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INFLUENCE OF AGRO-ECOLOGICAL CONDITIONS AND FOLIAR FERTILIZATION ON YIELD AND YIELD COMPONENTS OF BUCKWHEAT IN CONVENTIONAL AND ORGANIC CROPPING SYSTEM

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Abstract: Forgotten or neglected arable land plants, such as buckwheat, are becoming increasingly important in crop production. Grain and one seed nuts are in the usage for humans and domestic animals diet. On the fields of the Institute of Field and Vegetable Crops, Backi Petrovac, researches were conducted in terms of conventional (2010-2012) and organic cropping systems, 2012. Analysis of the average yields showed that Novosadska buckwheat variety achieved a statistically significantly higher yield in 2010th (2,996 kg ha^{-1}) compared to the 2011th and 2012th ($p < 0.01$). The year showed statistical significance based on the analysis of variance. The average yields of Novosadska buckwheat variety, the variant with foliar fertilization in the conventional cropping system, were significantly higher compared with the control. The average yields amounted 1.395 kg ha^{-1} and were higher by 214 kg ha^{-1}, or 18.12% compared to the control. The average plants height was 144 cm. 1000 grain weight was on the average of 23.72 g for the entire experiment. Average yields in the organic cropping system were higher in variants with foliar fertilization (1322 kg ha^{-1}) by 7% compared to the control and plants were higher by 7.28%. Plants were higher in the organic system of cultivation by 13 cm, or 9% compared with plants grown in conventional cropping system, while the yields fell for 73 kg ha^{-1}, respectively by 5.52%. Foliar fertilizers proved to be a possible method for yield, 1000 grain weight and plant height increasing in conventional and organic cropping systems.

Key words: Buckwheat, agro-ecological conditions, foliar fertilization, conventional and organic cropping system, yield and yield components.

Introduction

Buckwheat (*Fagopyrum esculentum* Moench) is a plant species from the group of alternative cereals which originated from wide area of Central Asia (south-western China, Nepal and India). Buckwheat areal of prevalence on the northern and southern hemisphere coincides with the area of winter wheat cultivation. Areas under buckwheat were doubled in the past decade from one million up to two million hectares. Buckwheat is an annual monocarpic plant of the Polygonaceae family, genus Fagopypum. Nowadays, it becomes a very important food in the diet of humans, especially in countries where special emphasis is put on the safe food, produced in organic production. Grain is in the usage for humans and domestic animals nutrition (nut) and it is similar to the grain of bread wheat by nutrient and nutritive value. Above-ground biomass can be used for domestic animal feeding in fresh, as silage or dried *(Glamoclija et al., 2011)*. Buckwheat seed contains powdery endosperm *(Nikolić et al., 2010)*. The most important ingredients of plant are flavonoids *(Arsic et al., 2008)*. The seed coat makes 25-40% of the total weight *(Jevdjovic et al., 2012)*. 1000 grain weight is 24-30 g *(Popović et al, 2013)*, and the density 50-70 g. Above-ground biomass can be used for animal feed in fresh, ensiled or dried, and the highest quality is obtained by cutting plants during the and of blooming period. The flowers are rich in nectar and flowering lasts long. The buckwheat crop is also suitable pasture for the bees, and the yield varies from 120-300 kg of honey per hectare. Buckwheat can be used as siderat what increase the natural fertility of the soil. Lysimetrics research of water consumption of *siderate* in field conditions. Best siderat for plowing will be achieved after flowering because the biomass at this stage rapidly mineralized in the soil and enriches it with important plant assimilates *(Glamoclija et al., 2011)*. Buckwheat is a plant with very modest needs for environmental conditions, can be grown on poor soils, it is grateful as a preceding crop, and chemicals are rarely used for its protection *(Berenji, 2008)*. Therefore, it is suitable for organic production. As response on the conventional production method which has a number of negative consequences, a number of agro-ecological production systems were developed, aimed to make sustainable agriculture and overall sustainable development. Within these systems organic agriculture highlights and it represents sustainable agriculture model in the EU. Multifunctional organic agriculture contributes to the conservation of genetic resources and ecosystem diversity. Production methods help reducing the losses caused by soil erosion from 20% to 40%. Organic products are safe because they are subjects of regular production process control, certified production is transparent and traceable, and documents and the logos are guarantee that food is organically produced *(Lazić, 2008)*.

The aim of this study was to investigate the effect of agro-ecological factors and foliar fertilization on buckwheat productivity in conventional and

organic cropping systems, in particular agro-ecological conditions of Backi Petrovac.

Materials and Methods

The experiment was conducted at the experimental field of Institute of Field and Vegetable Crops in the locality Backi Petrovac during 2010th, 2011th and 2012th, on the calcareous chernozem soil type, subtype loess and loess-like sediments, calcareous gleyed variety, in the conventional cropping system, 2010-2012, and in organic, certified, cropping system during the 2012th, according to the modified block design system with three replications. The subject of the study was Novosadska buckwheat variety. In the conventional growing system basic tillage (deep tillage) and fertilization with mineral fertilizers NPK (15 x 15 x 15) in the amount of 200 kg ha^{-1} was carried out at the optimum time. During the investigation a standard production technology was applied. Plant density was 50 x 4 cm in row spacing of 50 cm, and a depth was 3 cm. Surfaces of basic plots amounted 10 m^2. Fertilizer urea was entered in the amount of 100 kg ha^{-1} on March 23 rd, 2012. Seedbed preparation has been done on March 24th, 2012 and April 30th, 2012 with micro-experiments planter in the recommended rate of 60 kg ha^{-1} Hand harvesting was carried out at the stage of technological mature.

In the organic growing system basic tillage (deep tillage) was carried out on November 11th, 2011. Manure was dismantled in the amount of 15 t ha^{-1} on November 11th, 2011. Seedbed preparation has been done on March 24th, 2012 and April 30th, 2012. Planting was done with plants assembly of 50 x 4 cm in row spacing of 70 cm, on the depth of 3 cm by micro-experiments planter in the recommended rate of 60 kg ha^{-1} on May 5th, 2012. Hand harvesting was carried out at the stage of technological mature.

Soil of the experimental field was of weak alkaline reaction (pH in KCl =7.48), plenty humified (2.42%), medium provided with nitrogen (0.184 %), highly provided with available phosphorus (33.7 mg/100g of the soil) and well supplied with potassium (20.5 mg/100g of the soil). The yield of buckwheat grains was determined by measuring of each elementary plot and average value calculated on 13% of humidity was presented. Foliar fertilization was performed twice during the growing season. Organic fertilizer Bioplant flora was applied in the amount of 60 ml / 10 liters of water per plot, in July, when the buckwheat plants were in the flowering stage. The height of 10 plants from each parcel was measured and average values were taken for the calculations. The analysis of the experimental data was performed by descriptive and analytical statistics with usage of the statistical package STATISTICA 10 for Windows. Significance of the difference between the calculated mean values of the investigated factors (year) testing was performed by usage of one-factorial model, and fertilization by usage of one-

factorial model of variance analysis. All reviews of relevance were derived based on the LSD-test for significance level of 5% and 1%. The most important characteristics are presented in tables and graphs.

Agro-ecological conditions. For seed production it is necessary to monitor the environmental conditions variations, especially because the fact that weather conditions are changeable, unstable and unpredictable in a particular area, so we could mitigate climate limiting factors by timely agricultural measures (*Popović, 2010*). Data for the analysis of the weather conditions were used from the Backi Petrovac meteorological center.

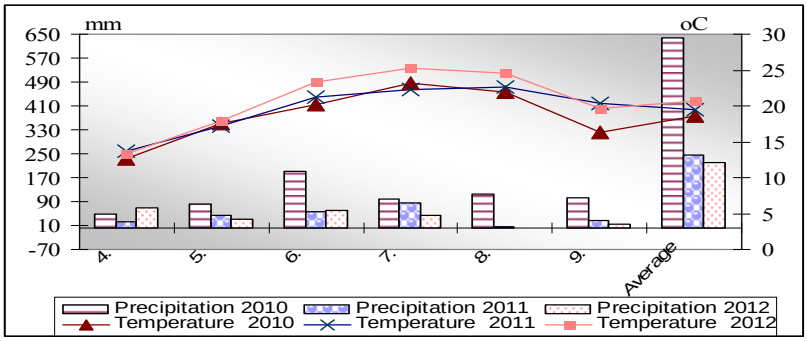

Figure 1. Average air temperature and precipitation, Bački Petrovac, 2010-2012

The most favorable year for buckwheat production was 2010th (T=18.76 ºC, precipitation 636 mm). 2011th was less favorable (T=18.76 ºC, precipitation 636 mm), while 2012th was the most unfavorable (T = 20.68 ºC, precipitation 221.5 mm). Recorded average air temperature in the 2012th amounted 20.68 ° C, and it was higher by 2.1 ° C compared to 2010th, and 1.15 ° C compared to 2011th, while precipitation of 414.6 mm was lower compared to 2010th. The main limiting factor in 2011th and 2012th was the lack of water in the soil in most of the growing season and high air temperatures, especially in June (23.4 °C), July (25.2 °C) and August (24.5 °C), Figure 1.

Results and Discussion

Buckwheat grain yield in conventional cropping system. The yield is the most important but also the most complex characteristics of each genotype *(Popović, 2010, Popović et al., 2011)*. The average yield of investigated buckwheat variety had an average of 2,156 kg ha^{-1} during the 2010-2012 period. Yields ranged from 1,215 (2012) up to 2,996 kg ha^{-1} (2010). Realized buckwheat yields in 2010th were highly significantly higher than in 2011th and 2012th ($p < 0.01$). The yields recorded stability within a year while there were large variations among the years. The largest yield stability was observed in 2012 (Cv = 5.05%) (Tab. 1, 2, Figure 2).

Table 1. Buckwheat yield, Backi Petrovac, 2010-2012

Effect	Variety	Yield kg ha^{-1}	Change of rate, Ch.R %	CV %	Average, %		
					Yield kg ha^{-1}	Ch.R	CV
Year, 2010	Novosadska	2.996	12.66	12.77	2.156	-36.32	41.50
Year, 2011		2.257	5.29	6.62			
Year, 2012		1.215	4.25	5.05			

Indicator	LSD test	0.05	0.01
	Year	479	727

Weather conditions during the study period significantly affected the yield. The most favorable year for the buckwheat production was 2010. That was contributed with sufficient rainfall, its balanced distribution, favorable temperature and properly applied agro-technical measures. The genetic potential of variety came to the fore during that year.

Table 2. Descriptive statistics for Buckwheat yield, 2010- 2012

Effect	No	Yield Mean	Yield Std. Dev.	Yield Std. Error	Yield -95,00%	Yield +95,00%
Total	9	2.156	793,65	264,55	1552,39	2772,50
Year 2010	3	2.996	382,84	221,03	2044,98	3947,016
Year 2011	3	2.256	149,59	86,36	1885,06	2628,27
Year 2012	3	1.215	62,40	36,03	1079,64	1389,70

According to *Nikolić et al. (2010)* in good years the average yield of Novosadska buckwheat variety ranged from 2,216 kg ha^{-1} up to 3,660 kg ha^{-1}. In the aforementioned environmental conditions following varieties distinguish: Novosadska, Prekmurska, Czecka, Darya and Celebica.

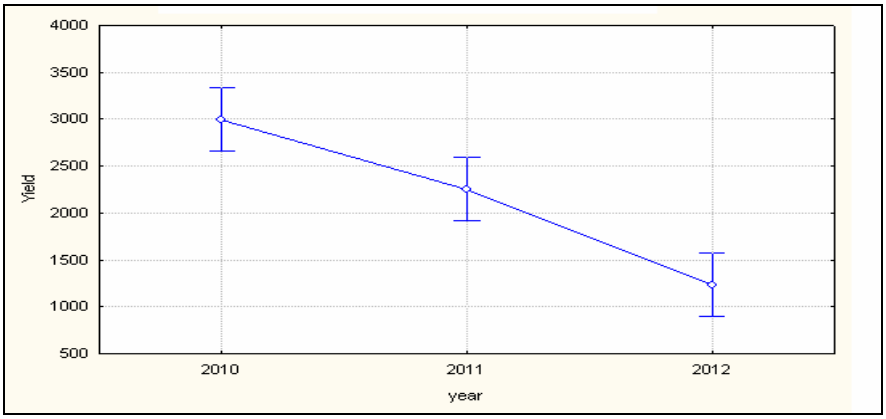

Figure 2. Buckwheat yield, Backi Petrovac, 2010-2012

Popović et al. (2013) reported that the Novosadska variety especially excelled and achieved significantly higher yields compared to other examined buckwheat varieties in that period.

Grain yield, 1000 grain weight, grain weight and buckwheat plant height in conventional organic cropping system. The average yields of buckwheat Novi Sad variety, in conventional production in 2012, in the version of foliar fertilizing, were significantly higher compared to the control variant ($p < 0.05$). Achieved results of 1000 grain weight and plants height in the foliar fertilizing variant were higher compared to the control variant, but the differences were not statistically significant ($p > 0.05$). In the conventional growing system plant height was 144 cm on average, and ranged from 142 cm (control) to 146 cm (fertilization). 1000 grain weight was on average 23.72 g and grain weight per the plant was 6.70 g. Buckwheat yields in the foliar variant had an average of 1395 kg ha^{-1} and were higher by 214 kg ha^{-1}, or 18.12% compared to the control variant (Table 3).

Table 3. Buckwheat grain yield,1000 grain mass and plant height in CP, 2012

Variety	Variant	Yield (kg ha^{-1})	1000 grain mass (g)	Plant grain in mass (g)	Plant height (cm)
Novosadska	Control	1,181	23.47	6.74	142
	Foliar nutrition	1,395	23.96	6.65	146
Average		1,288	23.72	6.70	144

LSD test	Yield in CP	1000 grain mass	Plant grain mass	Plant height
0.05	164	2.35	2.89	26.94
0.01	272	3.91	4.79	31.12

Average yields for Novi Sad buckwheat variety in the organic cropping system had an average of 1,278 kg ha^{-1} in the 2012th. Analysis of variance for fertility indicators, 1000 grain weight, grain weight per plant and plant height in the organic cropping system showed that there was no significant variation between the versions of foliar fertilization and control variant, $p > 0.05$. The results show that there were achieved 7% higher yields in organic cropping system in the variant with foliar fertilization (1322 kg ha^{-1}) compared to the control variant. Plants were higher by 7.28%, while the 1000 grain weight was higher by 0.52%, Table 4.

Table 4. Buckwheat grain yield, 1000 grain mass and plant height in OP, 2012

Variety	Variant	Yield (kg ha^{-1})	1000 grain mass (g)	Plant grain weight (g)	Plant height (cm)
Novosadska	Control	1,235	23.35	6.02	151
	Foliar nutrition	1,322	23.47	5.97	162
Average		1,278	23.41	6.00	157

LSD test	Yield in OP	1000 grain mass	Plant grain mass	Plant height
0.05	141	1.37	2.62	26.94
0.01	233	2.26	4.34	44.67

Obtained results are in accordance with the results of *Popović et al. (2013b).* Plant height in the organic cropping system was on average 157 cm, and ranged from 151 cm (control) to 162 cm (fertilization). 1000 grain weight was on average 23.41 g while the weight of grains per plant was 6.00 g, Table 4. Research shows that foliar fertilization may be possible method for buckwheat grain yields increasing per unit area as well as 1000 grain weight and plant height in organic and conventional cropping systems, Table 3, 4, 5.

Table 5. Analysis of variance of the yield and morphological traits, between cropping system

Indicator	LSD test	Yield	1000 grain mass	Plant grain weight	Plant height
Control OP-CP	0.05	121	1.93	2.10	22.52
	0.01	201	3.20	3. 46	37.35
Foliar Nutrition OP-CP	0.05	188	1.92	3.29	23.88
	0.01	312	3.18	5.45	39.61

Analysis of variance on yielding indicators showed that there was no significant variability for investigated buckwheat traits in organic and conventional cropping systems, Table 6. The average buckwheat yields, 1000 grain weight, grain weight and plant height, produced in the organic cropping system were relatively

balanced with yields obtained by conventional production. Differences of significance from the point of buckwheat production technology were not statistically significant ($p > 0.05$), Table 6.

Table 6. Descriptive statistics for tested parameter in OP and CP

	Descriptive Statistics					
Variable	No	Mean	Std.Dev.	Std.Err.	Confidence -95,00%	Confidence +95,00%
Yield, kg ha^{-1}						
Yield CP	6	1288	81.539	37,371	1146	1338
Yield OP	6	1278	73.372	29,954	1201	1355
Mass 1000 grain, g						
Mass 1000 grain, CP	6	23.71	0.666	0.272	22.696	24.726
Mass 1000 grain, OP	6	23.41	0.967	0.394	22.638	24.038
Mass grain in plant, g						
Mass grain in plant, CP	6	6.69	1.062	0.433	4.877	7.106
Mass grain in plant, OP	6	5.99	1.139	0.465	5.497	7.889
Plant height, cm						
Plant height, CP	6	143.98	7.769	3.171	135.83	152.136
Plant height, OP	6	156.48	12.279	5.013	143.39	169.330

In the organic cropping system plants were higher by 13 cm or 9.0% compared with plants grown in conventional cropping system, while the yields were lower by 10 kg ha^{-1} or 0.8%, grain weight 0.7 g and 1000 grain weight for 0.3 g respectively 1.28%.

Arid 2012th has not been favorable for buckwheat production, and the reasons are extremely low precipitation and high temperatures in June, July and August. Differences between buckwheat yields in organic and conventional production were not significant, because the soil where the organic production trials carried out had a high content of nutrients. In such years irrigation is recommendation, and that is the measure which can mitigate limiting production factors.

Based n these results, it was determined that application of foliar fertilizers is reasonable for buckwheat crops, whether in conventional or organic production.

Conclusion

Based on the results obtained in this study regard conventional and organic cropping system, it can be concluded:

Based on the analysis of variance the year was statistically significant. Analysis of the average buckwheat yields, 2010-2012, showed that the Novi Sad variety realized a significantly higher yield in 2010th compared to 2011th and 2012th.

Foliar fertilization is a good method to increase buckwheat grain yield, plant height and grain weight in conventional and organic cropping systems.

The average yield of buckwheat variety Novi Sad in the conventional cropping system, the variant with foliar fertilization, amounted 1,395 kg ha^{-1} and were higher by 214 kg ha^{-1}, or 18.12% compared to the control. Plant height was 144 cm on average, and ranged from 142 cm (control) to 146 cm (fertilization). 1000 grain weight was on average of 23.72 g.

In the organic cropping system average yields were higher in variants with foliar fertilization (1,322 kg ha^{-1}) for 7% compared to the control variant, the plants were higher by 7.28%.

Obtained differences of significance, from the point of production systems influence on the average traits values were not statistically significant.

In the organic cropping system plants were higher for 9% compared with plants grown in conventional cropping system, while the yields were lower by 0.8% and 1000 grain weight by 1.28%.

Obtained results have great importance because they showed that buckwheat is suitable for growing in organic cropping system.

Uticaj agroekoloških uslova i folijarne prihrane na prinos i komponente prinosa heljde u konvencionalnom i organskom sistemu gajenja

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Rezime

Zaboravljene ili zapostavljene njivske biljke, kao što je heljda, postaju sve značajnije u biljnoj proizvodnji. U ishrani ljudi i domaćih životinja koristi se zrno, odnosno jednosemeni plod orašica. Na parcelama Instituta za ratarstvo i povrtarstvo, u Bačkom Petrovcu, sprovedena su istraživanja u uslovima konvencionalnog (2010-2012) i organskog sistema gajenja, 2012. Analiza prosečnih prinosa pokazala je da je sorta heljde Novosadska ostvarila visoko statistički značajno veći prinos u 2010 (2.996 kg ha^{-1}) u odnosu na 2011 i 2012. godinu ($p < 0,01$). Na osnovu analize varijanse godina je pokazala statističku značajnost.

Prosečni prinosi zrna heljde sorte Novosadska u konvencionalnom sistemu gajenja, u varijanti sa folijarnom prihranom bili su statistički značajno veći u odnosu na kontrolu. Prosečni prinosi su iznosili 1.395 kg ha^{-1} u i bili su veći za 214 kg ha^{-1}, odnosno za 18,12 % u odnosu na kontrolu. Prosečna visina biljka iznosila je 144 cm. Masa 1000 zrna iznosila je u proseku za ceo ogled 23,72 g.

U organskom sistemu gajenja prosečni prinosi bili su veći u varijanti sa folijarnom prihranom (1.322 kg ha^{-1}) za 7 % u odnosu na kontrolu i biljke su bile više za 7,28 %. Ustanovljene razlike značajnosti sa stanovišta uticaja sistema proizvodnje na prosečne vrednosti ispitivanih osobina statistički nisu bile signifikantne ($p > 0,05$). U organskom sistemu gajenja biljke su bile više za 13 cm, odnosno za 9 % u odnosu na biljke gajene u konvencionalon sistemu gajenja, dok su prinosi bili manji za 73 kg ha^{-1} odnosno za 5,52 %.

Folijarna prihrana pokazala se kao moguć metod za povećavanje prinosa, mase 1000 zrna i visine biljaka u konvencionalnom i u organskom sistemu gajenja.

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