BIOLOGICA NYSSANA
9 (2) • December 2018: 133-139
DOI: 10.5281/zenodo.2538606

Original Article

Received: 24 January 2018
Revised: 22 August 2018
Accepted: 6 November 2018

Influence of growing season on some agronomic characteristics of winter wheat cultivars

Aleksandra Jevtić[1], Vera Đekić[2]

[1]High Agricultural food School of Professional Studies, Ćirila and Metodija 1, 18400 Prokuplje, Serbia

[2]Small Grains Research Centre, Save Kovačevića 31, 34000 Kragujevac, Serbia

** E-mail: verarajicic@yahoo.com*

***Abstract*:**

Jevtić, A., Đekić, V.: ***Influence of growing season on some agronomic characteristics of winter wheat cultivars. Biologica Nyssana, 9 (2). December, 2018: 133-139.***

The experiment was established in the experimental field of the Small Grains Research Centre in Kragujevac during the two years. The winter wheat varieties used in the experiment was Takovčanka, Kruna, Toplica and Planeta. The following characteristics were analysed: grain yield, plant height, number of plants per m^2, 1000 grain weight and test weight. The highest yield of all tested varieties of winter wheat was achieved by Takovčanka (4.124 t/ha). The highest plant height for all years was recorded for the cultivar Toplica (81.90 cm). The highest 1000 grain weight of investigation on winter wheat Takovčanka cultivar (44.05 g). The highest two-year average value of test weight was found in the cultivars Kruna and Planeta (71.03 kg/hl). Analysis of variance was found to have the highly significant effect of years in grain yield, plant height, 1000-grain weight and test weight and significant differences in number of plants per m^2 at investigated wheat were found in relation to the year.

Key words: cultivar, grain yield, winter wheat

***Apstrakt*:**

Jevtić, A., Đekić, V.: ***Uticaj vegetacije na neke agronomske osobine kod ozime pšenice. Biologica Nyssana, 9 (2). Decembar, 2018: 133-139.***

Eksperiment je izveden na oglednom polju Centra za strna žita u Kragujevcu tokom dve vegetacione godine. U eksperimentu su korišćene sorte ozime pšenice Takovčanka, Kruna, Toplica i Planeta. Analizirane su sledeće osobine: prinos zrna, visina biljke, broj biljaka po m^2, masa 1000 zrna i hektolitarska masa. Najveći prinos kod svih ispitanih sorti ozime pšenice ostvarila je sorta Takovčanka (4.124 t/ha). Najveću visinu biljaka tokom eksperimenta ostvarila je sorta Toplica (81,90 cm). Najveću masu 1000 zrna kod ispitivanih sorti ozime pšenice ostvarila je sorta Takovčanka (44,05 g). Najveću prosečnu dvogodišnju vrednost hektolitarske mase ustanovljena je kod sorti Kruna i Planeta (71,03 kg/hl). Analizom varijanse utvrđen je veoma značajan efekat godine na prinos zrna, visinu biljaka, masu 1000 zrna i hektolitarsku masu, a značajne razlike ustanovljene su kod broja biljaka po m^2.

Ključne reči: ozima pšenica, prinos zrna, sorta

Introduction

New perspective wheat lines and varieties has more and better filled grain, higher yield, grain mass and farinaceous content, while proteins and lysine were smaller compared with older varieties (Đekić et al., 2012, Jelić et al., 2013). Wheat cultivars that were in production until the end of the eighties were characterized by the lower yields, good technological quality and higher stem sensitive on lodging (Zečević et al., 2007). Due to lower resistance on lodging, that cultivars were grown at modest soils and therefore they had lower yields (Đekić et al., 2014; Jelić et al., 2012). Agronomic cultivar value depends not only on its genetic potential for yield, but also on its ability to achieve genetic potential under different conditions of production (Malešević, 2008). New varieties are characterized by good technological quality, better resistance to lodging and diseases, shorter stem and more efficient assimilates usage (Browne et al., 2006; Jovanović et al., 2006; Malešević et al., 2008; Hristov et al., 2011; Đekić et al., 2016).

Several factors are decisive in increasing wheat yields: the cultivar, cultural practices, agroecological conditions, local climatic and soil characteristics, mineral nutrition and adequate protection from plant diseases, pests and weeds. In regard to the elements of mineral nutrition, nitrogen plays a major role in increasing the yield of wheat (Kastori et al., 2005; Jovanović et al., 2006; Malešević, 2008; Đekić et al., 2014; Jelić et al., 2014).

The aim of this study was the determination of the cultivars and ecological environmental factors influence on differences in stability and adaptability of cultivars regard the grain yield, plant height, number of plants per m^2, 1000 grain weight and test weight of tested winter wheat cultivars, as well as specificity cultivars exploring in relation to growing seasons conditions.

Material and methods

Experimental design and statistical analysis

During the 2011/12 and 2012/13 growing seasons, four cultivars of winter wheat (Takovčanka, Kruna, Toplica and Planeta), cultivated at the Small Grains Research Centre in Kragujevac were investigated. Experiments have been conducted in randomized block systems, with a plot size of 10 m^2 (2 m x 5 m) in five replicates. The usual techniques for wheat production were applied, and it was done in the optimum sowing time in late October. 400 kg/ha of fertilizer NPK 15:15:15 was added in the fall on the investigated plots, while during the spring fertilization, 300 kg/ha (KAN) was supplemented. The following properties were analyzed: grain yield (t/ha), plant height (cm), number of plants per m^2, 1000 grain weight (g) and test weight (kg/hl).

On the basis of achieved research results the usual variational statistical indicators were calculated: average values, standard error and standard deviation. Statistical analysis was made in the module Analyst Program SAS/STAT (SAS Institute, 2000).

Meteorological conditions

This study was conducted over a three-year period in the Šumadija region, Central Serbia, on a Vertisol soil, at Kragujevac location, 173-220 m a. s. l. (44° 22′ N, 20°56′ E), in a temperate continental climate having an average annual temperature of 11.5 °C typical of Šumadija districts in Serbia and a rainfall amount of about 550 mm. Kragujevac area is characterized by a moderate continental climate, which general feature is uneven distribution of rainfall by month.

The data in **Tab. 1** for the investigated period (2011-2013) clearly indicate that the years in which the researches were conducted differed from the typical multi-year average of Kragujevac region regard the meteorological conditions.

Table 1. Middle monthly air temperature and precipitation amount (Kragujevac)

Year	Months									Average
	X	XI	XII	I	II	III	IV	V	VI	
Mean monthly air temperature (°C)										
2011/12	10.4	3.1	4.6	0.7	-3.7	8.1	12.9	16.1	23.0	8.35
2012/13	13.5	9.5	1.7	2.9	4.0	6.5	13.4	18.2	19.9	9.96
Average	12.5	6.9	1.9	0.5	2.4	7.1	11.6	16.9	20.0	8.87
The amount of rainfall (mm)										
2011/12	33.3	1.3	43.3	117.2	60.1	5.7	74.5	87.3	57.8	480.5
2012/13	56.2	17.7	16.4	62.4	84.3	102.0	41.2	70.8	30.3	481.3
Average	57.6	70.4	71.5	58.5	62.7	45.4	48.9	56.6	58.2	529.8

The average air temperature in 2011/12 was lower by 0.52 °C and 2012/13 was higher by 1.09 °C. The sum of rainfall precipitation in 2011/12 was lower by 49.3 mm, where the sum of rainfall in 2012/13 was 48.5 mm lower than the average of many years and with a very uneven distribution of precipitation per months. Spring months March and April in 2011/12 were the surplus of precipitation, what affected unfavorable on the crops. During the March in 2012/13 it was 102.0 mm of rainfall, what was 56.6 mm more compared with the perennial average.

Regarding the high importance of sufficient rainfall amounts during the spring months, particularly May for small grains production, the distribution and amount of rainfall over the growing season 2011/12 were considerably more favorable, resulting with the increment of yields during that year. Based on the fact that sufficient amounts of rainfall in these months are very important for the successful production of cereal crops it can be concluded that the years in which the researches were conducted were favorable for the wheat growing.

Soil and weather conditions

Before the commencement of the experiment, soil samples were taken from the sample surface and the chemical analysis of soil was performed. On the basis of obtained results, it was revealed that the soil belongs to the smonitza type, with relatively high clay content, and unfavorable physical properties. The humus content in the surface layer of soil was low (2.38-2.64%), and a substitution and total hydrolytic acidity were quite high (pH H_2O=5.99, KCl=4.56). The soil was medium provided with total nitrogen (0,11-0,13% N) and easily accessible potassium (10-14 mg/100 g soil K_2O), while the available phosphorus content was low (under 10 mg/100 g of soil P_2O_5).

Results and discussion

Average values of grain yield (t/ha), plant height (cm), number of plants per m^2, 1000-grain weight (g) and test weight (kg/hl) at investigated Kragujevac's winter wheat cultivars grown at the Small Grains Research Centre in Kragujevac during two growing seasons, 2011/12 and 2012/13, are presented in **Tab. 2**.

During the first year of investigations, cultivar Takovčanka achieved the highest grains yield (4.729 t/ha), followed by Kruna (4.642 t/ha) and Toplica (4.473 t/ha), while the lowest yield was at Planeta cultivar (4.395 t/ha). During the second year of investigations (2012/13), the yield of Takovčanka cultivar was the highest with 3.518 t/ha, while the slightly lower yield was realized by Kruna cultivar (3.276 t/ha). Average grains yield observed in the two-year period was the highest at Takovčanka variety (4.124 t/ha), while the lowest yield was obtained by Kruna cultivar (3.959 t/ha).

During the first and second years of investigation, Toplica cultivar achieved the highest average plant height (85.80 cm and 78.00 cm) compared with other tested wheat cultivars. In the two-year period, the highest average plant height of winter wheat cultivar investigated was achieved in the Toplica cultivar (81.90 cm) and Planeta cultivar (78.60 cm).

Number of plants per m^2 of wheat significantly varied across years, from 374 to 454 in 2011/12, from 342 to 368 plants per m^2 in 2012/13. During the first year of investigations, the highest average value of number of plants per m^2 of wheat achieved the Kruna cultivar (454) and Planeta (437). During the second year of investigations, the highest average value of number of plants per m^2 of wheat achieved the Kruna cultivar (368). In the two-year period, the highest average number of plants per m^2 of winter wheat cultivar investigated was achieved in the Kruna cultivar (411 plants per m^2).

During the first years of investigation, Planeta cultivar achieved the highest average 1000 grain weight (44.90 g) and Takovčanka cultivar (44.72 g). During the second year of investigations (2009/10), the highest average value of 1000 grain weight achieved the Takovčanka cultivar (43.38 g) compared with other tested wheat cultivars. In the two-year period, the highest average thousand grain weight of winter wheat cultivar investigated was achieved in the Takovčanka and Planeta cultivars (44.05 g and 43.31 g).

The wheat cultivar Kruna has achieved the highest test weight in the first years of investigation compared to other tested wheat cultivars (73.05 kg/hl). During the second year of investigations (2012/13), the test weight of Planeta cultivar was the highest with 69.81 kg/hl, while the slightly lower test weight was realized by Kruna cultivar (69.01 kg/hl). The average two-year value of test weight at Kruna and Planeta cultivars was 71.03 kg/hl, while the lowest average was at Takovčanka and Toplica cultivars (70.00 kg/hl and 69.50 kg/hl).

Table 3 shows the impact of the year, cultivar and interaction of year x cultivar on yield, plant height, number of plants per m^2, 1000-grain weight and test weight. Analysis of variance was found highly significant effect of year on the grain yield ($F=48.911^{**}$), plant height ($F=26.863^{**}$), 1000-grain weight ($F=2.616^{**}$) and test weight ($F=3.634^{**}$), and

Table 2. Average values of investigated wheat cultivars characteristics

Varieties	2011/12			2012/13			Average		
	x	S	Sx	x	S	Sx	x	S	Sx
Grain yield, t/ha									
Takovčanka	4.729	0.567	0.253	3.518	0.566	0.253	4.124	0.832	0.263
Kruna	4.642	1.014	0.454	3.276	0.278	0.124	3.959	1.005	0.318
Toplica	4.473	0.258	0.115	3.125	0.692	0.309	3.799	0.864	0.273
Planeta	4.395	0.757	0.338	3.160	0.402	0.180	3.778	0.866	0.274
Plant height, cm									
Takovčanka	83.60	9.317	4.166	71.20	2.588	1.158	77.40	9.180	2.903
Kruna	83.40	4.722	2.112	72.20	3.365	1.505	77.80	7.056	2.231
Toplica	85.80	9.418	4.212	78.00	3.021	1.351	81.90	7.770	2.457
Planeta	81.80	6.140	2.746	75.40	2.631	1.177	78.60	5.587	1.767
Number of plants per m^2									
Takovčanka	374	73.245	32.756	362	38.220	17.093	368	55.44	17.532
Kruna	454	66.969	29.949	368	88.136	39.416	411	86.493	27.351
Toplica	375	71.688	32.060	342	46.785	20.923	359	59.630	18.857
Planeta	437	82.384	36.843	362	48.711	21.784	399	75.113	23.753
1000 grain weight, g									
Takovčanka	44.72	1.994	0.892	43.38	1.240	0.554	44.05	1.717	0.543
Kruna	43.86	2.317	1.036	41.82	1.215	0.543	42.84	2.049	0.648
Toplica	44.24	1.212	0.542	41.20	2.051	0.917	42.72	2.256	0.713
Planeta	44.90	1.044	0.467	41.92	1.305	0.583	43.41	1.925	0.609
Test weight, kg/hl									
Takovčanka	72.92	0.784	0.351	67.08	1.994	0.892	70.00	3.393	1.073
Kruna	73.05	1.789	0.800	69.01	2.128	0.952	71.03	2.823	0.893
Toplica	71.37	1.647	0.736	67.63	2.706	1.210	69.50	2.889	0.913
Planeta	72.25	1.661	0.743	69.81	1.152	0.515	71.03	1.863	0.589

significant effect for the number of plants per m^2 ($F=5.910^{*}$).

Discussion

In regard to the tested genotypes winter wheat, variety Takovčanka achieved the highest yield of grain (4.124 t/ha). Of the tested years, particularly in 2011/12 year, the highest yields were achieved. Considerable variation in yield depending on years of research have established Biberdžić et al. (2005), Jovanović et al. (2006), Malešević et al. (2008), Hristov et al. (2011), Jelić et al. (2013), Đekić et al. (2016). Perišić et al. (2009), pointing out that among the KG cultivars, very high grain yield demonstrated winter wheat cultivars Kruna and Vizija. The Takovčanka cultivar had stable and high grain yields, while cv. Toplica demonstrated good yield followed by high quality.

Wheat productivity and grain quality in Central Serbia are governed by a range of factors, notably climate, soil, genetics and crop nutrition. Soil acidity in wheat fields in Central Serbia has become a severe problem that leads to a significant decline in grain yield and quality of wheat (Đekić et al., 2013, Jelić et al., 2015). The yield per unit area is the result of the action of factors of variety in interaction with environmental factors. Therefore, the yield a relative term and is determined by the variety, environmental conditions and the level of applied technology. Yield is largely dependent on the genetic potential, which could be defined the yield of variety which was grown in conditions on which it had been adapted, with adequately amounts of water and nutrients and efficient control of pests, diseases, weeds and other stresses (Đekić et al., 2016). Yields considerably vary primarily as a result of agro-ecological conditions during the growing season (Zečević et al., 2010; Hristov et al., 2011; Đekić et al., 2015). Analysis of variance showed highly significant effect of year on the grain yield ($p<0.01$). Considerable variation in yield depending on years of research has been established by Glamočlija et al. (2010), Milovanovic et al. (2011), Đekić et al. (2012; 2014) and Jelic et al. (2015).

Table 3. Analysis of variance of the tested parameters (ANOVA)

Effect of year on the traits analyzed				
Traits	Mean sqr Effect	Mean sqr Error	F(df1,2) 1, 38	p-level
Grain yield (t/ha)	16.64	0.340	48.91138	0.000000
Plant height (cm)	893.03	33.243	26.86321	0.000007
Number of plants per m^2	26419.60	4470.631	5.90959	0.019886
1000-grain weight (g)	55.22	2.616	21.10920	0.000047
Test weight (kg/hl)	161.20	3.634	44.35568	0.000000
Effect of cultivar on the traits analyzed				
Traits	Mean sqr Effect	Mean sqr Error	F(df1,2) 3, 36	p-level
Grain yield (t/ha)	0.259	0.800	0.324121	0.807880
Plant height (cm)	41.825	56.411	0.741432	0.534361
Number of plants per m^2	6177.467	4938.089	1.250983	0.305709
1000-grain weight (g)	3.715	3.986	0.932025	0.435230
Test weight (kg/hl)	5.878	7.824	0.751257	0.528824
Effect of the year x cultivar interaction				
Traits	Mean sqr Effect	Mean sqr Error	F(df1,2) 3, 32	p-level
Grain yield (t/ha)	0.015	0.378	0.040450	0.988943
Plant height (cm)	19.825	33.697	0.588333	0.627103
Number of plants per m^2	3028.667	4445.800	0.681242	0.570020
1000-grain weight (g)	1.658	2.603	0.636829	0.596804
Test weight (kg/hl)	4.906	3.305	1.484619	0.237321

**Statisticaly significant difference (P<0.05) **Statisticaly high significant difference (P<0.01)*

Milovanovic et al. (2011), states that in Serbia higher yields are achieved by varieties with shorter growing season because they manage to form the largest part of the yield before the occurence of high temperatures. In this study, in both years, the wheat was not exposed to extremely high temperatures so early growth did not come into its own.

The 1000-grain weight of winter wheat significantly varied across cultivars, from 42.72 g in cultivar Toplica to 44.05 g in cultivar Takovčanka. Highly significant influence of the year on 1000-grain weight was established at investigated winter wheat cultivars by variance analysis. A number of authors (Jelić et al. 2013; Đekić et al. 2014, 2016), underline that 1000-grain weight is a cultivar-specific trait, with considerably higher variations being observed among genotypes than among treatments or environmental factors. Jelic et al. (2015) have presented the 1000-grain weight of three winter wheat cultivars (Pobeda, Planeta and Nora). The 1000-grain weight of wheat variety was 42.62 g in control to 47.06 g while wheat treatment in the combined treatment with lime, manure and mineral NPK fertilizer at the rates of CaCO3 of 5 t/ha and phosphorus of 100 kg/ha. A number of authors underlined that 1000-grain weight is a cultivar-specific trait, with considerably higher variations being observed among genotypes than among treatments or environmental factors (Malešević et al., 2008; Hristov et al., 2011; Đekić et al., 2012, 2013; Jelic et al., 2015).

The genotype Kruna had an extreme value (73.05 kg/hl) in the first years (2011/12) were recorded. The average two-year value of test weight at Kruna and Planeta cultivars was 71.03 kg/hl. Particularly in the second year, genotypes had significantly lower test weight compared to first year. Based on the analysis of variance, it can be concluded that there are significant differences in test weight in regard to the year of investigation, which is in accordance with the results obtained by Đekić et al. (2015). The test weight of winter wheat ranged from 80 (Takovčanka) to 82 kg/hl in cultivar Toplica (Protić et al., 2013). Jelic et al. (2015) have examined the average test weight of winter wheat, which ranged from 68.66 kg/hl to 70.91 kg/hl. A number of authors (Browne et al., 2006; Đekić et al., 2013, 2016; Jelić et al., 2013, 2014) underline that grain of investigated wheat cultivars was characterized by good physical characteristics; especially regarding the test weight and 1000 grain weight. Determined average values of these characteristics in the study were slightly higher than the values obtained by Jelić et al. (2013) and Đekić et al. (2015).

In the growing season 2011/12 which were more favourable for wheat production in terms of agro-meteorological conditions, a significantly higher grain yield was obtained in all winter wheat cultivars. Highly significant impact of the year on grain yield, plant height, 1000-grain weight and test weight were determined in investigated winter wheat cultivars by using the variance analysis, while the influence of year on number of plants per m^2 was statistically significant. There are significant phenotypic differences among wheat cultivars with regard to grain quality. These differences result from the action of different genes that control characters for wheat quality (Perišić et al., 2009). Nonetheless, environmental factors play a major role in the expression of genotype characteristics (Misic & Mladenov, 1998; Glamočlija et al., 2010; Milovanović et al., 2011; Đekić et al., 2013; Jelić et al., 2013). Their impact, however, is rarely optimal; one or more of them will always limit the yield and quality of the product. For this reason, it is very important to determine the variation of environmental factors and their effects on the processes that determine wheat quality. The present results confirm the opinion of many authors that the traits analyzed are genetically determined but are strongly modified by the nutrient status of the environment and weather conditions (Jelić et al., 2014; Đekić et al., 2016).

Due to the global change of climate, drought is a frequent occurrence both in southern parts of central Europe and in the Balkan. Owing to such climatic conditions, southern parts of central Europe and southern Europe are considered suitable for the production of bread wheat (Misic and Mladenov, 1998; Glamočlija et al., 2010; Milovanović et al., 2011).

Conclusion

Based on the results during the two-year investigation on four Kragujevac's winter wheat cultivars, it can be concluded that the grain yield of wheat ranged from 3.778 t/ha (Planeta) to 4.124 t/ha (Takovčanka). The highest average plant height of winter wheat cultivar investigated was achieved in the Toplica cultivar (81.90 cm). During the two-year the 1000 grain weight of investigation on winter wheat cultivars ranged from 42.72 g (Toplica) to 44.05 g (Takovčanka). Winter wheat cultivars had test weight greater than 70 kg/hl, except of cultivar Toplica (69.50 kg/hl).

During 2011/12, statistically significantly higher grain yield per area unit, as well as 1000 grain weight was achieved, compared with 2012/13 year. Highly significant differences in yield, plant height, 1000-grain weight and test weight and significant differences in number of plants per m^2 at investigated wheat were found in relation to the year. The interaction of grain yield, plant height, number of plants per m^2, 1000-grain weight and test weight and year x cultivar had no significant differences at investigated wheat cultivars.

Rainy weather in the spring month during 2013 caused water lodging, the occurrence of plant lodging and plant diseases, which influenced poorer quality and lower average yield of wheat in the 2013/14 season compared to the 2011/12 season.

Acknowledgements. Investigations necessary for this paper are part of the project TP 31054 "Development of new cereals cultivation technologies on acid soils by usage of modern biotechnology", financed by the Ministry of Education, Science and Technology Development of Republic of Serbia.

References

Biberdžić, M., Đorđević, M., Barać, S., Deletić, N., & Stojković, S. 2005: Productivity of some winter wheat genotypes. *Genetika*, 37(2), 131-136.

Browne, R.A., White, E.M., Burke, J.I. 2006: Responses of developmental yield formation processes in oats to variety, nitrogen, seed rate and plant growth regulator and their relationship to quality. *Journal Agriculturae Science*, 144: 533-545.

Đekić, V., Milovanović, M., Staletić, M., Stevanović, V., Milivojević, J. 2012: Influence of growing season on some agronomic characteristics of six winter wheat cultivars grown in acidic soil. *Proceedings. 47rd Croatian and 7rd International Symposium on Agriculture*, 13.-17. Februar, Opatija, Croatia, 478-482.

Đekić, V., Staletić, M., Jelić, M., Popović, V., Branković, S. 2013: The stability properties of wheat production on acid soil. *Proceedings, 4th International Symposium "Agrosym 2013"*, 03-06. Oktober, Jahorina, 84-89.

Đekić, V., Milovanović, M., Popović, V., Milivojević, J., Staletić, M., Jelić, M., Perišić, V. 2014: Effects of fertilization on yield and grain quality in winter triticale. *Romanian Agricultural Research*, 31: 175-183.

Đekić, V., Milovanović, M., Milivojević, J., Staletić, M., Popović, V., Simić, D., Mitrović, M. 2015: Impact of year and grain quality of winter wheat. *Proceedings of research papers PKB Agroekonomik, Belgarde*, 21(1-2): 79-86.

Đekić, V., Milivojević, J., Jelić, M., Popović, V., Branković, S., Staletić, M., Terzić, D. 2016: The influence of mineral nutrition on winter wheat yield. *Proceedings, VII International Scientific*

Sympozium "Agrosym Jahorina 2016", 06-09. October, Jahorina, 392-398.

Glamočlija, Đ., Staletić, M., Ikanović, J., Spasić, M., Đekić, V., Davidović, M. 2010: Possibilities alternative grain production in the highlands area of central Serbia. *Economics of Agriculture-Multifunctional Agriculture and Rural Development* (V), EP 2010 (57) SI-2, 71-77, Belgrade.

Hristov, N, Mladenov, N, Kondić-Špika, Ankica, Marjanović-Jelonmela, Ana, Jocković, B, Jaćimović, G. 2011: Effect of enviromental and genetic factors on the correlation and stability of grain yield components in wheat. *Genetics*, 43(1): 141-152.

Jelić, M., Milivojević, J., Paunović, A., Biberdžić, M., Nikolić, O., Madić, M., Đekić, V. 2012: Response of wheat genotypes to liming and fertilization on pseudogley soil. *Proceedings. 47rd Croatian and 7rd International Symposium on Agriculture*, 13.-17. Februar, Opatija, Croatia, 488-491.

Jelić, M., Dugalic, G., Milivojevic, J., Djikic, S., Đekić, V., Savic, N., Gudzic, N. 2013: Influence of perennial application of fertilizers and ameliorative measures on changes of pseudogley soil properties and grain yield of winter wheat. *1st International Congress Soil-Water-Plant*, 23-26 September, Belgrade, 195-207.

Jelić, M., Milivojević, J., Đekić, V., Paunović, A., Tmušić, N. 2014: Impact of liming and fertilization on grain yield and utilization of nitrogen and phosphorus in wheat plant grown on soil type pseudogley. *Proceedings of research papers PKB Agroekonomik*, Belgrade, 20(1-4): 49-56.

Jelic, M., Milivojevic, J., Nikolic, O., Đekić, V., Stamenkovic, S. 2015: Effect of long-term fertilization and soil amendments on yield, grain quality and nutrition optimization in winter wheat on an acidic pseudogley. *Romanian Agricultural Research*, 32: 165-174.

Jovanović, Z., Djalović, I., Komljenović I., Kovacević V., Cvijović, M. 2006: Influences of liming on vertisol properties and yields of the field crops. *Cereal Research Communications*, 34(1): 517-520.

Kastori, R. et al. 2005: Nitrogen: Agrochemical, Cultural Practice, Physiological and Ecological Aspects, *Monografija*, urednik R. Kastori, Institute of Field and Vegetable Crops, Novi Sad, 1-419.

Malešević, M. 2008: Mineral nutrition of small grains in integrated crop management system. *Proceedings Institute of Field and Vegetable Crops*, 45(1): 179-193.

Malešević, M., Starčević, LJ., Jaćimović, G., Đurić, V., Šeremešić, S., Milošev, D. 2008: The yield of winter wheat depending on the conditions and the level of nitrogen fertilization. *Proceedings, XIII Counseling on Biotechnology*, Čačak, 28-29. March, 2008, Faculty of Agronomy, 13(14): 135-141.

Milovanović, M., Staletić, M., Đekić, V., Nikolić, O., Luković, K. 2011: Seed production and contribution of KG varieties to biodiversity of small grains in the period 2006-2010. Beograd, *Economics of agriculture*, Belgrade, Book II, (58), СБ/SI-1, str. 103-111.

Misic, T., and Mladenov, N. 1998: Results of winter wheat breeding at the Novi Sad Institute. *Proceeding of 2nd Balkan Symposium of Field Crops*. S. Stamenkovic, ed. Inst. Field and Vegetable Crops: Novi Sad, Vol. 1, 15-22.

Perišić, V., Milovanović, M., Đulaković, V., Janković, S., Staletić, M. 2009: Actual cultivars of winter wheat, barley and spring oat created in Kragujevac [Serbia]. *Poljoprivredne aktivnosti*.

Protic, R., Todorovic , G., Protic, N., Djordjevic, R., Vicentijevic, D., Delic, D., Kopanja, M., Prodanovic, R. 2013: Effect of genotype x environment interaction on grain yield of winter wheat varieties. *Bulgarian Journal of Agricultural Science*, 19(4), 697-700.

SAS/STAT (2000). User's Guide, Version 9.1.3. SAS Institute Inc.

Zečević, V., Knežević, D., Mićanović, D. 2007: Variability of technological quality components in winter wheat. *Genetics*, Belgrade, 39: 365-374.

Zečević, V., Bošković, J., Knežević, D., Mićanović, D., Madić, M. 2010: Ecological and genetic variability of wheat quality components. *Kragujevac Journal Science*, 32: 89-94.