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ANALYSIS OF BUCKWHEAT PRODUCTION IN THE WORLD AND SERBIA[1]

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Summary

During the period 2010-2011 about 2.113 million ha of buckwheat was sown annually worldwide. Average yield of buckwheat during the monitored period was 913 kg ha^{-1}. Areas and average yield have a rising tendency. The most significant producers of buckwheat in the world are: China, Russia and Ukraine. In Serbia buckwheat is produced on small areas.

The paper presents results of testing of four buckwheat varieties, produced on plots of the Institute for crops and vegetables as follows: Novosadska, Godijevo, Bamby and Češka. Analysis of average yield has shown that Novosadska variety produced statistically significant higher yield (2626 kg ha^{-1}) compared to the other varieties tested ($p < 0.05$).

From the results shown we can see that buckwheat yield in Serbia is significantly higher compared with the world average yield, which tells us that this plant can be successfully produced in our agro-ecological conditions of growing.

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Introduction

Buckwheat (*Fagopyrum esculentum* Moench) is annual monocarp plant from a group of alternative wheat form family of *Poligonaceae*, species *Fagopyrum* (Sharma, Jana, 2002). Primary gene of buckwheat origin is from wider area of Central Asia.

The name of this species is derived from two words fagus (beech) and pyros (beech and wheat). Sown areas in the world in a last decade are doubled, from a million to over two million hectares. This cultivated plant species is notable by its exceptional nutritive values (Popović et al., 2013a, 2013b). In our country, cultivation of buckwheat is cultivated on small areas, mostly in hilly-mountain areas of South-western Serbia, but there is an increasing interest of farmers for the cultivation of this crop in recent years (Glamočlija at al., 2011).

Buckwheat is grown for grain, in other words for nut-like fruits. Buckwheat grain has a great nutritional value, almost like a bread grain crops. 1000-grain weight is 24-30 g (Popović et al., 2013a). Buckwheat grains contain about 52.11% starch, 11-12.55% of the total protein, 8.7% of the pulp, 2.23% oil, 11% water and 1.75% of N protein (Popović et al., 2013b, 2013c). The most important ingredients of this plant are flavonoids (Arsić et al., 2008). Grain contains a large amount of indispensable amino acids (EAA), primarily lysine and methionine and dietary protein. Shelled fruits can be used as a food in different ways. Complete grain is used as a nutritive supplement for different stews, while flour is used for preparation of porridge (polenta) or mixed with wheat or rye for preparation of bread with higher digestion value. Because of the beneficial chemical composition, and the absence of adhesive proteins, buckwheat is suitable for diabetics and children diets. Buckwheat can be used as *siderite* to increase natural soil fertility. The highest quality green mass to plough in will be acquired from biomass after flowering, because at that stage it quickly mineralizing the soil and enriches the soil with plant assimilating in a short time (Glamočlija et al., 2011). It is very suitable for crop rotation, because there is no usage of chemical substances for protection (Berenji, 2011, Popović at al., 2013a).

Buckwheat is a plant of modest demands towards environmental conditions; it is also grown on poor soils (Popović at al., 2013a, 2013d, Ikanović at al., 2013). Kreft (1995) pointed out that buckwheat suppresses weeds. The competitive and allelopathic effects of buckwheat towards weeds is better expressed in mountain then lower regions, because cooler summers are more appropriate for buckwheat then thermo-philic weeds (Đukić at al., 2007). Therefore, buckwheat is suitable for organic production.

The goal of this research is to study the analysis of buckwheat production in the world and influence of agro-ecological factors to buckwheat productivity in conditions of Bački Petrovac.

Materials and methods

This paper analyses the buckwheat production parameters in the world during the period from 2010 to 2011. The research is based on the available data already existing in related statistical publications. Data from FAO 2013 were used (http:// faostat.fao.org/). For the calculation of the yield and the size of the area, we used a basic statistical method comprising of the following:

- for calculation of variation degree of area size and yield coefficient of variation (CV) was applied in equation: $C_v = b \cdot 100 / \overline{X}$
- movement of occurrences was calculated using an exponential trend in equation: $Yt = a \cdot b^{xi}$.

We used original data from Institute of Field and Vegetables Crops, Novi Sad. Trials were set up on testing from Institute of Field and Vegetables Crops, located in Bački Petrovac, area in the period 2010-2011, on a soil type carbonated chernozem, sub type loess and loess-like sediments, variety of carbonated ogley, in a conventional system of cultivation, in three repetitions. The subjects of research were the following varieties of buckwheat: Novosadska, Godijevo, Bamby and Češka. In conventional system of cultivation basic machining (deep tillage) and fertilizing with mineral fertilizers 15 x 15 x 15, in a quantity of 200 kg/ha was performed in an optimal time-line. During the field trials standard technology of cultivation was applied. Composition of plants was 50 x 4 cm in an interlinear distance of 50 cm and depth of 3 cm. The size of basic plot was 10 m^2. Pre-sowing preparations and sowing were completed in optimal time-line. Harvest was performed manually in technological ripeness.

Soil in trial plot was of mild alkali reaction (pH in KCl=7.48), with a lot of humus 2.42 %, medium provided with nitrogen 0.184 %, highly provided with available phosphorus (33.7 mg/100 g of soil) and well provided with potassium (20.5 mg/100 g of soil).

Grain yield of buckwheat was determined by measuring from every basic parcel and calculated to 13 % of moisture. Analysis of acquired experimental data was performed with descriptive and analytical statistics with use of statistical package STATISTICA 10 for Windows. The testing of significance of differences between calculated average values of analysed factors (year and genotype) was performed with application of two-factor model of variant analysis. All evaluations of significance ware performed on the basis of LSD-test for a level of significance 0.05 % and 0.01 %.

Results and discussion

Buckwheat is planted to an average of 2.113 million hectares worldwide. There is an increasing trend of areas under buckwheat with a rate of 22.46% per year and variation (CV = 14.28%), Table 1.

The highest production of buckwheat of 93.67 % in the world was in Europe and on Asian continent (1,133 ha, 846,799 ha), that is 53.61 % and 40.06 %, respectively.

The lead producers Europe and Asia have a tendency to increase areas with rate of 38.71 % and 5.01 % respectively. Adequate participation by continents, the most significant producers of buckwheat in the world are: China (34.25 %), Russia (32.43 %), Ukraine (11.46 %) and have trend of increase of areas per rate of 6.85 %, 47.90 % and 43.86 %. While major producers of buckwheat are: Poland (3.38 %), USA (3.68 %), Japan (2.46 %), Brazil (2.17 %) and France (1.61 %). Unlike the most significant world producers, Poland, USA and France have a trend of decreasing the buckwheat production areas, Table 1.

Table 1. Area under buckwheat in the world, 2010-2011

Area (ha)	2010	2011	Average values	Rate of change, %	CV, %	Share, %
Continents						
World	1900409	2327409	2113909	22,46	14,28	100
Europe	949486	1317103	1133294	38,72	22,94	53,61
Asia	816800	876798	846799	7,37	5,01	40,06
America	124169	123244	123706	-0,74	0,52	5,85
North America	78269	77244	77756	-1,31	0,93	3,68
South America	45900	46000	45950	0,21	0,16	2,18
Africa	10030	10264	10147	1,63	2,33	0,48
Countries						
China	700000	748000	724000	6,85	4,68	34,25
Russian	570100	843200	706650	47,90	27,33	33,43
Ukraine	198600	285700	242150	43,86	25,43	11,46
Poland	88525	75768	82146	-14,41	10,98	3,88
USA	78269	77244	77756	-1,31	0,90	3,68
Japan	47700	56400	52050	18,23	11,82	2,46
Brazil	45900	46000	45950	0,21	0,15	2,17
France	36900	31000	33950	-15,98	12,28	1,61
Slovenia	1198	1180	1189	-1,50	1,07	0,06

Source: faostat.fao.org, 2013.

Average yield worldwide in the period 2010-2012 was 913 kg ha^{-1} in total and have a tendency to increase with rate of 17.12 %. In 2011, a higher yield of 144 kg ha^{-1} was produced. Around 68 % buckwheat hectarage is located in Russia and China. Ukraine takes the third place per planted hectarage, followed by significant buckwheat producers Poland, USA, Brazil, Japan, France, etc., Table 2.

The highest average yield per continents was produced in America with 1,115 kg ha^{-1}. Average yield in America was varying from 1,237 kg ha^{-1} in South America to 1,042 kg ha^{-1} in North America. The lowest yield was produced in Africa of 848 kg ha^{-1} and Asia 890 kg ha^{-1}. The highest average yield in the world was produced France (3,173 kg ha^{-1}), followed by Brazil (1,237 kg ha^{-1}), Poland (1,162 kg ha^{-1}), Slovenia (1,099 kg ha^{-1}) and USA (1,042 kg ha^{-1}), Table 2.

Table 2. Average yield of buckwheat in the world, 2010-2011

Yield (kg ha^{-1})	2010	2011	Average	Rate of change, %	CV, %
Continents					
World	841	985	913	17,12	11,15
Europe	778	1027	902	32,01	19,51
Asia	872	908	890	4,12	2,86
America	1122	1108	1115	-1,24	0,88
North America	1055	1029	1042	-2,46	1,76
South America	1.235	1.239	1237	0,32	0,22
Africa	820	876	848	6,83	4,66
Countries					
China	595	949	772	59,49	32,42
Russian	928	962	945	3,66	2,54
Ukraine	673	985	829	46,35	26,61
Poland	1098	1227	1162	11,74	7,85
USA	1055	1029	1042	-2,46	1,76
Japan	622	567	614	-8,84	6,54
Brazil	1235	1239	1237	0,32	0,22
France	3411	2935	3173	-13,95	10,26
Slovenia	1143	1055	1099	-7,69	5,66

Source: faostat.fao.org, 2013.

In our country, buckwheat is cultivated in small areas, mostly in hilly-mountain areas of south-western Serbia. Buckwheat was cultivated at the Institute of Field and Vegetables Crops, Department for alternative plant species, which is located in Bački Petrovac.

Production of buckwheat in Serbia

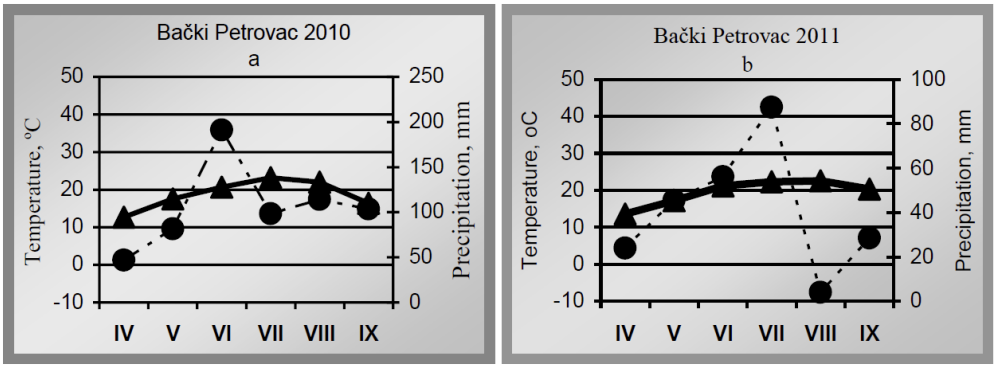
Agro-ecological conditions

Considering that weather conditions are changeable, unstable and unpredictable in certain areas for production of seed, it is necessary to follow varying of outer factors, in order to timely temper climate limiting factors with agro-technical measures (Popović et al., 2011). Data for analysis of weather conditions was used from weather station Bački Petrovac.

More favourable year for a buckwheat production was 2010 (T = 18.76 °C, P = 636 mm), while unfavourable year was 2011 (T = 19.53 °C, P = 245.6 mm). Recorded average temperature (T) in 2011 was 19.53 °C and was 0.77 °C higher compared to 2010 while quantity of precipitation (P) was lower for 390.4 mm in relation to 2010.

Limiting factor in 2011 was a deficiency and unfavourable disposition of precipitation in soil during the vegetation period (Graph 1a and 1b).

Graph 1a and 1b. Average temperature and total precipitation (2010-2011), B. Petrovac



Source: Meteorological station Bački Petrovac, 2010-2011

Buckwheat grain yield

Average yield of buckwheat in Bački Petrovac for tested varieties in 2010-2011 amounted to 2,263 kg ha^{-1} in average. Yield varied from 1,733 kg ha^{-1} (2011) to 2,792 kg ha^{-1} (2010). The most favourable year for buckwheat production was 2010. Produced buckwheat yield for all tested genotypes in 2010 were significantly higher in relation to 2011 ($p<0.01$). Analysis of average grain yield per varieties showed that Novosadska variety produced statistically significantly higher yield (2,626 kg ha^{-1}) in relation to other tested varieties ($p<0.05$). Year and genotype showed a great significance ($p< 0.01$), Table 3.

Table 3. Buckwheat yields (2010-2011), Bački Petrovac

Source of variation	Yield, 2010 (kg ha^{-1})	Yield, 2011 (kg ha^{-1})	Average (kg ha^{-1})	CV, %
Variety				
Novosadska	2996	2257	2626	19,89
Godijevo	2497	2103	2300	11,80
Bamby	2216	1412	1814	31,34
Češka	3462	1161	2312	70,39
Average	2792	1733	2263	33,09
Indicator	**LSD test**	**Year**	**Genotype**	**Interaction**
Yield	0.05	191	270	360
	0.01	264	373	527

Source: Original data from Institute of Field and Vegetables Crops, Novi Sad, 2010 -2011.

Buckwheat varieties Novosadska and Godijevo produced the highest stability of yield, while variety Češka had the highest oscillations (Cv= 70.39 %). Variety Bamby in researched period produced statistically significantly lower yield in relation to other tested varieties, $p<0.01$. Interaction of year x genotype has shown a great significance, $p< 0.05$, Table 3.

Weather conditions significantly influenced yield quantity during the researched period. In 2010, all tested genotypes produced exceptionally high yield, which was contributed by sufficient amount of precipitation, balanced allocation, favourable temperatures and proper use of cultural methods. In the same year, the genetic potential of varieties became prominent. Novosadska, Česka and Godijevo varieties were leading in trial fields of Bački Petrovac area.

According to et al (2010), average grain yield of buckwheat from Novosadska variety was in range from 2,216 kg ha^{-1} to 3,660 kg ha^{-1} in favorable years. In given ecological conditions Prekmurska, Česka, Darja and Čelebica varieties were notable.

According to the research results, it is apparent that Serbia can successfully produce buckwheat, because the average yield of buckwheat was higher than the average world yield of 1,350 kg ha^{-1}. It is important to mention that buckwheat belongs to a group of melliferous plants and presents an excellent honey-bee pasture. The flowers are rich with nectar. Blooming is successive and lasts a long period of time. There can be up to 2,000 flowers on one plant. From one hectare of buckwheat 100 - 400 kg of therapeutic honey can be produced (Glamočlija et al., 2011).

A variety of natural conditions and resources allow the use of various agricultural production systems (Popović et al., 2012). In addition, buckwheat is suitable for crop rotation (Nikolić et al., 2010). Chemical substances are not used as a protection measure on buckwheat. Buckwheat has a short vegetation period; it is resistant to drought, therefore, it can be cultivated as a stubble crop. Buckwheat is a plant of modest demands towards environmental conditions.

Conclusion

Based on the results attained during the research we can conclude the following:

- During the period of research buckwheat was planted on approximately 2.113 million ha in the world. Average areas of buckwheat in the world and yield have a trend of increase. Average world yield was 913 kg ha^{-1} and there was a recorded trend of increase of 17.12 % and great stability (Cv= 11.15 %).
- The highest production of buckwheat in the world of 93.67 % was realized in Europe and Asian. The most significant buckwheat producers in the world are: China (34.25 %), Russia (32.43 %) and Ukraine (11.46 %).
- Average buckwheat yield produced in Bački Petrovac for tested varieties in 2010-2011, amounted to average of 2,263 kg ha^{-1}. Genotype, year and their interaction in 2010-2011 showed statistical significance. More favourable year for buckwheat production was 2010. Statistically significantly higher yield was produced in 2010 in comparison to 2011.
- Analysis of average buckwheat yield in the period 2010-2011 showed that Novosadska variety produced statistically significantly higher yield in relation to other tested varieties.

- Buckwheat can successfully be produced in Serbia because buckwheat yield was significantly higher than average world yield of 1,350 kg ha^{-1}.

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ANALIZA PROIZVODNJE HELJDE U SVETU I U SRBIJI[9]

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Sažetak

U svetu je, u periodu 2010-2011., pod usevom heljde bilo zasejano godišnje u proseku oko 2,113 miliona ha. Prosečni prinosi heljde u posmatranom periodu iznosili su 913 kg ha^{-1}. Površine i prinosi beleže trend rasta po stopi od 22,46 % i 17,12% godišnje. Najznačajni proizvođači heljde u svetu su: Kina, Rusija i Ukrajina. U Srbiji se heljda proizvodi na malim površinama.

U radu su prikazani i rezultati ispitivanja četiri sorte heljde, proizvedene na parcelama Instituta za ratarstvo i povrtarstvo: Novosadska, Godijevo, Bamby i Češka. Analiza prosečnih prinosa pokazala je da je sorta Novosadska ostvarila statistički značajno viši prinos (2626 kg ha^{-1}) u odnosu na ostale ispitivane sorte ($p < 0,05$).

Iz prikazanih rezulata vidimo da su prinosi heljde u Srbiji značajno viši u odnosu na prosečne svetske prinose što nam govori da se ova gajena biljka može uspešno proizvoditi i u našim agroekološkim uslovima gajenja.

Ključne reči: *heljda-Fagopyrum esculentum, površine, prinos, svet, Srbija.*

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