Original scientific paper
Оригиналан научни рад
UDC: 633.11-155.9(497.6)
DOI: 10.7251/AGREN1704263K

University of Banjaluka, Faculty of Agriculture
Agro-knowledge Journal

The Spike Characteristics of Winter Wheat (*Triticum aestivum* L.) Varieties in Agro–Ecological Conditions of Banja Luka Region

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Abstract

The aim of this study was to analyze the spike length, number of grains per spike and grain weight per spike of winter wheat in agro–ecological conditions of Banja Luka at different sowing densities. Three winter wheat varieties (NS 40S, Prima and Nova Bosanka) were examined at seven sowing densities (384, 424, 451, 504, 544, 588 and 604 seeds/m^2) in two growing seasons (2013/14 and 2014/15). Experimental design was a completely random system with four replications. In all wheat varieties, sowing was carried out from the 6th to 8th November in 2013/14 and from the 3rd to 5th November in 2014/15. Sampling of plants was done in the first decade of July in both experimental years. Factorial ANOVA 2×8×3 and *LSD*–test were performed, with year, sowing density and variety as main factors. For different varieties, the average number of grains per spike ranged from 34.53 to 38.19 while the average grain weight per spike (g) ranged from 1.58 to 1.73 g. The spike length ranged from 7.58 to 8.20 cm for varieties with statistically significant interaction effect variety × year at $P \leq 0.01$. Spike parameters were generally higher in the second experimental year (2014/15).

Key words: cultivar, sowing density, productivity, grain, interaction

Introduction

Production of sufficient amounts of food is a global challenge now and in the future, which will obviously be characterized by a world population increase and climate change.

In 2050, when the human world population is expected to stabilize, 65% of world population will live in urban areas, and increasing of sufficient food quantities is possible only by increasing plant productivity per unit area (Conor and Minguez, 2012). It is clear that a global aim is the production of sufficient amounts of crops, including wheat, to provide enough food for the human population. In order to increase wheat production appropriate plant density should be chosen among other things (Li et al., 2016). Also, for 2050 rising of average global temperature for 1 to 8°C is predicted (Meehl et al., 2007).

The response of crop species to temperature primarily reflects on their development stages (Hatfield and Prueger, 2015). Plant density is an agronomic important factor that manipulates micro environment of the field and affects the growth, development and yield formations of crops (Caliskan et al., 2007). Plant density, which is determined by the sowing rate, provides the living space for the plant, as well as the availability of water and mineral nutrition. The recommended planting density usually does not take into account the varietal differences, respectively tillering and the ability for survival, in particular agro–ecological conditions (Valerio et al., 2009). Wheat rows–spacing also affect wheat yields (Sandler et al., 2015). Due to the abovementioned issues, and taking into consideration interaction of variety and environmental conditions, it is necessary to examine the response of varieties in specific ecological conditions.

Several studies were done in order to investigate wheat spike parameters, such as number of grains per spike (Lloveras et al., 2004, Đurić et al., 2016, Stojković et al., 2004, Guberac et al., 2000), grain weight per spike (Knežević et al., 2015, Barić et al., 2008, Protić et al., 2013, Zečević et al., 2010, Gaile et al., 2017) and spike length (Banjac, et al., 2010; Kobiljski and Denčić, 1997; Shankarrao et al., 2010; Petrović et al., 2007; Petrović et al., 2000; Zečević et al., 2004). It is also widely known that the obtained yield in specific environmental conditions is affected by the realization of yield components.

Studying the yield components enables a plant breeder to breed for high–yielding genotypes with desired combinations of traits (Khan and Dar, 2010). The aim of this research was to evaluate the effect of sowing density, variety as well as specific agro–ecological conditions on different spike parameters of winter wheat.

Materials and Methods

Three winter wheat varieties (NS 40S, Prima and Nova Bosanka) were examined at seven different sowing densities (384, 424, 451, 504, 544, 588 and 604 seeds/m^2).

The experiment was set up in the region of Banja Luka (44°46' N; 17°11' E) during two growing seasons: 2013/14 and 2014/15 growing season. Each experimental unit was 1 m^2 in size, with four replications. From each replication 30 wheat spikes were taken for analyses. Sowing was carried out manually at 4±1 cm depth in all combinations. Experiments were placed on the Cambisol (Dystric) soil.

Standard agronomic practices for winter wheat were performed. Sowing was carried out from the 6th to 8th November in 2013/14 and from the 3rd to 5th November in 2014/15 growing season. Wheat plants were sampled in the first decade of July in both growing seasons for morphological analysis of spike. Three spike parameters were analyzed: spike length (cm), number of grains per spike and grain weight per spike (g).

Statistical analysis was performed in MS Office Excel 2013 using factorial analysis of variance 2×8×3 [factorial design: year (2) × sowing density (8) × variety (3)] while significant differences between treatments were tested by Fisher's least significant difference test (*LSD*–test).

Based on the climate diagram shown in Figure 1 it can be seen that the seeding period (November) in 2013 was not stressed by drought, while a relatively short period of drought appeared in December, when the wheat crop was in winter dormancy.

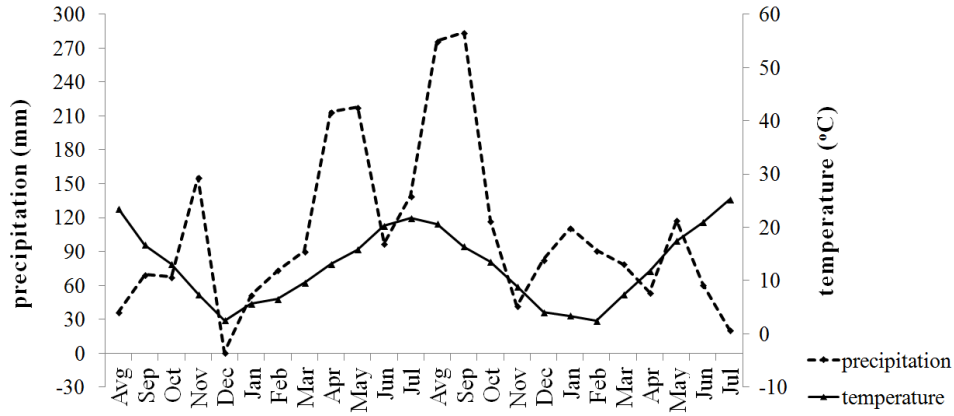

Fig. 1. Climate diagram for 2013/14 and 2014/15
Клима–дијаграм за 2013/14 и 2014/15

Wheat vegetation period in 2014 was characterized by a relatively high precipitation, until June when a short period of drought appeared. Seeding period during November in 2014 was stressed by relatively short periods of drought, which could have an impact on the process of germination and plant emergence. Drought period occurred again in April 2015 when the wheat crop was in the intensive growth and development phases.

Results and Discussion

Spike length. Table 1 presents the average spike length (cm) for winter wheat varieties NS 40S, Prima and Nova Bosanka at different sowing densities in the 2013/14 and 2014/15 growing seasons.

Tab. 1. The spike length (cm) for NS 40S, Prima and Nova Bosanka varieties
Дужина класа (cm) за сорте НС 40С, прима и нова босанка

Sowing density (seeds/m^2)	Variety / *Сорта* / Year / *Година*	NS 40S	Prima	Nova Bosanka	$\bar{X} \pm SD$ for sowing densities
384	*2013/14*	7.01 ± 0.44	7.27 ± 0.40	6.81 ± 0.38	7.87 ± 0.14
	2014/15	8.40 ± 0.24	9.29 ± 0.25	8.41 ± 0.23	
424	*2013/14*	7.26 ± 0.40	7.40 ± 0.31	7.03 ± 0.20	7.84 ± 0.08
	2014/15	8.33 ± 0.20	9.02 ± 0.22	7.98 ± 0.29	
451	*2013/14*	7.25 ± 0.26	7.43 ± 0.32	7.38 ± 0.16	7.81 ± 0.24
	2014/15	8.01 ± 0.22	8.85 ± 0.26	7.95 ± 0.21	
504	*2013/14*	7.09 ± 0.27	7.45 ± 0.25	7.05 ± 0.31	7.71 ± 0.30
	2014/15	8.04 ± 0.10	9.00 ± 0.15	7.64 ± 0.12	
544	*2013/14*	7.32 ± 0.28	7.48 ± 0.34	7.35 ± 0.28	7.89 ± 0.25
	2014/15	8.15 ± 0.17	8.84 ± 0.21	8.22 ± 0.25	
588	*2013/14*	7.33 ± 0.35	7.56 ± 0.22	7.41 ± 0.18	7.91 ± 0.27
	2014/15	7.95 ± 0.20	9.12 ± 0.12	8.06 ± 0.25	
604	*2013/14*	6.98 ± 0.11	7.24 ± 0.14	7.28 ± 0.24	7.66 ± 0.28
	2014/15	8.10 ± 0.17	8.83 ± 0.19	7.50 ± 0.14	
$\bar{X} \pm SD$ for varieties		7.66 ± 0.14	8.20 ± 0.22	7.58 ± 0.13	
$F_{\text{variety}} = 27.612^{**}$; $F_{\text{sowing density}} = 0.917^{ns}$; $F_{\text{year}} = 223.595^{**}$;					
$F_{\text{variety × sowing density}} = 0.348^{ns}$; $F_{\text{variety × year}} = 10.845^{**}$; $F_{\text{sowing density × year}} = 1.827^{ns}$					
$F_{\text{variety × sowing density × year}} = 0.362^{ns}$.					
ns – not significant (P > 0.05), * (P ≤ 0.05), ** (P ≤ 0.01)					

The spike length ranged from 7.58 to 8.20 cm for varieties and from 7.66 to 7.91 cm for densities. ANOVA indicated that variety and year, as the main effects, were statistically significant at $P \leq 0.01$. Interaction variety × year was statistically significant at $P \leq 0.01$ (Table 1).

Kobiljski and Denčić (1997) obtained spike length ranging from 6.6 to 12.5 cm in 100 tested high–yielding genotypes and from 5.0 to 16.8 in 100 tested low–yielding genotypes. A total of 22 wheat genotypes from different parts of the world obtained spike length ranging from 7.9 to 11.3 cm (Petrović et al., 2000).

According to Zečević et al. (2004) fifty wheat varieties from different countries had the average spike length of 11.0 cm. In Petrović et al. (2007), the average spike length ranged from 7.1 to 9.7 cm for 10 winter wheat varieties, with significant differences between varieties at both *LSD* levels. The average spike length ranged from 6.45 to 8.31 cm for eight wheat varieties in three years (Banjac, et al., 2010).

In order to achieve maximum wheat grain yield, it is necessary to achieve the spike length of 15 cm with a high value of grain weight (Borojević, 1990). In the study of 30 wheat genotypes Shankarrao et al. (2010) obtained an average spike length of 16.5 cm. Therefore, tested wheat varieties in our study can be characterized as having a relatively short spike length.

The average spike length was the highest in Prima in 2015 (8.992 cm), which was statistically significant at $LSD_{0.01}$ in comparison with all other tested combinations (Table 2).

Tab. 2. *LSD* test for significant interaction variety × year – spike length (cm)
LSD тест за значајан интеракцијски ефекат сорта × година – дужина класа (cm)

variety × year *сорта × година*	average spike length (cm) *просјечна дужина класа (cm)*
Prima in 2015	8.992
NS 40S in 2015	8.140**
Nova Bosanka in 2015	7.966**
Prima in 2014	7.404**
Nova Bosanka in 2014	7.186**
NS 40S in 2014	7.177**
LSD test	0.05 0.25
($F_{\text{variety x year}}$)	0.01 0.34

*** significant at $LSD_{0.01}$*

Figure 2 presents the analysis of detected significant interaction effect variety × year. According to data, in 2013/14 growing season, the highest average spike length was achieved in Prima variety (7.40 cm), followed by Nova Bosanka (7.19 cm) and NS 40S (7.18 cm) varieties. In 2014/15 growing season, the highest average spike length was also achieved in Prima variety (8.99 cm), followed now by NS 40S (8.14 cm) and Nova Bosanka (7.97 cm) varieties. All winter wheat varieties achieved higher average spike length in the second growing season (2014/15). This increase was intense in Prima variety while other two varieties had mutual and less intense increase. It can be said that Prima variety was dominant regarding average spike length.

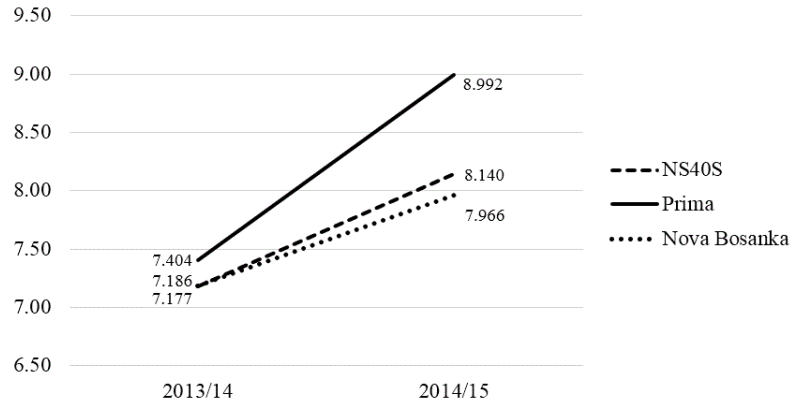

Fig. 2. Significant interaction effect variety × year for the spike length (cm)
Значајан интеракцијски ефекат сорта × година за дужину класа (cm)

Number of grains per spike. The number of grains per spike ranged from 34.53 to 38.19 for varieties and from 34.56 to 37.97 for sowing densities. According to ANOVA, main effect variety was statistically significant at $P \leq 0.01$ (Table 3). This is in accordance with some studies (Knežević et al., 2012; Guberac et al., 2000), whereas the effect of different years was also statistically significant. Similar results are confirmed by other authors (Shankarrao et al., 2010; Tahmasebi, 2013; Racz et al. 2015).

The number of grains per spike ranged from 33.9 to 40.8 for different wheat varieties in Lloveras et al. (2004) and the effects of variety, sowing density and year were significant at $P \leq 0.01$, as well as their two–factor interactions. Stojković et al. (2004), who investigated 20 winter wheat cultivars found that this parameter ranged from 37 to 54 in the first year, with average of 44 grains per spike and from 21 to 31 in the second year, with average of 26 grains per spike, while significant differences at both *LSD* levels for year and variety were present.

In Đurić et al. (2016) the number of grains per spike ranged from 68.84 to 68.97 for varieties, with no significant differences (< $LSD_{0.05}$) and from 67.02 to 71.02 for years, with significantly (> $LSD_{0.01}$) higher number of grains per spike in the second year (2010). In our study, sowing density and year had no significant effect on the number of grains per spike, and none of the interaction effects were statistically significant (P > 0.05).

Regardless of sowing density and year, the average total number of grains per spike was highest in NS 40S variety (38.19). However, based on *LSD* test (Table 3) this was not statistically significant in comparison to variety Nova Bosanka (36.75), but was statistically significant at $LSD_{0.01}$ in comparison to variety Prima (34.53).

Tab. 3. The number of grains per spike for NS 40S, Prima and Nova Bosanka varieties
Број зрна у класу за сорте НС 40С, прима и нова босанка

Sowing density (seeds/m^2)	Variety / *Сорта* / Year / *Година*	NS 40S	Prima	Nova Bosanka	$\bar{X} \pm SD$ for sowing densities
384	*2013/14*	37.36 ± 5.01	33.78 ± 3.18	33.18 ± 3.84	37.15 ± 1.28
	2014/15	39.79 ± 1.62	37.73 ± 1.49	41.03 ± 2.61	
424	*2013/14*	38.37 ± 4.23	33.14 ± 1.81	33.19 ± 3.08	36.15 ± 1.11
	2014/15	39.68 ± 2.61	35.24 ± 1.34	37.26 ± 2.38	
451	*2013/14*	39.70 ± 2.92	35.32 ± 2.86	39.70 ± 2.11	37.97 ± 0.70
	2014/15	38.34 ± 2.97	36.69 ± 2.10	38.05 ± 1.67	
504	*2013/14*	38.83 ± 2.83	32.59 ± 2.11	36.01 ± 2.66	36.33 ± 0.84
	2014/15	37.03 ± 1.14	36.45 ± 1.95	37.05 ± 1.25	
544	*2013/14*	39.83 ± 2.53	35.51 ± 2.86	39.17 ± 1.98	36.77 ± 1.13
	2014/15	38.23 ± 1.73	32.65 ± 1.66	35.21 ± 1.87	
588	*2013/14*	38.92 ± 2.93	33.39 ± 1.54	36.99 ± 1.16	36.54 ± 0.85
	2014/15	35.52 ± 1.74	35.76 ± 1.57	38.64 ± 1.07	
604	*2013/14*	35.26 ± 2.00	30.68 ± 1.19	34.69 ± 3.38	34.56 ± 0.94
	2014/15	37.88 ± 1.74	34.54 ± 1.19	34.28 ± 2.57	
$\bar{X} \pm SD$ for varieties		38.19 ± 0.40	34.53 ** ± 0.51	36.75 ns ± 0.65	
$F_{\text{variety}} = 8.750^{**}$; $F_{\text{sowing density}} = 1.209^{ns}$; $F_{\text{year}} = 2.017^{ns}$;					
$F_{\text{variety} \times \text{sowing density}} = 0.224^{ns}$; $F_{\text{variety} \times \text{year}} = 0.908^{ns}$; $F_{\text{sowing density} \times \text{year}} = 1.601^{ns}$					
$F_{\text{variety} \times \text{sowing density} \times \text{year}} = 0.411^{ns}$.					
ns – not significant (P > 0.05), * (P ≤ 0.05), ** (P ≤ 0.01)					
LSD (variety)		0.05	1.74	ns – *not significant*	
		0.01	2.31	** *significant at* $LSD_{0.01}$	

*Grain weight per spike***.** According to Table 4 the grain weight per spike ranged from 1.58 to 1.73 g for varieties and from 1.54 to 1.72 g for sowing densities. According to analysis of variance, main effects variety and year were statistically significant at $P \leq 0.01$. There were no statistically significant interaction effects ($P > 0.05$).

Tab. 4. The grain weight per spike (g) for NS 40S, Prima and Nova Bosanka varieties
Маса зрна по класу (g) за сорте НС 40С, прима и нова босанка

Sowing density (seeds/m^2)	Variety / *Сорта* / Year / *Година*	NS 40S	Prima	Nova Bosanka	$\bar{X} \pm SD$ for sowing densities
384	*2013/14*	1.53 ± 0.23	1.59 ± 0.17	1.51 ± 0.20	1.69 ± 0.14
	2014/15	1.70 ± 0.10	1.78 ± 0.09	2.04 ± 0.18	
424	*2013/14*	1.56 ± 0.19	1.53 ± 0.11	1.49 ± 0.14	1.65 ± 0.12
	2014/15	1.77 ± 0.19	1.71 ± 0.10	1.82 ± 0.12	
451	*2013/14*	1.58 ± 0.13	1.65 ± 0.14	1.80 ± 0.09	1.72 ± 0.10
	2014/15	1.63 ± 0.15	1.77 ± 0.11	1.89 ± 0.14	
504	*2013/14*	1.53 ± 0.15	1.56 ± 0.13	1.60 ± 0.13	1.60 ± 0.09
	2014/15	1.53 ± 0.08	1.68 ± 0.11	1.68 ± 0.04	
544	*2013/14*	1.60 ± 0.12	1.63 ± 0.17	1.81 ± 0.12	1.66 ± 0.09
	2014/15	1.61 ± 0.08	1.54 ± 0.09	1.74 ± 0.10	
588	*2013/14*	1.55 ± 0.15	1.57 ± 0.09	1.68 ± 0.08	1.66 ± 0.09
	2014/15	1.54 ± 0.08	1.69 ± 0.09	1.89 ± 0.06	
604	*2013/14*	1.36 ± 0.13	1.44 ± 0.08	1.56 ± 0.15	1.54 ± 0.10
	2014/15	1.62 ± 0.09	1.64 ± 0.07	1.64 ± 0.12	
$\bar{X} \pm SD$ for varieties		$1.58^{**} \pm 0.03$	$1.63^{*} \pm 0.03$	1.73 ± 0.04	
$F_{\text{variety}} = 5.040^{**}$; $F_{\text{sowing density}} = 1.343^{ns}$; $F_{\text{year}} = 11.611^{**}$;					
$F_{\text{variety} \times \text{sowing density}} = 0.335^{ns}$; $F_{\text{variety} \times \text{year}} = 0.413^{ns}$; $F_{\text{sowing density} \times \text{year}} = 1.316^{ns}$					
$F_{\text{variety} \times \text{sowing density} \times \text{year}} = 0.349^{ns}$.					
ns – not significant ($P > 0.05$), * ($P \leq 0.05$), ** ($P \leq 0.01$)					
LSD (variety)		0.05	0.09	ns – *not significant*	
		0.01	0.12	** *significant at* $LSD_{0.01}$	
LSD (year)		0.05	0.08	** *significant at* $LSD_{0.01}$	
		0.01	0.10		

These results are in accordance with Knežević et al. (2015), who concluded that genotype and environment cause the variation of values for grain weight per spike. This parameter was found to be highly dependent on genotype (Sabo et al., 2002).

In Barić et al. (2008), grain weight per spike ranged from 0.63 to 1.12 g at density of 420 seeds/m^2 and from 0.60 to 1.03 g at 600 seeds/m^2, with significant differences between sowing densities at $LSD_{0.05}$. Zečević et al. (2010) found significant differences and high variability of grain weight per spike (ranging from 2.0 to 2.9 g) in different varieties. In Protić et al. (2013) grain weight per spike in the period 2004–2006 varied from 1.89 to 2.58 g for analyzed wheat varieties and significant differences at $P \leq 0.01$ were present considering variety, year and their interaction effect.

In three tested sowing densities (300, 400 and 500 seeds/m^2) the average grain weight per spike of 1.49 g was obtained (Gaile et al., 2017).

The grain weight per spike in this study was the highest in Nova Bosanka (1.73 g). Based on *LSD*–test (Table 4) this was statistically significant at $LSD_{0.05}$ in comparison to Prima (1.63 g), and statistically significant at $LSD_{0.01}$ in comparison to NS 40S (1.58 g). The average grain weight per spike was higher in 2014/15 growing season (1.71 g) which was statistically significant at $LSD_{0.01}$ in comparison to 2013/14 (1.58 g).

Conclusion

Analyzed winter wheat varieties in this study achieved higher average spike length, number of grains per spike as well as grain weight per spike in the second experimental year (2014/15). Highest average spike length was obtained in Prima in 2014/15 experimental year (8.992 cm). Nevertheless, tested wheat varieties in this study can be characterized as varieties with relatively short spike length.

The average number of grains per spike was highest in NS 40S (38.19), followed by Nova Bosanka (36.75). Variety and agro–ecological conditions caused the variation of values for grain weight per spike. The grain weight per spike in our study was the highest in Nova Bosanka (1.73 g). However, different sowing densities in this study did not affect examined spike parameters.

Acknowledgements

This research was financially supported by the Ministry of Science and Technology of the Republic of Srpska.

References

Banjac, B., Petrović, S., Dimitrijević, M. and Dozet, D. (2010). Estimation of correlation coefficient among yield parameters of wheat under stress conditions. *Letopis naučnih radova*, *34*(1), 60–68.

Barić, M., Jurman, M. Habuš–Jerčić, I., Kereša, S. and Šarčević, H. (2008). Evaluation of grain yield structure of winter wheat (*Triticum aestivum* L.) cultivars and lines. *Sjemenarstvo*, *25*(2), 91–101.

Borojević, S. (1990). Genetic progress in increasing wheat yield (Genetski napredak u povećanju prinosa pšenice). *Savremena poljoprivreda*, *38*(1–2), 25–47.

Caliskan, S. M., Aslan, M., Uremis, I. and Caliskan, M. E. (2007). The effects of row spacing on yield and yield components of full season and double–cropped soybean. *Turkish Journal of Agriculture and Forestry*, *31*(3), 147–154.

Conor, D. J. and Minguez, M. I. (2012). Evolution not revolution of farming systems will best feed and green the world. *Global Food Security*, *1*(2), 106–113.

Đurić, N., Matković, M., Cvijanović, G. and Dozet, G. (2016). Analysis of main additive effects and multiplicative interactions of components of yield of certain wheat genotypes. *Ratarstvo i povrtarstvo*, *53*(2), 61–68.

Gaile, Z., Ruza, A., Kreita, D. and Paura, L. (2017). Yield components and quality parameters of winter wheat depending on tillering coefficient. *Agronomy Research*, *15*(1), 79–93.

Guberac, V., Martinčić, J., Marić, S., Bede, M., Jurišić, M. and Rozman, V. (2000). Grain yield components of winter wheat new cultivars in correlation with sowing rate. *Cereal Research Communications*, *28*(3), 307–314.

Hatfield, J. L. and Prueger, J. H. (2015). Temperature extremes: Effect on plant growth and development. *Weather and Climate Extremes*, *10*(A), 4–10.

Khan, M. H. and Dar, A. N. (2010). Correlation and Path coefficient analysis of some quantitative traits in wheat. *African Crop Science Journal*, *18*(1), 9–14.

Knežević, D., Radosavac, A. and Zelenika, M. (2015). Variability of grain weight per spike in wheat grown in different ecological conditions. *Acta Agriculturae Serbica*, *20*(39), 85–95.

Knežević, D., Zečević, V., Stamenković, S., Atanasijević, S. and Milošević B. (2012). Variability of number of kernels per spike in wheat cultivars (*Triticum aestivum* L.). *Journal of Central European Agriculture*, *13*(3), 617–623.

Kobiljski, B. and Denčić, S. (1997). Spike characteristics – selection criterion for yield in wheat. *Selekcija i sjemenarstvo*, *4*(3–4), 17–22.

Li, Y., Cui, Z., Ni, Y., Zheng, M., Yang, D., Jin, M., Chen, J., Wang, Z. and Yin, Y. (2016). Plant density effect on grain number and weight of two winter wheat cultivars at different spikelet and grain positions. *PLOS ONE*, *11*(5), 1–15.

Lloveras, J., Manent, J., Viudas, J., Lopez, A. and Santiveri, P. (2004). Seeding Rate Influence on Yield and Yield Components of Irrigated Winter Wheat in a Mediterranean Climate. *Agronomy Journal*, *96*(5), 1258–1265.

Meehl G.A., Stocker T.F., Collins W.D., Friedlingstein P., Gaye A.T., Gregory J.M., Kitoh A., Knutti R., Murphy J.M., Noda A., Raper S.C.B., Watterson I.G., Weaver A.J.

and Zhao Z.C. (2007). Global climate projections In Climate Change 2007: the Physical Science Basis. In Solomon S., Qin D., Manning M., Chen Z., Marquis M., Averyt, K.B., Tignor M. and Miller H.L. (Eds.), *Contribution of the Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 749–845). Cambridge, UK: Cambridge University Press.

Petrović, S., Dimitrijević, M. and Kraljević–Balalić, M. (2000). Genotypic and phenotypic interrelations of yield components in wheat (*Triticum aestivum* L.). *Letopis naučnih radova, 24*(1–2), 133–144.

Petrović, S., Dimitrijević, M. and Belić, M. (2007). Stem height and spike parameters heritability in wheat grown on black humic–gley soil. *Letopis naučnih radova*, *31*(1), 146–152.

Petrović, S., Dimitrijević, M. and Kraljević–Balalić, M. (2000). Genotypic and phenotypic interrelations of yield components in wheat (*Triticum aestivum* L.). *Letopis naučnih radova*, *24*(1–2), 133–144.

Protić, R. Todorović, G., Protić, N., Kostić, M., Delić, D., Filipović, M., Filipović, V. and Ugrenović, V. (2013). Variation of grain weight per spike of wheat depending on variety and seed size. *Romanian agricultural research*, *30*, 51–55.

Racz, I., Has, I., Moldovan, V., Kadar, R. and Ceclan, A. (2015). The contribution of yield components to the achievement of production in some winter wheat genotypes. *Bulletin UASVM Agriculture*, *72*(2), 489–495.

Sabo, M., Bede, M. and Hardi, Ž. U. (2002). Variability of grain yield components of some new winter wheat genotypes (*Triticum aestivum* L.). *Rostlinná výroba*, *48*(5), 230–235.

Sandler, L., Nelson, K. A. and Dudenhoeffer, C. (2015). Winter wheat row spacing and alternative crop effects on relay–intercrop, double–crop, and wheat yield. *International Journal of Agronomy*, *2015*, 1–8.

Shankarrao, B. S., Mukherjee, S., Pal, A. K. and De, D. K. (2010). Estimation of variability for yield parameters in bread wheat (*Triticum aestivum* L.) grown in Gangetic West Bengal. *Electronic Journal of Plant Breeding*, *1*(4), 764–768.

Stojković, S, Deletić, N., Biberdžić, M. and Stojanović, J. (2004). Variability of dry substance accumulation and utilization parameters of winter wheat plant. *Genetika*, *36*(3), 237–243.

Tahmasebi, G., Heydarnezhadian, J. and Pour–Aboughadareh, A. (2013). Evaluation of yield and yield components in some of promising wheat lines. *International Journal of Agriculture and Crop Sciences*, *5*(20), 2379–2384.

Valerio, I. P., Carvalho, F. I. F., Oliveira, A. C., Benin, G., Souza, V. Q., Machado, A. A., Bertan, I., Busato, C. C., Silveira, G. and Fonseca, D. A. R. (2009). Seeding density in wheat genotypes as a function of tillering potential. *Scientia Agricola*, *66*(1), 28–39.

Zečević, V., Bošković, J., Dimitrijević, M. and Petrović, S. (2010). Genetic and phenotypic variability of yield components in wheat (*Triticum aestivum* L.). *Bulgarian Journal of Agricultural Science*, *16*(4), 422–428.

Zečević, V., Knežević, D., Kraljević–Balalić, M. and Mićanović, D. (2004). Genetic and phenotypic variability of yield components in wheat (*Triticum aestivum* L.). *Genetika*, *36*(2), 151–159.

Особине класа сорти озиме пшенице (*Triticum aestivum* L.) у агро–еколошким условима Бање Луке

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Сажетак

Циљ овог истраживања је анализа дужине класа, броја зрна по класу и масе зрна у класу различитих сорти озиме пшенице у агро–еколошким условима Бање Луке у различитим густинама сјетве зрна. Испитиване су три сорте пшенице (НС 40С, прима и нова босанка) у седам густина сјетве (384, 424, 451, 504, 544, 588 и 604 зрна по m^2) и двије експерименталне године (2013/14 и 2014/15). Експеримент је постављен у потпуно случајном распореду, са четири понављања. Све сорте су посијане у периоду од 6. до 8. новембра у 2013/14 и у периоду од 3. до 5. новембра у 2014/15. Биљке су узорковане у првој декади јула у обје експерименталне године. Факторијална анализа варијансе 2×8×3 и *LSD*–тест су коришћени, са годином, густином сјетве и сортом као основним факторима. За различите сорте, просјечан број зрна у класу се кретао од 34,53 до 38,19, док се просјечна маса зрна (g) кретала од 1,58 до 1,73 g. Дужина класа кретала се од 7,58 до 8,20 cm за сорте, са статистички значајним интеракцијским ефектом сорта × година при $P \leq 0,01$. Генерално, параметри класа су имали веће вриједности у другој експерименталној години (2014/15).

Кључне ријечи: сорта, густина сјетве, продуктивност, сјеме, интеракција

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Received: December 14, 2017
Accepted: January 17, 2018