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The Effect of Genotype, Mineral Nutrition and Soil Improver on Wheat Grain

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ABSTRACT

During the two-year trials we examined the quality of wheat grain (absolute weight, hectolitre weight and protein content) depending of genotype and application of nutrition and soil improver. The experiments were carried out in the laboratory of the Agricultural Faculty of the University of East Sarajevo in 2012/13 and 2013/14 with three wheat cultivars (Orion, Kristina and Bosanka) that have been created in the Agricultural Institute of the Republic of Srpska and four variants of the soil nutrition (control or the substrate itself, $N_{15}P_{15}K_{15}$, $N_{15}P_{15}K_{15}$ + natural zeolite and synthetic zeolite $N_{15}P_{15}K_{15}$ +), in order to determine the relationship between different genotypes of domestic wheat cultivars and substrate enriched with NPK fertilizers, natural and synthetic zeolites and their impact on the qualitative properties of wheat grain. As a substrate Novobalt was used. Cultivar Bosanka had the highest absolute weight, while a variety of Orion had the highest hectoliter weight and protein content. Soil improvers (natural and synthetic) in combination with NPK fertilizers had a positive impact on the quality of wheat grain.

Key words: variety, zeolites, wheat, quality, fertilizers.

INTRODUCTION

Thanks to its nutritional value the wheat grain is the most important arable product used in human nutrition. The mere fact that bread is used as food by over 70% of the population of the planet speaks of the importance of this grain in the diet (Roljević *et al.*, 2011). Wheat bread is characterized by high protein content (16-17%), carbohydrates (77-78%), fat (1.2-1.5%) and good digestibility. In addition to bread, flour created by the process of the fine grinding is used for making a range of food products in the form of finished or semi-finished foods.

The genotype observed from the biological and agronomic aspects is one of the crucial factors to the quantitative and the qualitative level of production. In other words, the yield and quality of wheat grain that we get during the production depend on the grown cultivar to a large extent. Cultivars, as the decisive factors, have been examined by many authors who have given their views and presented their results (Borojevic, 1983; Mladenov *et al.*, 2008, Dencic *et al.*, 2003, 2007, 2010). Here the most common cultivars are those created in Serbia (Pobeda, Evropa 90, Renaissance, Dragana, Ljiljana and Russia), but there are also domestic cultivars created in the Agricultural Institute of Republic of Srpska (Bosanka, Kristina, Granada and Prijedorcanka).

Zeolites have the ability to bind other substances by the mechanism of ion exchange or adsorption. There are about 50 natural and 180 synthetic zeolites

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(International Zeolite Association – IZA; www.iza-structure.org). Apart from the application in the chemical industry the zeolites are used in agriculture as well (Millan *et al.*, 2008; Mumpton, 1999; Polat *et al.,* 2004; Rakic V. *et al.,* 2014; 2015). Clinoptilolite is widespread in nature and has a high adsorption capacity, ion-exchange capacity, catalytic activity and dehydration activity, and therefore it is important for crop production because it improves the soil and affects the quality and yield (Faghihian *et al.,* 2005; Leggo, 2000 Wajima, 2011). Mumpton (1999) stated that the use of zeolites in the amount of 8 to 16 tons per hectare increased wheat yield. Clinoptilolite combined with manure or fertilizers slowly releases fertilizer because the effect have been observed for several months after application (Simic *et al.*, 2014; Polat *et al.*, 2004).

The objective of these studies is to determine the relationship between different genotypes of domestic wheat cultivars and substrate enriched with NPK fertilizers, natural and synthetic zeolites and their impact on the qualitative properties of wheat grain.

MATERIALS AND METHODS

Experiments have been conducted in the laboratory of Faculty of Agriculture in 2012/13 and 2013/14, with the controlled conditions of heat and humidity. Two-factorial experiment with four replications according to a randomized block design included a survey with three wheat genotypes (A_1 - Orion, A_2 - Kristina and A_3 - Bosanka) and four variants of nutrition (B_0 - control, namely the substrate, B_1 – $N_{15}P_{15}K_{15}$, B_2 - $N_{15}P_{15}K_{15}$ +natural zeolite and B_3 - $N_{15}P_{15}K_{15}$ + synthetic zeolite). As a substrate Novobalt was used in an amount of 2 kg per pot, except for control variant where on 1 m^3 of substrate 1200 grams of $N_{15}P_{15}K_{15}$ were placed, 10% of natural and synthetic zeolites. Natural zeolite was obtained from the Mining Institute Prijedor and synthetic one was obtained from the factory "Birac" Zvornik. Sowing was carried out on 20 November 2012, ie on 2 December 2013 at 48 pots with 30 seeds per pot. At full maturity of the wheat samples from all the pots were taken and quality analysis was performed regarding: absolute weight (g), hectolitre weight (Schopper balance, volume 0,250 l), expressed in kilograms per hectolitre and protein content by Kjeldahl (%).

Statistical analysis was done by the method of factorial analysis of variance (ANOVA), using the statistical package Statistics 5.5 (Windows, analytical software), and the score differences between values was performed using LSD test.

RESULTS AND DISCUSSION

It is desirable that wheat has higher hectolitre weight and 1000 kernel weight, which is important for determining quality parameters. The higher 1000 grain weight gives a higher proportion of the endosperm in grain and thus higher yield of flour. The higher hectolitre weight the greater the flour yield (Horvat, 2005). Our results are consistent with the results of Knezevic (2005), who stated that the 1000 grain weight was varietal characteristics and hence it was observed among the different genotypes more than the variation between varieties of mineral nutrition.

During two-year trial the cultivar Orion had the lowest absolute mass, which was statistically highly significant compared with the absolute mass of cultivars Kristina and Bosanka, while the differences between Kristina and Bosanka, while the differences between Kristina and Bosanka did not have statistical significance in 2013, while in

2014 there was statistically significant difference between Kristina and Bosanka (Table 1). In nutrition varieties we found significant differences between the control variant (B_0) and variants NPK + natural zeolites (B_2) in both years of study, while that difference was observed in 2014 between the control variant and variants where NPK + synthetic zeolites were applied. In experiments with buckwheat similar results were obtained by Dolijanović *et al.*, (2014), who got more absolute weight value in variants where the application of microbial fertilizers and soil improvers were used compared with alternatives on which only microbiological fertilizers were used (Table 1).

Table 1. The absolute weight (g)

	2013				2014				Average
Type (A) / Substrate (B)	Orion (A_1)	Kristina (A_2)	Bosanka (A_3)	Average	Orion (A_1)	Kristina (A_2)	Bosanka (A_3)	Average	
B_0	22.40	28.97	31.44	27.60	23.14	29.32	31.37	27.94	27.77
B_1	24.70	32.10	34.01	30.27	24.89	31.75	36.31	30.98	30.63
B_2	27.49	34.20	35.99	32.56	29.75	33.64	37.89	33.76	33.16
B_3	28.61	32.46	34.21	31.76	27.22	33.18	36.74	32.38	32.07
Average	25.80	31.93	33.91	30.54	26.25	31.97	35.57	31.26	30.90

LSD	A	B	AxB	A	B	AxB
0,05	3.000	4.242	7.348	2.836	4.010	6.946
0,01	4.042	5.717	9.905	3.821	5.404	9.363

Table 2. Hectolitre weight (kg/hl)

	2013				2014				Average
Type (A) / Substrate (B)	Orion (A_1)	Kristina (A_2)	Bosanka (A_3)	Average	Orion (A_1)	Kristina (A_2)	Bosanka (A_3)	Average	
B_0	83.63	73.54	74.54	77.23	81.54	74.82	72.37	76.24	76.73
B_1	86.54	79.43	79.72	81.89	85-84	80.03	77.54	81.13	81.51
B_2	87.83	79.01	80.04	82.29	89.52	80.36	78.23	82.70	82.49
B_3	87.11	78.53	78.33	81.32	86.37	77.43	77.27	80.35	80.83
Average	86.28	77.63	78.16	80.68	85.81	78.16	76.35	80.11	80.39

LSD	A	B	AxB	A	B	AxB
0,05	2.568	3.631	6.289	2.852	4.022	6.289
0,01	3.459	4.879	8.471	3.841	5.415	9.406

Hectolitre weight varies from 60 to 84 kg/hl. Saric *et al.*, (1996) reported that according to the criteria for the assessment of processing quality varieties *Triticum aestivum*, intended for whole grains processing, demanding minimum for bulk density was 800 kg/m^3. In our experiments, the average hectolitre weight was slightly above 80 kg/hl (Table 2). The cultivar Orion, compared with the cultivars Kristina and Bosanka, had statistically significant higher hectolitre weight, which is in accordance with the results of Ivanovski (1991) who proved the heritability of hectolitre weight. In varieties Bosanka and Kristina, in both years, hectoliter weight was less than 80 kg/hl, which is in contrast with the results of years of research by Protica *et al.*, (1993, 1994, 1995) who concluded that the hectolitre weight of winter wheat in our agroecological conditions ranges from 80.0 (PKB Padinka) to 86.4 (BG-Maksima) kg/hl. The presented results of research on the effect of different varieties of nutrition on hectolitre weight have significant value. The lowest hectolitre weight of wheat was found in control variant. The determined differences had statistical significance in the years of research and compared with alternatives on which NPK and NPK + natural zeolites were applied (Table 2).

Quality of the wheat grain depends on a number of environmental factors where mineral nutrition has particular importance. The provision of land with accessible forms of nutrients depends on the applied agricultural practices, where fertilization is one of the most important ones. Regarding the quality of the wheat grain, participation of proteins is of particular importance. They determine not only nutritious but also technological value of grain. The nutritional value of grain actually depends on protein content. Proteins are highly caloric substances and only fat may contain more calories. The protein content is the most important chemical parameter of a complex grain quality. From the technological point of view, the quality of flour is made by gluten content, which makes 80-85% of total wheat proteins. Gluten quality is genetically determined and characteristic of the wheat cultivar, and its quality is influenced by conditions during storage of wheat, flour milling and storage (Milena Gavrilovic, 2011).

Table 3. Protein content (%)

	2013				2014				Average
Type (A) / Substrate (B)	Orion (A_1)	Kristina (A_2)	Bosanka (A_3)	Average	Orion (A_1)	Kristina (A_2)	Bosanka (A_3)	Average	
B_0	12.93	12,33	11.06	12.10	13.05	11.45	10.64	11.71	11.91
B_1	13.86	13.75	11.86	13.15	14.01	12.43	11.56	12.66	12.91
B_2	13,63	13.86	11.44	12.97	14.85	13.04	12.53	13.47	13.22
B_3	15.13	14.82	11.24	13.79	15.04	14.31	12.84	14.06	13.93
Average	13.89	13.69	11.41	13.00	14.24	12.81	11.89	12.98	12.99

LSD	A	B	AxB	A	B	AxB
0,05	0.638	0.903	1.564	0.954	1.345	2.336
0,01	0.860	1.215	2.106	1.285	1.811	3.146

Gluten proteins are responsible for rheological properties of dough and baking because they affect the water-binding capacity, cohesiveness, viscosity and elasticity of dough. The amount and quality of gluten with only the optimal ratio of glutenin: gliadin, provide considerable flexibility and elasticity of dough. Although there are some variations, gluten is typically composed of gliadin and glutenin, 52% and 48% respectively. Dough rich in gliadin retains gases during fermentation, but not during baking, while dough rich in glutenin can retain gases during baking (Zezelj, 2005).

Proteins with a higher content of irreplaceable amino acids have a higher nutritional value, where the most important role is played by lysine content, being the first amino acid deficient in grain (Mosse *et al.*, 1988; Milovanovic *et al.*, 2001).

In our study, the protein content mostly depended on the cultivar, then the variant of fertilization (Table 3). All examined genotypes had significantly higher protein content on fertilized variants compared with the control. In the first year of studying cultivars of Orion and Kristina, compared with cultivar Bosanka, had more protein which was highly statistically significant, while in the second year this difference were observed only in cultivar Orion. During studies in Rimski Sancevi (Djuric *et al.*, 2006; Djuric, 2002) it was found that the quality values (protein content, sedimentation value, Hagberg falling number, the energy of dough per extensograph number and value mid-bread) were dependent on weather conditions, administered dose of nitrogen and variety and it had large statistical significance. In our research regarding protein content, the cultivar Orion was dominant. This cultivar which is used with mineral nutrition and natural and synthetic soil improvers had higher protein content. This cultivar had higher percentage of protein in the second year compared with the first year (Table 3).

CONCLUSION

On the basis of the average value of the absolute weight, hectolitre weight and protein content in wheat grain in this experiment it can be concluded that the examined cultivars and nutrition variant had a significant effect on the studied parameters.

The cultivar Orion was dominant in examination of hectolitre weight and protein content, having the lowest absolute mass at the same time. The cultivar Bosanka had the highest absolute mass, while the other parameters had the lowest indicators.

Soil conditioners (natural and synthetic) that were used in combination with NPK fertilizers have significantly affected the quality of wheat grain. In variants where the natural zeolites were applied, we had the highest absolute and hectolitre weight of wheat grain, while the highest protein content was received applying synthetic zeolite.

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