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VARIABILITY OF STEM HEIGHT IN WHEAT TRITICUM AESTIVUM L.

Desimir KNEŽEVIĆ[*1], Dušan UROŠEVIĆ[2], Aleksandar PAUNOVIĆ[3], Danijela KONDIĆ[4], Vesna ĐUROVIĆ[3], Jelica ŽIVIĆ[5], Mirela MATKOVIĆ[2], Adriana RADOSAVAC[6], Milomirka MADIĆ[3], Veselinka ZEČEVIĆ[2]

[1]University of Pristina, Faculty of Agriculture, Kosovska Mitrovica-Lešak, Kopaonička bb.,38228 Lešak, Kosovo and Metohija, Serbia
[2]University Megatrend, Belgrade, Faculty of Biopharming Backa Topola, M. Tita 39, Serbia;
[3]University of Kragujevac, Faculty of Agronomy Cacak, Cara Dušana 34, 32000 Cacak, Serbia
[4]University of Banja Luka, Faculty of Agriculture Banja Luka, Boulevrd Vojvode Petra Bojovića, 1A, 78000 Banja Luka, Republika Srpska, Bosnia and Herzegovina
[5]College of Agriculture and Food Technology, Prokuplje, Serbia
[6]Faculty of Applied Management, Economics and Finance, University Business Academy in Novi Sad, Jevrejska 24, Belgrade, Serbia
*Corresponding author: deskoa@ptt.rs

Abstract

The stem height of wheat has impact on grain yield. Variability of height of wheat stem depends from environment and genetic structure of varieties. The aim of this study was estimation of impact of genetic components and environmental conditions on variability of stem height in 10 genetically divergent wheat varieties. The experiment was set up as a randomised block design in three replications. Obtained results indicated differences in average values of stem height among tested wheat varieties in each year of experiment. In the first year of study, the least stem height had Danica variety (44.87 cm) and the highest stem height had wheat variety Ljubičevka (64.73 cm. In the second year stem height varied between 64.37 cm in Danica variety and 87.97 cm in Šumadija variety. In average for all varieties the height of stem was higher in the second year than in the first year of experiment. Also, in average the value of height of stem was higher in second year than in the first year, in all analysed wheat varieties. The highest height of stem, expressed Šumadija variety in average (87.97 cm) in the second year. The least value of stem height (44.87 cm) in average had Danica variety in the first year of experiment. Based on the results significant differences between the wheat varieties according to stem height was established and impact of genetic factors prevailing compare to impact of environmental factors.

Keywords: *wheat, variability, height of stem, varieties*

Introduction

Stem height of wheat is component of plant architecture with connection to lodging of plant, variability of grain harvest index and grain yield. The resistance to plant lodging are determined by genetic factors and under influence of environmental factor (Zečević et al., 2005; Madić et al., 2016). In wheat breeding in period of "Green Revolution" breeders achieve introduce genes for reduction height of plant (dwarfing genes) which affected decreasing of stem height, increasing resistance to lodging of plant, increasing of grain yield and reduction of cost. The main role in stem reduction of wheat have *Rht-B1* and *Rht-D1* genes which response to gibberellin insensitivity and influence on number of grain and grain yield. The study of European recent winter wheat varieties showed that in the most the *Rht-D1* was significantly associated with plant height (Zanke et al., 2014; Würschum et al., 2015; Würschum et al., 2017). Also, other studies reported that dwarfing genes *Rht-B1b* and *Rht-D1b* are associated with Type I susceptibility to *Fusarium head blight* in wheat and low

anther extrusion (He et al., 2016). Numerous studies on *Rht* genes have concluded that *Rht8* gene reduces the plant height (Ellis et al., 2004; Rebetzke et al., 2011) but it has negligible effect on coleoptile length (Trethowan et al., 2001; Liatukas and Ruzgas, 2011; Grover et al., 2018). The wheat variety which carried *Rht-B1b* and *Rht-D1b* are not suitable for growing in area where heat and drought stress condition prevails during phase of grain filling (Ellis et al., 2005). However, wheat variety which carried combination gibberellic acid responsive *Rht8* gene and gibberellic acid insensitive (*Rht-B1b* and *Rht-D1b*) genes, are more adaptive on heat and drought conditions during phase grain filling and achieved higher grain yield (Rebetzke et al., 2011; Kaya et al., 2015). It mean than interaction of environmental factor and genotype affect expression of plant height in wheat varieties (Knežević et al., 1993). Also, technology measures of growing, as well application of different doses of fertilizer and plant growth regulators have influence on plant height (Spolidorio and Lollato, 2019). They reported that application of plant growth regulator (12% trinexapac-ethyl) during jointing phase, with standard dose of nitrogen fertilization, influence decreasing of wheat plant, in average 1,5 cm. The aim of this study was establish (i) variability of plant height in wheat varieties grown under different environmental condition of two years of experiment (ii) impact of genetic factor environmental factor and interaction of genotype/environment on plant height of wheat varieties.

Materials and Methods

This research encompasses 10 genetically divergent wheat varieties. Selected wheat genotypes were sown in field conditions in Kraljevo (city area in Serbia). Experiment was designed by randomized block system in three repetitions on plots of 1 m^2, in two growing seasons, (2015/16 and 2016/17). Sowing was done manually, by laying the seeds at a distance of 0.1 m in rows 1.0 m long, with a space of 0.20 m between rows. Sparse sowing was performed in order to enable the examined plants to fully manifest their traits. The plants were harvested for analysis in the phenology phase of full maturity. For all 10 wheat genotypes, 60 plants (20 plants per replicate) were used for stem height analysis. Mathematical-statistical analysis was performed, The analysis of variance (ANOVA) of monofactorial system examination by years was performed according by using the MSTAT C 5.0 version, The F-test was used to assess the significance of differences between average stem heights in the analyzed wheat genotypes. The LSD test was used for estimation significance of differences in values.

Weather conditions in the vegetation period

In the experimental year 2015/2016, the values of average monthly air temperatures and the total amount of precipitation per month differed in relation to the long-term period. In the first year of the experiment, the average temperature was 9.9 ° C and the total rainfall was 651.00 mm, which is significantly higher than in the second year in which the average temperature during the growing season was 8.7 ° C and the total rainfall 523.1 mm. In both years of the experiment with the varieties, the average temperature and the total amount of precipitation were higher in relation to the ten-year average (2000-2010) of the temperature values which were 8.5 ° C and 417.8 mm. For the development of plants, a more favorable temperature and precipitation regime was in the second year of cultivation. In the second year in the period October-November, the conditions for plant emergence were more favorable with the amount of precipitation of 161.7 mm, while in the first year in the same period there was a smaller amount of precipitation - 120.8 mm. In this period, the average temperature was higher by 0.8 °C in the first year, in which there was a smaller amount of precipitation, which could affect the slower emergence and development of plants in the crop. In the period February-March, in both experimental years, the average temperatures were similar but higher in

relation to the long term period average value, and there were also higher amounts of precipitation in relation to average of long term period. In the period February-April in the first year of the experiment, the amount of precipitation was 250.5 mm, which is higher than it was in the second year - 174.0 mm, but the distribution of precipitation was more favorable in the second year of the experiment. In the first year in April the average temperature was higher and the average amount of precipitation was lower than in the second and in relation to the multi-year period. In May, the temperatures were approximately the same in both years of the experiment and in the long-term period, while the amount of precipitation was significantly higher in the first year by 135.9 mm than in the second 100.0 mm and in both years significantly higher precipitation compared to the perennial period 52.6 mm.

Table 1. Average monthly temperatures and total monthly precipitation in Kraljevo
(*source: Republic Hydrometeorological service of Serbia)

Parameter	Period	Oct	Nov	Dec	Jan	Feb	March	April	May	June	Xm	Total
Temperature ^{0}C	2015/16	11,6	7,3	3,3	-0,1	8,8	7,8	14,1	15,5	21,3	**9,96**	89,64
Temperature ^{0}C	2016/17	10,6	6,8	0,0	-4,7	5,2	10,8	11,1	16,8	22,1	**8,74**	78,66
Temperature ^{0}C	2000-2010	11,8	6,4	1,7	-0,1	2,6	5,9	11,6	16,4	20,4	**8,5**	76,5
Precipitation (mm)	2015/16	56,8	64,0	9,0	86,2	52,7	157,9	39,9	135,9	48,6	72,3	**651,0**
Precipitation (mm)	2016/17	84,1	77,6	9,4	22,0	35,0	57,0	82,0	100,0	56,0	41,1	**523,1**
Precipitation (mm)	2000-2010	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 height of the stem varied in the range from the lowest value - 44.87 cm in Danica, to the highest value - 64.73 cm in Ljubičevka in the first year of the experiment. The lowest stem height was 64.37 cm in Danica and the highest stem height was 84.33 cm in Ljubičevka in the second year of research. The average value of the height of a wheat stem in two years was the lowest 54.62 cm in Danica and the highest 74.53 cm in Ljubičevka. The average value of stem height for all wheat genotypes 53.4 cm in the first year was lower than in the second year 75.1 cm, while for all wheat varieties and in both years the height of the stem was 64.25 cm (Table 2).

Table 2. Variation of stem height (cm) in winter wheat varieties

Variety	Years		Average	Variety LSD		Year LSD		Variety x Year LSD	
	2015/16	2016/17		0.05	0.01	0.05	0.01	0.05	0.01
Fortuna	45.57lm	67.67gh	56.62FG	2.697	3.874	0.762	1.019	3.814	5.479
Sasanka	45.63lm	72.43e	59.03EF						
Danica	44.87m	64.37hi	54.62G						
Somborka	46.53lm	75.50de	61.02DE						
Kremna	49.07kl	68.33fg	58.70EF						
Kosmajka	52.50k	72.10ef	62.30D						
Šumadija	64.43hi	87.97a	76.20A						
Morava	59.00j	77.90cd	68.45C						
KG-56S	61.80ij	80.73bc	71.27B						
Ljubičevka	64.73ghi	84.33ab	74.53A						

Zečević et al. (2004) studied 50 wheat varieties from different selection centers in two years and found significant differences for plant height between years. In the first year plant height varied from 122,2 cm to 125,7 cm, while in second year plant height variate in ratio from 47,6 cm to 50.4 cm. The established that variability of plant height of wheat depends on

investigated variety and years and also, that significant differences between years according to values of plant height, indicated that two vegetation periods were ecologically different.
Analysis of variance showed that there were differences between wheat varieties for stem height, which were significant and highly significant. Differences between years for stem height in varieties indicate that there is an influence of environmental factors on the manifestation of plant stem height. In addition to this significance, the analysis of stem height variance for the total sample also revealed high significant differences for the values of the square mean for genotypes and for environments (weather conditions in the years).
The analysis of the components of variance for stem height confirmed that the environmental conditions in year had the greatest influence on the manifestation of stem height, 51.42%, while the share of genotype was 23.12% and the share of interaction was 4.24% (Table 3).

Table 3. Components of variance for stem height in wheat varieties

Sources of variation	DF	SS	MS	F-test	Probability	Components of variance	
						σ^2	%
Repetition	2	0.178	0.089	1.64322^{ns}	0.1755	-	-
Variety	9	3.352	0.372	7.4523**	0.0000	0,049	23,12
Year	1	3.023	3.023	64.2596**	0.0000	0,109	51,42
Variety x Year	9	0.588	0.065	1.6436^{ns}	0.1709	0,009	4,24
Error	38	1.746	0.045	-	-	0,045	21,22
Total	59	8.887	-	-	-	0.212	100,00

In similar studies conducted in a two-year experiment, was established the genetic factor had a share of 84.3%, environmental factors 7.5% and share of variety/year interaction was 6.7% in expression of plant height (Zečević et al., 2005). Similar studies conducted with bread wheat varieties showed a range of plant height variation between 66.5 cm and 112.2 cm and the average plant height for the examined varieties was 88.7 cm (Branković et al., 2015).

Conclusion

Based on the obtained results, the variation of stem height in the examined wheat varieties grown in two years, which differed according to weather conditions, was established. Varying the value of plant height in the same variety in two climatically different years shows the response of the genotype to the changed environmental conditions. The average value of the height of a wheat stem in two years was the lowest 54.62 cm in Danica and the highest 76.20 cm in Šumadija variety. The differences between genotypes were significantly high and highly significant for stem height. The expression of the studied trait was influenced by genetic factors, environmental factors and genotype/environment interaction. The largest share, 51.42%, on the height of the stem had environmental factors (years), and genotype.

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