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INFLUENCE OF METEOROLOGICAL PARAMETERS ON THE YIELD AND CHEMICAL COMPOSITION OF COMMON BUCKWHEAT (*Fagopyrum esculentum* Moench)

SUMMARY

Common buckwheat (*Fagopyrum esculentum* Moench) is an annual plant from Polygonaceae family which is well known as pseudocereal with high nutritional value. The yield and quality of the buckwheat`s kernel depend on weather conditions, mainly due to variations in the air temperatures and precipitation during the growing period. The aim of this study was to determine the impact of some metrological parameters on yields and chemical compositions in the kernel of buckwheat. Field experiments were conducted during three years (2011, 2012 and 2013) in the village Donje Selo, near Ilijaš. In this study grain yield, protein content, sludge, fats, mineral matter, cellulose and total phenols were determined. Experimental results suggested that the weather conditions in different years of the research have a significant impact on the yield and the chemical composition of the kernel. The yield of buckwheat varied from the year to year and ranged from 0.98 to 1.29 tons per hectare. Contents of protein and starch were also significantly dependent on the year of the research, as well as the content of phenol in the kernel. High total phenolic content was recorded in the year with the highest average monthly air temperature.

Keywords: buckwheat, meteorological parameters, yield, chemical composition

INTRODUCTION

Common buckwheat (*Fagopyrum esculentum* Moench) is an annual plant and belongs to botanical family *Poligonaceae*. It is a very old plant that is used as human or animal feed for more than 7.000 years (Gadžo et al., 2016). It originates from Asia and it was introduced to Europe in the 15th century. in agriculture and food technology common buckwheat is usually considered as a pseudocereal. In comparison with other cereals buckwheat has a low yield, however, there are some advantages. It is a short-season crop and it does not have

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particular soil or fertilization requirements. Also, buckwheat can grow at high altitudes (Khan et al., 2013). In its grains buckwheat contains a variety of nutrients, main compounds are proteins, polysaccharides, dietary fibers, lipids, polyphenols, minerals and vitamins (Ahmed et al., 2014). Thanks to the chemical composition, grain of buckwheat is primarily used to obtain high quality flour. Unlike flour of wheat, buckwheat's flour is gluten free (Gadžo et al., 2016.), contains proteins with good balanced amino acids (Selimović et al., 2014), and it is particularly rich in lysine and arginine (Christa and Soral-Śmietana, 2008). Compared to other cereals buckwheat kernel has a higher fiber content.

Buckwheat's flower and leaf in recent years become more popular due to their positive effect on human health. Healing properties of buckwheat are derived from the content of the phenolic compounds. It is believed that the consuming of buckwheat contributes to the alleviation or prevention of many diseases (Tomotake et al., 2001; Kawa et al., 2003; Li et al., 2016).

According to FAO data (FAOStat, 2018), in 2016, it buckwheat was cultivated on an area of 2.37 million hectares globally. The main producers of buckwheat in the world are Russian Federation, China and Ukraine and they have 70% of the sown areas of the world (Gadžo et al., 2016). In Bosnia and Herzegovina cultivation area for buckwheat is about 1056 ha with an average yield of 1.07 t ha^{-1} (FAOStat, 2018).

Grain yield and chemical composition of buckwheat depends on a large number of factors, and some of them are variety of buckwheat (Gavrić and Gadžo, 2011; Golob et al., 2016) and agrotechnical conditions of cultivation (Strakšas et al., 2011; Rahimić and Gadžo, 2012). An important role in formation and quality of yield also have weather conditions (Gavrić et all., 2018; Bavec et al., 2002), mainly due to variations in the air temperatures (Strakšas et al., 2011) and precipitation (Glamočlija et al., 2012) during the growing period. Considering that meteorological parameters are changeable, unstable and unpredictable in certain areas for production of buckwheat, the aim of this study was to determine the impact of some metrological parameters on yield and chemical composition in the kernel of buckwheat.

MATERIAL AND METHODS

Field experiments were conducted in 2011, 2012 and 2013 growing seasons in the village Donje Selo, near Ilijaš. Common buckwheat (variety Darja) originates from Slovenia and it was used in this research. Buckwheat was sown in three different sowing rates: 50 (S1), 80 (S2) and 100 (S2) kg per hectare. Experiment was set up by randomized block method in four repetitions. The size of basic plot was 4.8 m^2. The seeds were sown when the soil temperature was 10 ^oC and the sowing was done manually. During the vegetation, weeds were removed manually. Yield of buckwheat was measured in the field. Total protein, starch, fat, ash, cellulose and phenol contents were determined at Laboratories of the Faculty of Agriculture and Food Science Sarajevo. Content of nitrogen in kernel was determined by kjeldahl method described by ISO 5983 and distillation was made by Microkjeldahl apparatus (Foss Kjeltec 2200) to determine kernel nitrogen contents. After measurements, protein content was calculated by multiplying nitrogen contents in kernel with a constant factor of 6.25. Starch was determined by polarimetric method described by Ewers (ISO 6493), contents of lipids were determined by ISO 6492, contents of ash was determined by ISO 5984, and contents of cellulose was determined by Kürschner-Hanack (Kulić and Radojičić, 2011). The total phenolic contents of ethanolic extracts were measured by using of Folin Ciocalteau reagent as described by Bystrická et al. (2010). Statistical analyses were made using SPSS 22 software program.

RESULTS AND DISCUSSION

In table 1 monthly average air temperature and precipitation amount for the period of the research (2011-2013) is presented. Analysis of weather conditions was done on the basis of data for the weather station Sokolac. During the research period, dry and above average warm weather was recorded. The year 2012 has been particularly contradictory comparing to the climate reference period (1961 – 1990). In 2012, air temperature was 4.4 ^{o}C higher compared to climate reference period (1961 – 1990). The temperature increase was accompanied by droughts. The minimum amount of precipitation during vegetation period was recorded in August of 2012 (0.6 mm) and 2011 (9.2 mm). The weather conditions in 2013 were more favorable compared to the other two years (2011 and 2012).

Table 1. Average monthly air temperature and amount of precipitation

Year	**Month**												**Average**
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	
	Average monthly air temperature (^{o}C)												
1961-1990	-4.8	-2.2	1.6	6.4	11.4	14.3	16.0	15.5	12.0	7.2	2.1	-2.8	6.4
2011.	-2.5	-2.4	1.8	7.7	11.0	15.8	17.5	18.2	15.5	6.4	0.8	-1.0	7.4
2012.	-4.5	-7.2	3.6	7.4	10.9	18.7	20.4	19.7	15.1	9.5	6	-2.8	8.1
2013.	-0.7	0.0	2.3	8.9	12.5	15.6	18.1	18.5	12.3	9.4	4.7	-1.6	8.3
	Amount of precipitation(mm)												**Amount**
1961-1990	53	50	56	62	73	84	73	70	66	66	84	71	805
2011.	30.2	27.6	28.8	42.7	123	62.8	82.2	9.2	36.7	59.6	23.7	100.1	626
2012.	90.8	100.6	23.6	93.7	205.1	11.6	77.6	0.6	59.4	67	50.7	80.7	861
2013.	126.1	138.9	71.7	44	121.5	41.4	28.4	70.6	108	78.5	70.8	5.7	905

Results presented in Table 2. show that yield significantly depends on the year of research and the sowing rate. The results indicated that yield of buckwheat varied from the year to year and ranged from 0.98 (2012) to 1.29 (2013) t ha^{-1}.

Yield in 2013 was relatively high compared to the other two years (2011 and 2012). Buckwheat is a plant which achieves better yields in humid regions and wet years (Milić et al., 2013). Such conditions were not present during 2012 and it was one of the reasons why buckwheat achieved the lowest yields in this year (Table 1. and 2). During this three-year research, the highest monthly temperatures during the vegetation period were recorded in 2012 (Table 1.) and this fact is the second reason why the buckwheat had the low yield in this year. It is known that buckwheat has a long flowering period and that high temperatures have a negative impact on pollination and yield formation. Many studies found a close relationship between drought and yield of buckwheat (Gavrić and Gadžo, 2011; Glamočlija et al., 2012; Popović et al., 2014).

Table 2. Kernel Yield, t ha^{-1}

Sowing rate	**Year of the research**			
	2011	**2012**	**2013**	**Average**
50 kg ha^{-1} (S1)	0.57	0.83	1.04	0.81^{c}
80 kg ha^{-1} (S2)	0.70	1.16	1.32	1.06^{b}
100 kg ha^{-1} (S3)	1.82	0.95	1.52	1.43^{a}
Average	1.03^{b}	0.98^{b}	1.29^{a}	

Yield of buckwheat also significantly depended on sowing rate and they are in a positive relation. Therefore, the average grain yield in S1 variant was 0,81 t ha^{-1}, and increased to 1,43 t ha^{-1} in S3 variant. A similar effect of sowing rates was observed in all years of research except in the second year (Table 2). Influence of sowing rates on yield had been proved by many authors (Gavrić et al., 2018; Thakuria and Gogo, 2000).

Buckwheat kernel contains a variety of nutrients and the main compounds are proteins, starch, cellulose, lipids, minerals and phenols. The total content of some components depends on the variety of buckwheat and environmental factors (Christa and Soral-Śmietana, 2008). In this research, it was found that the sowing rates had no significant effect on the chemical composition.

Table 3. Chemical compose of buckwheat´s kernel

Year of research	**Crude protein, %**	**Starch, %**	**Cellulose, %**	**Fat, %**	**Ash, %**	**Total phenols, mg g^{-1}**
2011	10.94^{c}	63.78^{a}	9.86^{ns}	2.07^{ns}	2.20^{ns}	0.37^{b}
2012	14.26^{a}	60.71^{b}	10.55^{ns}	1.69^{ns}	2.18^{ns}	3.67^{a}
2013	12.08^{b}	62.34^{ab}	10.07^{ns}	1.97^{ns}	2.30^{ns}	0.35^{b}
Average	12.43	62.28	10.16	1.91	2.23	1.47

The results of chemical composition show that contents of crude protein and starch significantly depend on the research year. The average contents of crude protein ranged from minimal 10.94 % (2011) to maximal 14.26% (2012). During second year of research (2012), the largest content of crude protein in kernel of buckwheat was detected (14.26%). Higher content of crude protein was probably caused by lower precipitation levels during vegetation (Table 1.). Increasing protein content in kernel can be explained by the reduction in the content of starch in kernel. If we compare starch content (Table 3) with precipitation levels, it can be concluded that the lowest content of starch (60.71%) is recorded in the year with smallest amounts of rain during vegetation. The highest starch contents (62.34% and 63.78%) were determined in the years with a larger amount of precipitation (2011 and 2013). These results are similar to Erekul and Köhn (2009). They found that lack of rain in some years led to high crude protein contents and low starch contents in kernel of wheat and triticale. Similar observations have been reported by many authors (Vafa et al., 2014; Pierre et al., 2008; Sial et al, 2005).

Observing the results from Table 3, it can be concluded that contents of cellulose, fats and ash did not depend on any of the research factors. Their content in kernel has been in the range as in the literature (Christa and Soral-Śmietana, 2008; Kreft and Germ, 2008).

Total phenols have a vital part in the protection of plants against high or low temperatures (Kreft et al., 2013), droughts (Lim et al. 2012), UV radiation (Kreft et al.,2003; Germ, 2004), pathogens and herbivores (Guo et al., 2011) and their high concentration in plants suggest to environmental stress factors (Stagnari, et al., 2017). The results in Table 3. suggest that concentrations of total phenols depend on the years of the research. During 2012 (3.67 mg GAE g^{-1}), buckwheat had about ten times higher total phenol than in 2011 (0.37 mg GAE g^{-1}) and 2013 (0.35 mg GAE g^{-1}). Based on this fact, it can be concluded that buckwheat grew in stressful conditions during 2012, and it synthesized an additional amount of phenol to protect itself. High content was found in the years with a drought and higher average monthly air temperature, and it can be concluded that these factors are the main cause of differences. Kreft et al. (2013) and Lumingkewas et al. (2015) also found that temperature and humidity have effect on concentration of phenol in buckwheat.

CONCLUSIONS

According to the presented results of the research, influence of meteorological parameters on the yield and chemical composition of common buckwheat during the seasons of 2011, 2012 and 2014, following conclusions can be reached:

- -the yield of buckwheat significantly depended on sowing rate and meteorological parameters;
- -Increasing sowing rate had positive effect on yield of kernel, but it had no effect on chemical compose of kernel;
- -second year of research was with unfavorable weather conditions (drought and high temperature) which resulted in low average yield;
- -contents of crude protein, starch and total phenol in kernel depended on meteorological parameters.

-high content of protein and total phenols was recorded in the year with relatively unfavorable weather conditions;

-drought at 2012 year significantly caused a reduction in contents of starch in kernel.

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