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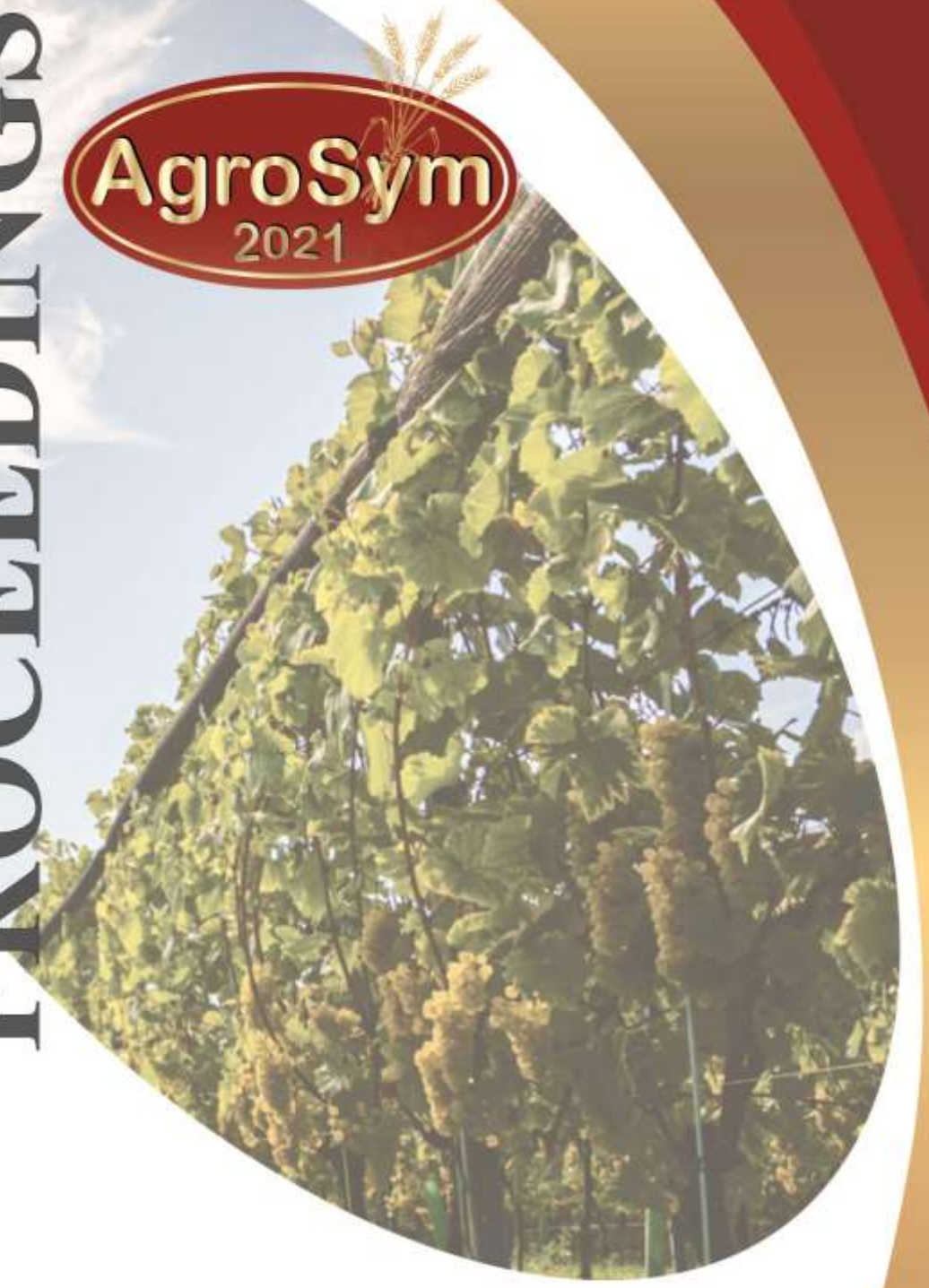

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STABILITY OF WHEAT CULTIVARS FOR YIELD AND QUALITY COMPONENTS IN DIFFERENT AGROECOLOGICAL CONDITIONS

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Abstract

Stability of grain yield, 1000 kernel weight and sedimentation value were analyzed in 10 winter wheat cultivars (Perfekta, Toplica, KG-52/3, Merkur, Vizeljka, Talas, NS 40S, Zvezdana, Javorka and Pobeda), created in different breeding institutions in Serbia. The experiment was carried out during 2019/2020 in two localities: Centre for Small Grains in Kragujevac and Institute for Forage Crops in Kruševac, Serbia. The analyses of variance showed highly significant differences in grain yield, between genotypes, investigated localities, as well as their interaction. The influence of the locality did not show statistical significance on the expression of 1000 kernel weight and sedimentation value. The highest average values were recorded by Perfekta for grain yield, Zvezdana for 1000 kernel weight and KG-52/3 for sedimentation value at both localities. The AMMI model was used for analysis of genotype × environment interaction. The most stabile cultivars were Vizeljka, NS 40S and Perfekta with values above the average for grain yield. Cultivars Talas, KG-52/3 and Javorka showed the highest stability for the 1000 kernel weight. Cultivar Javorka had the highest, while Talas and KG-52/3 had the lowest average values for this trait. Vizeljka and KG-52/3 were the most stable genotypes for sedimentation value, with KG-52/3 achieving the highest values of the observed trait at the level of the entire experiment. Both analyzed locations had high interaction value for all three analyzed traits.

Keywords: *wheat, yield, quality, AMMI, stability.*

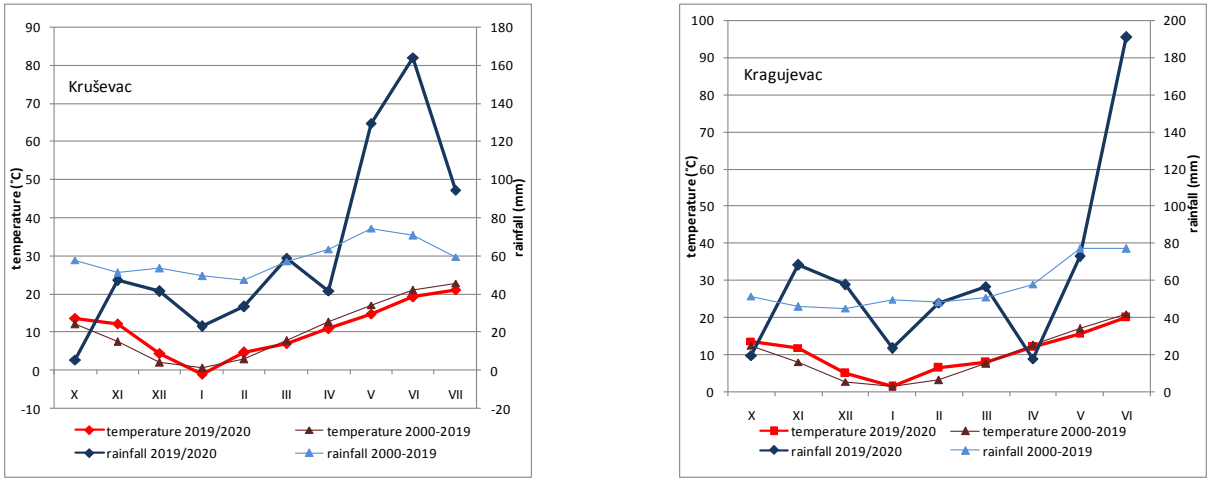
Introduction

Varieties of winter wheat represented in agricultural production have genetic potential for grain yield over 10 t ha^{-1} and good or satisfactory quality of grain and flour. However, average yields and grain quality, from year to year are extremely unstable. This variability can be largely attributed to unfavorable climatic conditions that accompany changes in the intensity and distribution of precipitation in critical phases of plant growing, as well as inadequate production technology (Luković et al., 2019; 2020; Ruiz et al., 2019; Senapati and Semenov, 2020). Poor soil preparation, late sowing, weeds, insufficient mineral nutrition of plants and inadequate protection significantly reduce grain yield and directly affect the unsatisfactory utilization of the genetic potential of the variety. In addition to climatic characteristics and applied production technology, the adaptation of varieties to agroecological conditions of a certain area has a significant impact in achieving high yields and grain quality. Yield stability and grain quality are crucial for agricultural producers when deciding on the choice of variety for sowing, especially

in agroecological areas with less favorable climatic and edaphic factors. The aim of this study was to evaluate the stability and adaptability of yield and quality of divergent wheat varieties, based on the results of experiments performed in central Serbia, where soils are heterogeneous and less fertile.

Material and Methods

As research material in this paper, 10 varieties of winter wheat were used, which were produced in three breeding institutes in Serbia: Center for Small Grains in Kragujevac (Perfekta, KG-52/3 and Takovčanka), Institute PKB Agroekonomik in Belgrade (Merkur, Vizeljka and Talas) and Institute for Field and Vegetable Crops in Novi Sad (NS 40S, Zvezdana, Javorka and Pobeda). The field experiments were performed during 2019/2020 at two locations: Center for Small Grains in Kragujevac and Institute for Forage Plants in Kruševac. The experiments were set in field conditions according to a completely random block system, in three replications with the size of the basic plot of 5 m^2. After the harvest, grain yield was measured for each plot and then converted to yield in t ha^{-1}. The 1000 kernels weight and sedimentation value were determined according to international standard methods (JUS E.B1.200; Zeleny, ICC No. 116/1, 1972, respectively). The AMMI model (Gauch and Zobel, 1996) was used to assess genotype × environment interaction. Statistical analysis of the data was performed using the computer statistical program GenStat 12th (GenStat, 2009).
The average values of the monthly air temperatures and the sum of precipitation by individual months, in the period of conducting the experiment, are shown in graph 1.



(a) (b)

Graph. 1. Average monthly air temperatures and total amount of precipitation for Kruševac (a) and Kragujevac (b) during the vegetation period 2019/2020

The year of the experiment was marked by a pronounced deficit of precipitation in October at both localities. The winter was mild with a lower amount of precipitation compared to the multi-year average. The periods of the intensive vegetative growth and anthesis of wheat, during April and May, had similar temperature conditions in both localities, with the amount of precipitation differing significantly by localities. The dry period with an extremely low amount of precipitation was characterized by April in Kragujevac (17.8 mm compared to 57.9 mm), while in May the amount of precipitation was around the multi-year average. In May, 129.4 mm of precipitation occurred in Kruševac which was 50 mm higher than the multi-year average for this time of the year. Finally, the stage of grain filling and grain maturity during the June were under extremely unfavorable weather conditions. During this period 163.8 mm of precipitation was recorded in Kruševac and 191 mm in Kragujevac, which represents twice and three times higher amount of precipitation compared to the multi-year average.

Results and Discussion

Analysis of the variance of the AMMI model showed that all sources of variation (genotype, environment and G × E) had statistically significant effects ($p < 0.01$) on grain yield expression, while the influence of locality was not statistically significant on the expression of 1000 kernel weight and sedimentation value (Table 1). Significant genotype / environment interaction indicates the existence of differences in stability between the examined genotypes, which justify application of AMMI analysis.

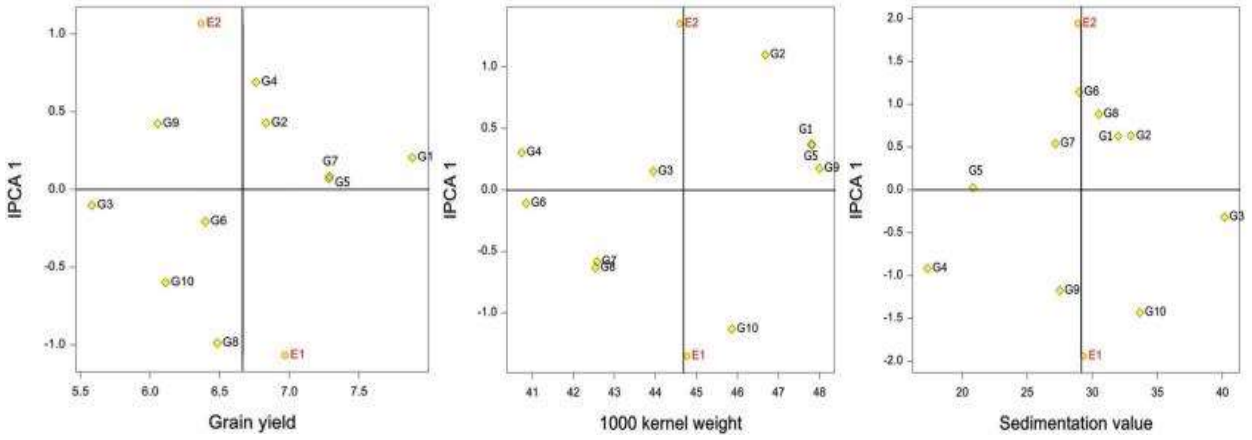
Table 1. AMMI analysis of variance for 1000 kernel weight, grain yield and sedimentation value

Source of variation	df	1000 kernel weight (g)		Grain yield (t ha^{-1})		Sedimentation value (ml)	
		MS	F	MS	F	MS	F
Genotypes	9	50.52	41.50**	2.83	102.51**	254.67	169.78**
Block	4	0.92	0.76^{ns}	0.01	0.51^{ns}	1.67	1.11^{ns}
Environment	1	0.43	0.47^{ns}	5.47	387.49**	2.82	1.69^{ns}
IPCA	9	4.46	3.66**	1.73	62.62**	18.96	12.64**
Error	36	1.22	-	0.03	-	1.50	-
Total	59	9.20	-	0.81	-	42.82	-

** Significant at P = 0.01 level, ^{ns} Non significant

The AMMI 1 biplot (Graph 2 a) shows the ratio of the average grain yield value and the value of the first main component (IPCA1). According to the value of the first main component (IPCA1), the highest stability was recorded in the varieties Vizeljka, NS 40S and KG-52/3 (G5, G7 and G3), followed by Perfekta and Talas (G1 and G6). At the same time, the variety Perfekta achieved the highest grain yield at the level of the whole experiment (7.88 t ha^{-1}) and stood out as the most productive variety. Varieties NS 40S and Vizeljka also had high yield (7.28 t ha^{-1}; 7.29 t ha^{-1}, respectively), while Talas and KG-52/3 although showed high stability, achieved a lower grain yield than the average of the experiment (6.4 t ha^{-1}; 5.58 t ha^{-1}, respectively). Zvezdana (G8) proved to be the least stable variety. Both environments showed a high value of interaction where by Kragujevac standing out as a more productive environment with higher average values compared to Kruševac. The most stable varieties for the 1000 kernel weight were Talas, KG-52/3 and Javorka (G6, G3 and G9) according to the values of the first main component (Graph 3 b), of which Javorka achieved higher, and Talas and KG-52/3 lower values

of the analyzed trait than the general average. The greatest effect of interaction and thus the least stability was observed in the cultivars Takovčanka and Pobeda (G2 and G10).
In the analysis of expression stability for sedimentation value, Vizeljka and KG-52/3 (G5 and G3) stood out as the most stable cultivars, followed by NS 40S, Perfekta and Takovčanka (G7, G1 and G2). However, although they expressed high stability, the cultivars Vizeljka and NS 40S achieved lower than average values (20.8 ml; 27.7 ml, respectively), while Perfekta, Takovčanka and KG-52/3 had above average values of the observed traits. At the same time, KG-52/3 proved to be superior in comparison with other varieties, achieving the highest value of sedimentation value at the level of the overall experiment (40.2 ml). This genotype also stood out in terms of quality traits in 2015, characterized as a year with extremely high rainfall during the periods of flowering and the beginning of grain filling, achieving high average values of sedimentation value at three sites in Serbia (Lukovic, 2020). The variety Pobeda (G 10), which represents a quality standard in experiments of Commission for the approval of new varieties, had the lowest stability (Graph 2 c).



(a) (b) (c)

Graf. 2. Average grain yield (a), 1000 kernel weight (b) and sedimentation value (c) in relation to the value of the first principal component of interaction for 10 wheat cultivars in two localities (Kragujevac, Kruševac);
Legend: 1-Perfekta; 2-Takovčanka; 3-KG-52/3; 4-Merkur; 5-Vizeljka; 6-Talas; 7- NS 40S; 8-Zvezdana; 9-Javorka; 10-Pobeda

Grain yield and quality depend on genetic differences between varieties, environmental factors as well as their interaction (Zečević et al., 2013; Đurić et al., 2020). Aktas (2020) emphasizes the predominant influence of the external environment on the variability of yield and grain quality. Similar results were published Mut et al. (2010) who state that the most stable variety (Bezostaya) gave the highest value to protein sedimentation. In the research of Gómez-Becerra et al. (2006) the most productive genotype was also the least stable, i.e. adapted to specific agroecological conditions. Hristov and Mladenov (2005) emphasized the Kremna variety as a stable genotype, with above-average values of protein sedimentation. In research of Khazratkulov et al. (2015) in addition to stable and high grain yields, singled out wheat genotypes which possess stable and good grain quality and can serve as desirable parents in wheat breeding programs. The year 2020 is characterized by a dry period in April in Kragujevac

and exceptionally large amounts of precipitation in June at both localities. In Kruševac alone, 163.8 mm of precipitation was recorded in June, and 191 mm in Kragujevac. Such unfavorable weather conditions negatively affected the processes of grain filling and maturity of grains, causing the formation of the poorly filled grains with lower quality. In such an unfavorable year, wheat genotypes without standing high stability of grain yield and quality were determined, so they can be considered as adapted to different agroecological conditions. In addition to stable yield, the stability of quality traits is an important characteristic of varieties, especially in years with unfavorable climatic conditions. Such varieties represent a valuable raw material in the milling and baking industry necessary for obtaining a quality end product.

Conclusion

Using the AMMI model, high stability of the varieties Vizeljka, NS 40S and Perfekta for grain yield, and KG-52/3, Perfekta and Takovčanka for grain sedimentation was established. These cultivars achieved higher values than the overall average cultivar Perfekta for grain yield and KG-52/3 for sedimentation value. The obtained results in this research indicate that, in central Serbia where the soils are heterogeneous, with pronounced acidity and poorer fertility, an advantage should be given to varieties with high adaptability and stability of yield and quality such as the varieties Perfekta and KG-52/3. These varieties can be considered highly adapted and desirable for cultivation in central Serbia.

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