Original Scientific Paper
DOI: 10.7251/AGRENG1601006G
UDC 633.12

THE INFLUENCE OF LOCALITY AND FERTILIZATION ON BUCKWHEAT QUALITY

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ABSTRACT

Buckwheat (Fagopyrum esculentum Moench.) is a plant species which has been spreading in Bosnia and Herzegovina in the last decade. Because of its brief vegetation period, this crop species is especially interesting for hilly-mountainous regions. In 2015, the experiments were set in three localities (experimental field of the Faculty of Agriculture "Kula", private economy "Sando" on the Nišići plateau and private economy "Jugović" in Mokro), and two variants of fertilization (control variant – without the use of organic and mineral fertilizers and the use of $N_{60}P_{60}K_{70}$). The Slovenian sort Darja was used for the experiments. The analysis of seed quality included the following analyses: humidity content (%), mineral matters content (%), protein content, starch content, carbohydrates content. In testing the qualitative characteristics for all localities and fertilizations we determined: 14.2% of humidity in seed, 1.47% of mineral matter in a peeled buckwheat grain, 11.88% of proteins in a peeled buckwheat grain, 51.9% of starch in a peeled buckwheat grain and 71.87% of carbohydrates.

Key words: *buckwheat, locality, fertilization, proteins, agroecological conditions, grain.*

INTRODUCTION

Buckwheat (*Fagopyrum esculentum* Moench) is an old plant species which originates from mountain regions of northeastern Asia. It was brought into Europe by Mongols in late 14^{th} century. Today, buckwheat is grown throughout the world on about 2.3 millions of acre, with average yield of about 1.0 t ha^{-1} .

After the World War II, the buckwheat production in Bosnia and Herzegovina stopped due to intensified production of wheat, migration of population from countryside to industrial areas and especially because of low and unstable yield, and therefore non-economical production. Since 1995, the buckwheat is returning again on the fields of Bosnia and Herzegovina (Milić et al., 2013). The surfaces under buckwheat are increasing year after year. The reasons for intensive increase in surfaces under buckwheat are: it is suitable for growing in hilly-mountainous regions which are dominant in our areas; it has humble demands in regards of

fertilizers and pesticides; there is a significant number of producers whose production is certified as organic. Due to various uses in nutrition and medication there is a big demand for buckwheat products on both domestic and foreign market. Peeled grain consists from around 80% starch, 10-15% proteins, 1-2% fibers, 2-3 % fats and 1-2 % of mineral matters, iron, phosphor and iodine (Jevđović et al., 2012) It also contains B vitamin complex (buckwheat grain contains 150% more of B vitamin complex than wheat grain), essential amino acids (8,6-9,3%).

Thanks to simple agrotechnics which implies growing without use of chemicals, it can be grown as main or additional crop, or as a part of „eco – corridor" between some crops *(Krupa-Kozak et al.,* 2011).

The purpose of this paper was to examine and compare the quality of buckwheat sort Darja on three different localities in the Sarajevo – Romania region (entity of Republic of Srpska, Bosnia and Herzegovina). This research, although they are short – term, can contribute to expansion of buckwheat grow, and also to determination of areas for production of quality buckwheat.

MATERIAL AND METHODS

In 2015, research was conducted on the territory of Sarajevo – Romania region (Bosnia and Herzegovina), to determine which locality is suitable for growing buckwheat, and does mineral nourishment influence the buckwheat quality. The experiments were set up on three localities, and seeds of buckwheat sort Darja were used for seeding. Darja was created by crossbreeding of black buckwheat and chosen genotypes of Russian buckwheat. The flowers are white, seeds dark brown, with slightly larger shell percentage. Diploid sort, lateral flower branches end in flower blossoms, while the main flower branch is of unlimited growth. It's drought and high temperatures, as well as lay down resistant, but it's sensitive on low temperatures. Soil samples were taken before setting of the experiment with agrochemical probe from the depth: 0–30 cm.

Chemical analyses were conducted in the laboratory of Faculty of Agriculture in East Sarajevo:

- PH values of soil: (I) in the water (H_2O) or active soil reaction, (II) in a 1M KCl solution or substitute soil reaction, electrometric.
- Determination of humus content, bicromatic Tjurin method,
- Deteremination of easy – access phosporus (P_2O_5) spectrophotometric and potassium (K_2O), photometric,
- Determination of total nitrogen by modified Kjehdals method.

Bifactorial experiment (locality and fertilization) is set by random block system with four repetitions.

Factor one – locality (A):

- Faculty of Agriculture in east Sarajevo, experimental field, located at 550 meters above sea level (A_1);
- private property of Jugović family in Mokro, located at 905 meters above sea level (A_2) and

- private property of Sando family at Nišići plateau at about 1000 meters above sea level (A_3).

Factor two – fertilization (Б):

- Control ($Б_0$)
- $N_{60}P_{60}K_{70}$ ($Б_1$)

Basic soil treatment was conducted at fall, plowing at a depth of 30 cm, and at pre - sowing soil treatment the NPK fertilizer was added in the part of the experiment where fertilization was required. The surface of basic parcel was 12 m^2. The sowing was conducted by hand at a depth of 4 cm and sets of 250 plants per m^2.

At the Faculty of Agriculture's experimental field the sowing was done by hand on 08.05.2015., and the harvest was done by hand on 18.09.2015. The experiment in Mokro was set on 25.05.2015., and the harvest was done on 14.09.2015. At Nišići plateau the sowing was done 01.06.2015, and harvest was done 22.09. 2015. The harvest, as well as threshing was done by hand.

Meteorological data (temperature and rainfall) were monitored at two registered Meteorological stations (Butmir and Sokolac).

Seed quality analysis included following analysis:

- moisture content (%) – using Sl.l. SFRJ : 74/88 M.BR.8,II-1 method
- mineral matters content (%) – using Sl.l. SFRJ : 74/88 M.BR.10 method
- proteins content (Nx6,25) y % - ISO 20483:2006
- starch content (%) - Sl.l. SFRJ 74/88 M.BR.28
- carbohydrates content (%) - Sl.l. SFRJ 74/88 M.BR.28

All of the data was statistically processed using the Sigma Plot Windows 2000 (Jandel Scientific, Erkhart, Germany) and Statistica for Windows programs. The differences between individual localities for every tested parameter as well as fertilization differences were tested with LSD test.

Agroecological conditions in 2015

Faculty of Agriculture's experimental field „Kula", East Ilidža Municipality

Faculty of agriculture's experimental field is located at 550 meters above sea level. Sarajevo Climate is under the strong influence of continental climate. Average annual temperature is 12,5 °C, and average rainfall amount is around 900 mm. The warmest month is august, and the coldest is January. There is the most rainfall in June, and the least in March. There is average of 85 days with temperatures over 30 °C in Sarajevo.

Table 1. Meteorological conditions in 2015 and perennial averages for Sarajevo (Meteorological station Sarajevo)

Month		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Average (1961-1990)	Temp.(°C)	-0.8	1.7	5.5	10	14.8	17.7	19.7	19.4	15.9	10.9	5.6	0.4
	Rfa. (mm)	74	69	73	76	85	94	83	73	73	79	98	88
2015.	Temp.(°C)	0.9	1.7	5.3	9.2	16.1	17.8	23.2	21.8	17.6	11.1	6	-0.5
	Rfa. (mm)	112.6	56.6	80.4	43.6	52.9	91	9.4	57.4	60.2	124	75	12.5

When comparing meteorological conditions during the experiment in 2015. On the experimental field at East Ilidža with perennial average we notice largger monthly temperature averages, as well as smaller amount of rainfall. In July there were only 9, 4 mm of rainfall, while the perennial average for this month is 83 mm. The experiment was set on alluvial soil (fluvisol) Chemical analysis is depicted in table 2.

Table 2. Chemical properties of soil on experimental field (East Ilidža – Kula)

Depth (cm)	pH/H_2O	pH/KCl	Humus	N	soluble mg/100g	
			%	%	P_2O_5	K_2O
0-30	7.16	6. 39	4.12	0.27	>40	36.41

Jugović private property (Mokro)

The experiment was set on a private property in the Mokro area. Average annual air temperature is 6,8°C, absolute maximum air temperature is 33,6°C, and absolute minimum temperature -30°C. According to Mićević (1979), the climate of the Romanija area is mostly mountainous, with harsh winters and chilly summers. Vegetation season starts on April 8th and lasts until October 22th, or 197 days in average. It's a period when air temperature exsceeds 5°C and when the movement of wood vegetation is noticable. Active duration of the vegetation season with temperatures over 10°C starts on May 6th and lasts until September 24th, that is 141 days. Late spring frosts can appear until the and of May, which is rear, and are almost regular in the first ten days of may. The intensity of theese frosts is milde od medium strong , with temperatures between -1°C and -4,2°C. During the year there is about 800 mm of rainfall, 430 mm which of are in the period April – September. Based on meteorological data(perennial average) it's visible that August is the critical month, because the amount of rainfall isn't suficient, considering that it's a month with high daily temperatures, so a lot is lost by evaporation. Meteorological conditions, as well as perennial average for Jugović private property is shown in table 3.

Table 3. Meteorological conditions in 2015. and perennial aerages for Sokolac (Meteorological station Sokolac)

Month		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Average (1961-1990)	Temp.(°C)	-4.2	-2.6	2.2	5.7	11.5	14.6	16	15.7	12.2	7.7	2.8	-1.8
	Rfa. (mm)	51	45	63	71	81	96	67	76	75	86	80	57
2015.	Temp.(°C)	-2.5	-1.3	2.1	6.2	13.4	15.3	19.8	18.9	14.5	8.4	3.2	-1.6
	Rfa. (mm)	89.9	56.1	74.7	53.2	75.4	113.3	25.2	85.7	84.3	106.9	71.2	0.3

When comparing meteorological conditions during the experiment in 2015. on the private properties in Mokro and Nišićki plateau, with perennial average we notice larger middle temperature averages, while there were variations with amount and disposition of the rainfall. There was less rainfall compared to perennial average in May, while there was 17,3 mm more rainfall in June, deficit of 41,8 mm in July, and in August around 10 mm more than the average.

According to Bosnia and Herzegovina soil map (Resulović and assoc., 2008) the most whidespred type of soil in the mokro area is acidly brown land (distric cambisol), which is found on the parcel where the experiment was set. The acidly brown soil (distric cambisol) is asoil with Ah-Bv-Cn type profile, and it is found on hilly – mountanious areas, 450 – 100 meteras above sea level. Distric cambisol forms on acid quartz – silicate substrates, compact roks and loose sediments. It is a soil characterized by high amounts of acids and low amounts of alkalies. It is suitable for growing potatoes and real and millet grains.
These soils require reparation measures so they could be cultivated. When grading soil's suitability for irrigation and agricultural production, mechanical composition is considered as one of the most important physical characteristic, because other physical characteristics depend on mechanical composition. Soil analysis is depicted in table 4.

Table 4. Chemical analysis of the soil

Depth of sample collection (cm)	pH/H_2O	pH/KCl	$CaCO_3$ (%)	Humus (%)	Total N	P_2O_5 (mg/100 g)	K_2O (mg/100 g)
0-30	6.22	5.17	1.1	5.1	0.336	1.43	34.3

Chemical analysis of acid brown soil samples collected from the depth of 0-30 cm showed that the soil is of acid reaction, rich in humus, rich in potassium, but poor in easy – access phosphorus (table 4) Values of the soil samples taken from the depth of 30-50 cm differ from the samples taken from the depth of 0-30 cm, in the way that they contain les carbonates, humus, easy-access phosphorus, as well as easy – access potassium. According to Resulović et al. (2008), these types of soils are poor in easy – access phosphorus , and have a large scale of physiologically accessible potassium, which was the case with the analyzed samples of acid brown soil taken from two depths, that they had low content of accessible phosphorus, and a relatively high content of accessible potassium.

Sando private property (Nišići plateau)

Nišići plateau is located at 950 to 1000 meters above sea level. This area is characterized by continental-mountain climate, specific for higher areas of central Bosnia. Main feature of this climate type are harsh winters with temperature minimums going as low as -30°C, while the summers are warm, with temperatures above 35°C . Annual rainfall amount is around 1200 mm. The closest meteorological station is in Sokolac (results depicted in table 3).

Table 5. Chemical analysis of the soil

Depth of sample collection (cm)	pH/H_2O	pH/KCl	$CaCO_3$ (%)	Humus (%)	Total N	P_2O_5 (mg/100 g)	K_2O (mg/100 g)
0-30	5.00	3.89	<1	6.68	0.34	2.32	23.03

The soil on this parcel was of a very strong acid reaction with high humus content (6.68%) and well supplied with nitrogen, poorly supplied with easy-access phosphorus and well supplied with potassium.

RESULTS AND DISCUSSION

Buckwheat grain contains a lot of nutrients, whose total content depends on species and growing conditions. Peeled grain is, in its nutritional composition, very much similar to other grains. It contains around 55% starch, 12% proteins, 7% of total nutritional fibers, 4% lipids, 2% soluble carbohydrates and 18% of other components, such as organic acids, polyphenol compounds, tannins, nucleotides and nucleic acids (Bonafaccia et al., 2003). Due to its positive properties, particularly high – quality proteins, flavonoids, phytosterols, fagopirins and thiamine – binding proteins, buckwheat flour is suitable for nutrition enrichment and production of many functional components and final products (Sarač and assoc., 2012). Compared to other grains, (wheat, corn, rice) buckwheat contains more magnesium, zinc, potassium, phosphorus, cuprum and manganese.

Beside the yield other grain, more and more attention is paid to physical quality (shell content, absolute and hectoliter mass) and the amount of some matters with high biological and nutritive values. Buckwheat is appreciated for its high proteins content, especially essential fatty acids, fats carbohydrates and proteins. Buckwheat's yield and quality depends on agroecological conditions and fertilizers application (Eggum et al., 1980).

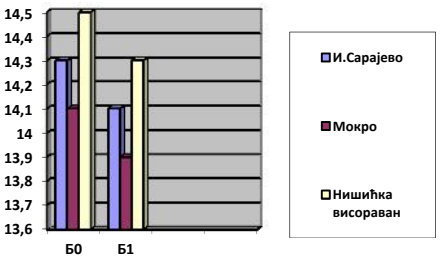
Milić et al. (2014) examined buckwheat quality on four localities. Depending on elevation, agroecological conditions, especially meteorological conditions and soil quality influenced the chemical content of peeled buckwheat grain.

Moisture content

Average moisture content in buckwheat grain for all localities and all fertilization varieties was 14.2 % (table 6, graph 1). Statistical analysis of locality influence on moisture content didn't found significant differences. Significant differences in moisture content weren't found between control variation and application of NPK fertilizer.

Table 6. The effects of locality and fertilization on grain's moist content (%)

Locality	Fertilization		Average
	$Б_0$	$Б_1$	
A_1	14.3	14.1	14.2
A_2	14.1	13.9	14.0
A_3	14.5	14.3	14.4
Average	14.3	14.1	14.2
	A	Б	AxБ
LSD 5%	0.532	0.321	1.137
1%	0.941	0.759	1.953



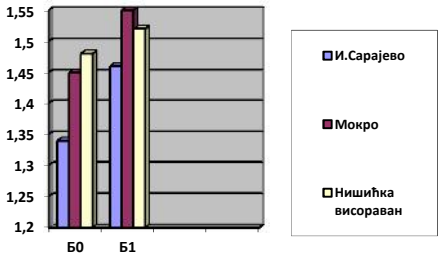
Graph.1 The effects of locality and fertilization on grain's moisture content

Mineral matters content

Mineral matters in buckwheat are primarily located in the shell and the involucre of the grain, so they are high in content in brans, as well as in the flours that mostly contain external parts of the grain (Bonafaccia et al., 2003; Stredman et al., 2001). According to these authors the largest content of mineral matters is in the shell.The average mineral matters content in peeled buckwheat grain was 1,47% (table 7 and graph 2). Statistical analysis didn't found significant differences in mineral matters content of peeled buckwheat grains grown on different localities, while significant differences were found for fertilizer use. In control variety mineral matters content was 1.42%, and in variety where mineral fertilizers were used 1.51%.

Table 7. The effects of locality and fertilization on mineral matters content

Locality	Fertilization		Average
	$Б_0$	$Б_1$	
A_1	1.34	1.46	1.40
A_2	1.45	1.55	1.50
A_3	1.48	1.52	1.50
Average	1.42	1,51	1.47
	A	Б	АхБ
LSD 5%	0.115	0.075	0.185
1%	0.161	0.135	0.265



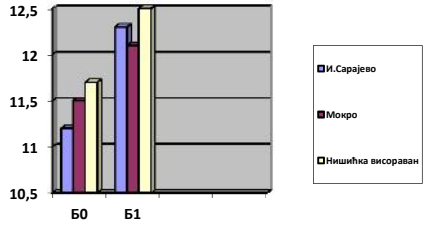
Graph 2. The effects of locality and fertilization on mineral matters content

Proteins content

Buckwheat proteins have high biological value because of well balanced content of amino acids and high content of lysins, which is limiting amino acid in wheat and barley. Main issue with buckwheat proteins is their low digestibility, which is caused by the presence of proteases (like tripsin inhibitors) and tannin (Ikeda et al., 1991; Ikeda, 2002). Average proteins content in peeled buckwheat grain was 11,88 (table 8 ad graph 3). Locality where buckwheat was grown had no influence on the proteins content, while the application of mineral fertilizers had statistically high influence. In variety where mineral fertilizers were used proteins content in peeled grain was 12,3%,and in control variety 11,47%.

Table 8. The effects of locality and fertilization on proteins content (%)

Locality	Fertilization		Average
	$Б_0$	$Б_1$	
A_1	11.2	12.3	11.75
A_2	11.5	12.1	11.80
A_3	11.7	12.5	12.10
Average	11.47	12.3	11.88
	A	Б	АхБ
LSD 5%	0.498	0.217	1.024
1%	0.951	0.743	1.642



Graph 3*. The effects of locality and fertilization on proteins content*

According to the data (*Fachmann-Souci-Kraut*, 1989/90) peeled buckwheat grain contains 9.1% proteins in total and 1.73% of oils, and in our research the average proteins content was 11.8%.

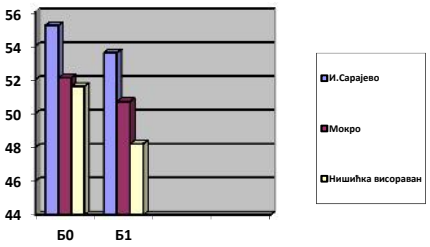
Starch content

Buckwheat starch is characterized by high fat and amylose content. From nutritious aspect there are three different starch fractions: fast digestible starch, slow digestible starch and resistant which is similar to nutritive fibers. Furthermore, resistant starch can be divided into: physically unreachable, natural granular and retrograde starch. Resistant starch in raw buckwheat grain varies in the interval between 33-38% of total starch, but is reduced by hydrothermal treatment to 7-10%. As opposed to that, the retrograde starch content is increased by hydrothermal treatment from 1% to 4-7% (Sakač et al., 2012).

Average starch content in peeled grain was 51.9 % (table 9 and graph 4). The biggest starch content (54.4%) was at East Sarajevo, and smallest (49.99 %) on Nišići plateau. Starch content in peeled buckwheat grain at East Sarajevo was statistically much larger compared to other localities, while there was no difference between starch contents on other localities.

Table 9. The effects of locality and fertilization on starch content (%)

Locality	Fertilization		Average
	$Б_0$	$Б_1$	
A_1	55.2	53.6	54.4
A_2	52.1	50.7	51.4
A_3	51.6	48.2	49.9
Average	52.97	50.83	51.9
	A	Б	АхБ
LSD 5%	2.132	1.548	3.217
1%	2.962	2.371	4.012



Graph 4. *The effects of locality and fertilization on starch content*

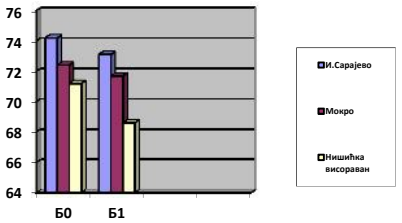
In control variety starch content (52.97%) was compared to variety with fertilizers use (50.82%). Determined differences were statistically significant.

Carbohydrates content

Soluble carbohydrates are located mostly in the germ (71.4 % of total soluble carbohydrates) and in bran, and are fewest in endosperm. Most widespread carbohydrates are saccharose and fagopiritols. The most widespread of the fagopiritols is the B1 (41.2 % of total soluble carbohydrates) (Sakač et al., 2012) Average carbohydrates content is 71.87 % (table 10 and graph 5. The biggest amount of carbohydrates was in buckwheat grains grown in East Sarajevo (73.65%), and the smallest at Nišići plateau (69.90%).

Table 10. The effects of locality and fertilization on carbohydrates content (%)

Locality	Fertilization		Average
	$Б_0$	$Б_1$	
A_1	74.2	73.1	73.65
A_2	72.4	71.7	72.05
A_3	71.2	68.6	69.90
Average	72.60	71.13	71.87
	A	Б	АхБ
LSD 5%	4.432	3.048	5.819
1%	5.362	3.911	6.643



Graph.5 The effects of locality and fertilization on carbohydrates content

CONCLUSION

Based on the results gathered from growing buckwheat on three localities (East Sarajevo, Mokro and Nišići plateau) and two fertilization varieties (control variety and $N_{60}P_{60}K_{70}$), the following conclusions can be made:

- Buckwheat is very interesting wheat whose grain has high nutritive value and can replace the true wheat in nutrition because it doesn't contain gluten;
- In our agroecological and land conditions it grows well, giving high yield in grains that are rich with proteins, mineral salts, oils and that contain considerable amounts of nutritive carbohydrates and cellulose;
- Buckwheat grown at East Sarajevo had the biggest % of starch and carbohydrates and smallest % of mineral matters and proteins;
- Buckwheat grown in Mokro had the smallest % of moisture;
- Buckwheat grown at Nišići plateau had the biggest % of proteins, and smallest % of moisture, starch, and carbohydrates;
- The application of mineral fertilizers affected the most of tested buckwheat properties in a positive way, the only deviation being % of starch and carbohydrates, which were bigger in buckwheat crops that weren't fertilized.

REFERENCES

Bonafaccia, G., Fabjan, N. (2003). Nutritional comparison of tartary buckwheat with common buckwheat and minor cereals. Reserch Reports, Biotehnološki fakultet, Univerzitet u Ljubljani, Slovenija, 81, 349–355.

Fachmann-Souci-Kraut (1989/90): Food Compositon and Nutrition Tables, Wiessenschaftlischeverlag, Stutgart. Specifikacija proizvođača, Kvalitet proteina (PQS) prema Suggested Amino Acid Requirement Paterns FAO-WHO-UNU.

Eggum A., Kreft I., Javornik B. (1980): Chemical Composition and protein quality of buckwheat. Buckwheat. Ljubljana.

Ikeda, K., Sakaguchi, T., Kusano, T., Yasumoto, K. (1991). Endogenous factors affecting protein digestibility in buckwheat. Cereal Chemistry, 68, 424–427.

Ikeda, K. (2002). Buckwheat: composition, chemistry and processing. Advances in Food and Nutrition Research., 44, 394–434.

Jevđović R., Filipović V., Marković J. (2012): Defining quality indicators of buckwheat seeds depending on the fraction size and the temperature regime. 47th Croatian and 7th Internat. Simposium on Agriculture. Opatija. Croatia, 284-288.

Krupa-Kozak, U., Wronkowska, M., Soral-Šmietana, M. (2011): Effect of buckwheat flour on microelements and proteins contents in gluten-free bread. Czech Journal of Food Science 29:103-109.

Mićević Z. (1979): Agroecoclimatic characteristics of Sokolac area. Republic hidrometeorologic institute SR BIH, Sarajevo.

Resulović H., Čustović H., Čengić I. (2008): Soil systematic – genesis, propertie and fertility. Sarajevo University, Sarajevo. Faculty of forestry's essays. Sarajevo.

Sakač, M., Sedej, I., Mandić, A., Mišan, A. (2012). Buckwheat – raw material for functional food production. Monography. Institute of science for nutritional technologies, Novi Sad.