25 ± 0.21	2.96 ± 0.22	2.67± 0.17
Julija Mono	2.28 ± 0.24	2.16 ± 0.20	2.27 ± 0.16	2.24± 0.20
Gruža	2.08 ± 0.14	1.88 ± 0.11	2.20 ± 0.15	2.05± 0.13
Kruna	2.68 ± 0.19	1.82 ± 0.18	2.16 ± 0.21	2.22± 0.19
Lasta	2.17 ± 0.13	1.40 ± 0.09	2.27 ± 0.22	1.95± 0.15
Balkan	1.81 ± 0.14	1.96 ± 0.16	2.06 ± 0.13	1.94± 0.14
Rodna	2.34 ± 0.21	1.96 ± 0.19	2.15 ± 0.11	2.15± 0.17
NS Rana 2	1.99 ± 0.14	2.05 ± 0.12	2.08 ± 0.16	2.04± 0.14
Partizanka	2.68 ± 0.18	1.96 ± 0.19	1.91 ± 0.15	2.18± 0.17
Pobeda	2.32 ± 0.15	2.08 ± 0.16	2.35 ± 0.12	2.25± 0.14
$\overline{X}B$	2.32± 0.16	1.95± 0.16	2.24± 0.16	2.17± 0.16

Factors		A	B	AB
$F_{computed}$		4.529*	11.698**	1.822
LSD	0.05	0.402	0.354	0.384
LSD	0.01	0.585	0.856	0.537

The obtained different values of grain weight spike^{-1} in analyzed cultivars of wheat, represents genotypes response to environmental conditions during onthogenetic development. The optimal conditions for development of productive organs (spike, spikelets, florets) as well optimal condition at the stage of flowering, pollination and fertilization and grain filling have big contribution for expression higher values of yield components. Also, pre-sowing plants had effect on wheat yield (Nasri et al., 2014). The different value of spike traits in the same cultivars in different years of study were found in other investigation that indicating high influence of agro-ecological factors on the expression of spike traits (Agoston and Pepo, 2005; Dakhim et, al. 2012). The very important for establishing response of genotypes to environmental conditions is study of yield stability, as well stability of yield component (Dimitrijevic et al., 2011).

Grain weight spike^{-1} is quantitative trait and it is in relation with other yield components because of complex correlation. Some of yield components are in positive while another are in negative correlation (Mohsin et al., 2009). So, in investigation (Ashfaq et al., 2003) of 15 wheat cultivars, reported direct positive influence of grain weight spike^{-1} to grain yield, as well as indirect positive influence via number of spikelets spike^{-1}, number of grains spike^{-1} and negative indirect influence via 1000-grain weight on grain yield per plant. These complex relation among yield components as well specificity of genotype response to environmental condition make a lot difficulties in breeding process in successful creation new enhanced cultivars.

In this investigation each year was different regime of temperature and precipitation. Each cultivars expressed specific response to environmental conditions. For efficient breeding is necessary to better understanding genotypic causes to expression values of traits, effect of environmental factors and genetic/environment interaction in all stages of plant breeding. These knowledge about the influence of genetic and environmental factor to variability of yield components will contribute to successfulness of breeding programs.

The optimizing the scientific farming measures as well as water supply, fertilizer and pesticide application is very important for achieving significant increase of value of grain yield and grain yield components (Jolánkai et al., 2006). Also, it is important to estimate level of genotype adaptation to limiting factor of environment as well how is ability of genotype to utilize favorable environmental factors (Kovačević, 2007).

Genetic difference was the main factor affecting grain-filling characteristics and contribute to the maximum grain weight at maturity. The efficiency of grain

filling rate is in strong relationship to increase of grain weight, what can use as one parameters in breeding process (Jocković et al., 2014). Genetic potential of tolerance of genotypes to environmental stress play important role for better productivity of wheat (Sohail et al., 2014).

Conclusion

The values of grains weight spike^{-1} in this investigation showed that there are differences among the analyzed cultivars in each year of experiment. Also, for same wheat cultivars established differences values of grains weight spike^{-1} in all three experimental years. Total variability of grain weight spike^{-1} was significant different within each experimental year, as well as among three years of experiment. This indicate that genotype and environment have influence to variation of values of grains weight spike^{-1}, which average value for all three years of this sudy ranged from 1.94g values in cultivar Balkan, to 2.67g in cultivar Ana Morava. Cultivars Ana Morava, Julija Mono, NS Rana 2, Kruna, Pobeda expressed high and stable value of grain weight spike^{-1} in different environmental conditions, and represent perspective parents for breeding program. In average, for all wheat cultivars, grain weight spike^{-1} was the highest (2.32g) in first experimental year and the least (1.95g) was in second experimental year, in third experimental year the average value of grain weight spike^{-1} was 2.24g. The total average value for all cultivars and three experimental year was 2.17g. For improvement of yield is necessary increase influence of genetic factor for all yield components. On the base of improvement of genetic control for increasing capacity of productive traits as well as improvement of anatomical structure and physiological function of vegetative and reproductive organs of wheat plants.

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VARIABINOST MASE ZRNA PO KLASU PŠENICE GAJENE U RAZLIČITIM EKOLOŠKIM USLOVIMA

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Rezime

Kod deset sorti ozime pšenice: Ana Morava, Julija Mono, Gruža, Kruna, Lasta, Balkan, Rodna, NS Rana 2, Partizanka, Pobeda, je izučavana varijabilnost mase zrna klasu^{-1}. Izučavanja su obavljena u različitim spoljašnjim uslovima koji su varirali u toku tri godine (2005/06 do 2007/08) u eksperimentu postavljenom po slučajnom blok sistemu u tri ponavljanja. Seme sorti je sejano na rastojanju od 0,05 m u redovima dužine 1,0 m, a razmak izmedju redova je bio 0,2 m. Za analize je korišćeno 60 biljaka (20 biljaka x 3 ponavljanja) u stadijumu pune zrelosti. Ustanovljene vrednosti mase zrna klasu^{-1} su pokazale da su se sorte medjusobno značajno razlikovale u istoj eksperimentalnoj godini, kao i da su sve sorte imale različite vrednosti mase zrana klasu^{-1} u različitim godinama izučavanja. Prosečna vrednost mase zrna klasu^{-1} za deset izučavanih sorti bila je najveća (2,32g) u prvoj eksperimentalnoj godini (2005/06) a najmanja prosečna vrednost (1,95g) u drugoj godini (2006/07), a u trećoj godini (2007/08) prosečna masa zrna klasu^{-1} (2,24g). Za deset izučavanih sorti pšenice trogodišnja prosečna vrednost mase zrna klasu^{-1} bila je 2,17g. Sorta Ana Morava je imala najveću prosečnu vrednost mase zrna klasu^{-1} u sve tri eksperimentalne godine (2,80g u prvoj, 2,25g u drugoj i 2,96 u trećoj) i najveći trogodišnji prosek za masu zrna klasu^{-1} (2,67g). Najmanja masa zrna klasu^{-1} je ustanovljena kod sorte Balkan (1,81g) u prvoj eksperimentalnoj godini, kod sorte Lasta (1,40g) u drugoj godini, i kod sorte Partizanka (1,91g) u trećoj eksperimentalnoj godini. Sorta Balkan je

imala najmanji trogodišnji prosek mase zrna klasu^{-1} (1,94g). Ustanovljene su značajne razlike izmedju sorti i godina što ukazuje da je masa zrna klasu^{-1}, svojstvo čija vrednost se ispoljava zavisno od genotipa u uslova spoljašnje sredine, kao i njihove interakcije. Potpunija znanja o prirodi ovog svojstva mogu biti korisna u procesu oplemenjivanja pšenice.

Ključne reči: pšenica, varijabilnost, masa zrna po klasu, spoljašnja sredina