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Effects of Fertilization on Vegetative Growth, Yield and Fruit Quality of Black Chokeberry (*Aronia melanocarpa* Elliot)

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Abstract

Black chokeberry (*Aronia melanocarpa* Elliot) is a deciduous fruit shrub from *Rosaceae* family that does not have a long cultivating tradition in Bosnia and Herzegovina. Therefore, the aim of this research was to determine the effect of variety, quantity and combination of fertilizers on characteristics of vegetative growth, yield and fruit quality of black chokeberry of Nero cultivar, in agro - ecological conditions of the Una – Sana Canton (Bosnia and Herzegovina). The experimental site fertilized with the combination of mineral and organic nitrate fertilizers gave the best results in morphometric characteristics of fruit, yield and vegetative characteristics of growth. Fruits from the control site had the highest values when it comes to the most of the following characteristics: dry matter content, ash, total acidity, vitamin C and total phenolic content. Statistical analyses showed that factors of quantity and the manner of fertilization influence significantly most of examined parameters in this research ($P \leq 0.05$).

Key words: black chokeberry, fertilization, phytochemical characteristics, morphometric characteristics

Introduction

Black chokeberry (*Aronia melanocarpa* Elliot) is a deciduous fruit shrub that belongs to *Roseceae* family. The researchers and seafarers of the Imperial Russia brought the plant from North America and cultivated it in Siberian area in the eighteenth century. In the nineteenth century, it was brought from the eastern to the western parts of Europe (Bossert, 2012). In the last decade, there was an increase in the cultivation of this fruit in Europe. It is considered to be one of the most profitable and the most perspective fruit types, given the price of fruit itself as well as the products from black chokeberry (Kurtović et al., 2016). In Bosnia and Herzegovina, the first orchards were established in the last couple of years. In comparison to other fruit types, black chokeberry cultivation is quite simple and suitable for organic cultivation. It may be successfully cultivated in the area with severe climate, in poor, sandy, acid and humid soils which are not suitable for other fruit types.

The reason for this is a notable resistance to the cold. It grows even in the conditions with winter temperatures below – 35 °C with high precipitation (Bussières et al., 2008). Berry fruits are characterized with high amount of sugar, very high content of polyphenol, anthocyanin, flavonol and flavonoid. In comparison with other fruit types, it has a strong antioxidative capacity (Skender et al., 2014; Skender et al., 2015). Black chokeberry fruits are a valuable source of biologically active matters with pharmatheuthical and therapeutic action (Calalb et al., 2014; Wu et al., 2014). The aim of this research was primarily to investigate what effect the type, quantity and combination of fertilizers have on the most important quantitative characteristics of black chokeberry. Since black chokeberry became very popular among fruit growers and nutritionists over the last couple of years and since there had been no previous research of this kind (according to the data available), the need for research in Bosnia and Herzegovina emerged.

Material and Methods

The material in this paper originated from an orchard in Bihać Municipality which has 5.2 ha of black chokeberry shrubs. The orchard was split into three experimental sites. One of the sites was the control site with untreated plants. The second site included cultivated plants treated with standard mineral nitrate fertilizers (UREA and KAN – calcium amonium nitrat). The plants from the third site were treated with UREA, KAN and organic foliar water soluble nitrate fertilizer (PEPTONE) based on natural compounds of amino acids and peptides.

At the site with plants treated with mineral fertilizer, 160 g of fertilizer was applied per shrub, twice in ratio 1:1 (KAN and UREA). When it comes to the site with combined fertilizers, the treatment with mineral fertilizer was the same as the one in the previous site, only with organic fertilizer PEPTONE being added to it. Fruit samples were obtained from all examined research sites in the period of full ripening. All morphometric and phytochemical analyses were conducted in the laboratory at Biotechnical faculty in Bihać. Morphometric analyses were performed on both leaf and fruit (Ochmian et al., 2012). Phytochemical analyses included determining dry matter content, ash, reduced and total sugars, sucrose, total acids (Vračar, 2001), vitamin C through iodometric titration (Helmenstine, 2007), anthocyanin using pH differential method (Wrolstad et al., 2001) and the content of phenolic compounds using Folin - Ciocalteu method (Dewanto et al, 2002). Measuring vegetative growth (Krawiec, 2008) and counting new shoots was performed at the experimental site (Kawecki & Tomaszewska, 2006).

Analyses of morphometric characteristics and vegetative growth of black chokeberry were conducted by ANOVA with the level of significance $\alpha \leq 0.05$. Significance of differences between treatments was tested by Tukey – test with the level of significance 0.05. Analyses of chemical and antioxidative characteristics were performed using Kruskal – Wallis test at the significance level of $\alpha \leq 0.05$ and the significance between treatments was determined by Mann - Whitney test at the level of significance of 0.05. Data were analysed using PAST statistical software (Hammer et al., 2001).

Results and Discussion

Results of morphometric characteristics of fruit

The highest fruit weight (1.2 g) was detected at the site where combined fertilization was used: mineral and organic fertilizers (Table 1). It is a bit higher value in comparison to the result of 0.61 – 0.85 g obtained in a similar research by Jeppsson (2000), and in comparison to the results of Polish researchers (Kawecki & Tomaszewska, 2006) which were 0.80 – 0.93 g. Ochmian et al. (2012) conducted a research on different cultivars of black chokeberry and obtained significantly higher average fruit width only for the Nero cultivar (14.1 mm). The highest average yield per cluster and the number of berries in a cluster were determined at the experimental site with a combined fertilization with mineral and organic fertilizers (Table 1). Kawecki & Tomaszewska (2006), who carried out five years of research investigating different ways of soil management, obtained the results similar to these regarding the number of berries per cluster (12. 4 to 14.1).

Tab. 1. Statistical analysis of average values of morphometric characteristics of fruit
Статистичка анализа просјечних вриједности морфолошких особина плода

Characteristics / *Особине*	Control / *Контола*	Mineral / *Минерално*	Min + Org / *Мин + Орг*	F-test / *F-тест*
Fruit mass (g) / *Маса плода (g)*	1.02 a*	1.14 bc	1.20 c	P < 0.05
Fruit height (mm) / *Висина плода (mm)*	10.44 a	11.22 bc	11.28 c	P < 0.05
Fruit width (mm) / *Ширина плода (mm)*	11.53 a	11.96 ab	12.25 b	P < 0.05
Yield per cluster (g) / *Принос по гроздu (g)*	12.22 a	15.72 ab	18.28 b	P < 0.05
Berries in cluster / *Број бобица у гроздu*	13.0	14.0	14.46	P > 0.05

*Note: Different letters indicate significant differences between means at P ≤ 0.05 by Tukey test / *Различита слова показују значајне разлике између средњих вриједности при P ≤ 0,05 према Tukey тесту*

Research results of black chokeberry vegetative growth

Research results of Nero black chokeberry vegetative growth, or more precisely, its vegetative growth and the number of new shoots are presented in the Table 2. Significantly the highest vegetative growth was recorded at the experimental site with mineral fertilization (38.33 cm). The largest number of new shoots was recorded in shrubs from the experimental site treated with combined fertilization, with 9.86 newly formed shoots per shrub (Table 2). That is a lower value comparing to the research by Kawecki & Tomaszewska (2006), whose result was within the range from 11.9 to 14.8 new shoots per shrub.

Tab. 2. Average values of characteristics of the black chokeberry vegetative growth with the results of statistical analysis
Просјечне вриједности особина вегетативног раста аронијe са резултатима статистичке анализе

Characteristics / *Особине*	Control / *Контола*	Mineral / *Минерално*	Min + Org / *Мин + Орг*	F-test / *F-тест*
Vegetative growth (cm) / *Вегетативни раст (cm)*	28.43 a	38.33 bc	37.66 c	P < 0.05
Number of new shoots / *Број нових изданака*	6.13	8.20	9.86	P > 0.05

*Note: Different letters indicate significant differences between means at P ≤ 0.05 by Tukey test / *Различита слова показују значајне разлике између средњих вриједности при P ≤ 0,05 према Tukey тесту*

Research results of morphometric characteristics of leaf

The widest (57.06 mm) and the longest (94.08 mm) leaf was found at the experimental site treated with the combination of mineral and organic fertilizers (Table 3). These results are close to the results obtained by Ochmian et al. (2012) in the area of Poland (leaf width 53 mm, and leaf length 87 mm). The biggest length and thickness of a leaf stem in this research were obtained at the experimental site treated with the combination of mineral and organic fertilizers (Table 3).

Tab. 3. Average values of black chokeberry leaf characteristics with the results of statistical analysis
Просјечне вриједности особина листа ароније са резултатима статистичке анализе

Characteristics / *Особине*	Control / *Контола*	Mineral / *Минерално*	Min + Org / *Мин + Орг*	F-test / *F-тест*
Width of leaf (mm) / *Ширина листа (mm)*	50.13 a	54.06 ab	57.06 b	P < 0.05
Length of leaf (mm) / *Дужина листа (mm)*	85.12 a	90.72 ab	94.08 b	P < 0.05
Length of leaf stem (mm) / *Дужина лисне дршке (mm)*	11.13 a	12.40 ab	13.18 b	P < 0.05
Thickness of leaf stem (mm) / *Дебљина лисне дршке*	1.72 a	2.06 bc	2.13 c	P < 0.05

*Note: Different letters indicate significant differences between means at $P \leq 0.05$ by Tukey test / *Различита слова показују значајне разлике између средњих вриједности при $P \leq 0,05$ према Tukey тесту*

Research results of chemical and antioxidative characteristics of fruit

The highest dry matter content of 21.78% was found in the fruits from the control experimental site (Table 4). It is much higher in comparison to the results (15.7%) from Poland by Ochmian et al. (2012), and a bit higher (18.92% – 20.14%) than the results obtained by Skupien et al. (2008). The highest ash content (Table 4) was determined in the fruits from the control experimental site (0.45%), which was much lower in comparison to the results (0.76%) by Šnebergova et al (2014) in Czech Republic. Fruits from the experimental site treated with mineral fertilizers had the highest content of total sugars (21.46%) and significantly higher content of reduced sugars as well (19.96%). The highest content of sucrose (Table 4) was determined in fruits from the experimental site treated with a combination of mineral and organic fertilizers (0.61%). Those data were much higher from data collected by Skupień et al. (2008): for the content of total sugars 6.91%, reduced sugars 6.58%, content of sucrose 0.48%. Furthernore, those data were higher than the data collected by Sójka et al. (2013): sucrose content 0.03% – 0.43%.

The highest content of total acids in this research (Table 4) was determined in fruits from the control site (1.34%). It is much higher in comparison to the results in Skupień & Ozmiański (2007) research of Nero black chokeberry fruits (0.54%), and in comparison to the results by Ochmian et al. (2012), who measured the total acidity content of 0.85%.

The highest content of vitamin C in this research was found in fruits from the control site (41.09 mg / 100 g FW), which is much higher when compared to the results by Kulling & Rawel (2008) in the area of Germany (13.7 mg / 100 g FW). The highest content of anthocyanin in fruits (626.67 mg GAE / 100 g FW) was found at the experimental site treated with the combination of mineral and organic fertilizers (Table 4). It is significantly higher than the results (447 mg / 100 g FW) by Wangensteen et al. (2014). The highest content of total phenols was found for fruits from the control site (152.20 mg / 100 g FW), which is much lower than the results (1921 mg GAE / 100 g FW) by Wangensteen et al. (2014).

Tab. 4. Average values of chemical and antioxidative characteristics of black chokeberry fruit with results of statistical analysis
Просјечне вриједности хемијских и антиоксидативних особина плода ароније са резултатима статистичке анализе

Characteristics / *Osobine*	Control / *Контола*	Mineral / *Минерално*	Min + Org / *Мин + Орг*	Kruskal–Wallis / *Kruskal – Wallis тест*
Dry matter (%) / *Сува материја (%)*	21.78 a	18.72 b	16.54 c	P < 0.05
Ash (%) / *Пепео (%)*	0.45	0.31	0.30	P > 0.05
Total sugars (%) / *Укупни шећери (%)*	13.41 a	21.46 b	11.35 a	P < 0.05
Reducing sugars (%) / *Редукујући шећери (%)*	13.02 a	19.96 b	10.60 c	P < 0.05
Sucrose (%) / *Сахароза* (%)	0.38 a	0.46 b	0.61 c	P < 0.05
Total acidity (%) / *Укупна киселост (%)*	1.34	1.01	1.24	P > 0.05
Vitamin C / *Витамин C (mg/100g FW*)*	41.09	31.78	31.50	P > 0.05
Anthocyanins / *Антоцијани (mg GAE / 100g FW)*	327.65 a	478.59 ab	626.67 b	P < 0.05
Total phenols / *Укупни феноли (mg/100g FW)*	152.20 a	39.70 b	51.20 b	P < 0.05

**Note:* FW – fresh weight / *svježa masa ploda;* GAE – Gallic Acid Equivalent / GAE – *ekvivalent galne kiseline*. The different letter indicates significant differences between means at *($P \leq 0.05$* by Kruskal–Wallis test) */ Различита слова показују значајну разлику између средњих вриједности ($P \leq 0,05$ по Kruskal–Wallis тесту)*

Conclusion

The experimental site treated with combination of mineral and organic fertilizers showed the highest results in pomological fruit characteristics, yield and vegetative growth characteristics. This research is the first of its kind in Bosnia and Herzegovina, so it is also necessary to continue and intensify the research into the effects of fertilization and other macro and microelements on the different properties of aronia in the coming period.

References

Bossert, R. (2012). Eine beere erobert die schwiez. *Schweizer zeitschrift für obst und weinbau*, (22), 10 – 12.

Bussières, J., Boudreau, S., Clèment-Mathieu, G., Dansereau, B. and Rochefort, L. (2008). Growing black chokeberry (*Aronia melanocarpa*) in cut – over peatlands. *Hort Science, 43* (2), 494 – 499.

Calalb, T., Nistreanu, A., Oroian, S. & Samarghitan, M. (2014). Callus induction and biomass accumulation in vitro in explants from chokeberry (*Aronia melanocarpa* (Michx.) Elliot) fruit. *Acta Agrobotanica, 67*(3), 53 – 64.

Dewanto, V., Wu, X., Adom, K. & Lui, R. H. (2002). Thermal processing enhances the nutritional value of tomatoes by increasing total antioxidant activity. *J. Agric. Food Chem., 50* (10), 3010-3014.

Hammer, Ø., Harper, DAT. & Ryan, P.D. (2001). PAST: Paleontological statistics software package for education and data analysis. *Palaeontologia Electronica, 4* (1), 1-9.

Helmenstine, A.M. (2007). Vitamin C determination by iodine titration, chemistry articles. Retrieved from the internet address https://www.thoughtco.com/vitamin-c-determination-by-iodine-titration-606322

Jeppsson, N. (2000). The effects of fertilizer rate on vegetative growth, yield and fruit quality, with special respect to pigments, in black chokeberry (*Aronia melanocarpa*) cv. „Viking“. *Scientia Horticulturae, 83*(2), 127 – 137.

Kawecki, Z. & Tomaszewska, Z. (2006). The Effect of various soil management techniques on growth and yield in the black chokeberry (*Aronia melanocarpa* Elliot). *Journal of Fruit and Ornamental Plant Research* 14: 67 – 73.

Krawiec, P. (2008). Effect of biostimulators on growth, cropping and fruit quality of chokeberry. *Fruit Crops – Biostimulators in Modern Agriculture*, (1), 42 – 48.

Kulling, E.S. & Rawel, H.M. (2008). Chokeberry (*Aronia melanocarpa*) – A review on the characteristic components and potential health effects. *Planta Med, 74*(13), 1625 – 1634.

Kurtović, M., Smajlović, H., Grbo, L. & Grahić, J. (2016). Morfološka obilježja i proizvodni efekti uzgoja aronije (*Aronia melanocarpa* Elliot) na području Nišićke visoravni. Rad prezentiran na Simpoziju unapređenja poljoprivrede, šumarstva i vodoprivrede u kraškim, brdskim i planinskim područjima - racionalno korištenje i zaštita, At ANUBiH, Sarajevo. *Posebna izdanja ANUBiH CLXIX, OPMN* 26, str. 85-96.

Ochmian, I., Grajkowski, J. & Smołik, M. (2012). Comparison of some morphological features, quality and chemical content of four cultivars of chokeberry fruits (*Aronia melanocarpa). NotBotHorti Agrobo, 40*(1), 253 – 260.

Skender, A., Ajdinović, T., Bećirspahić, D., Kurtović, M., Hadžiabulić, S., Aliman, J. & Ercisli, S. (2014). The Comparison of Phenotypic Characteristics of Improved and Wild Blackberry Genotypes. Paper presented (oral) at the 25th International Scientific – Expert Congress on Agriculture and Food Industry, Izmir/Turkey.

Skender, A., Ajdinović, T. & Bećirspahić, D. (2015). The comparison of phenotypic characteristics of current varieties and wild species of *Fragari*a. *Genetika, 47*(1), 45-52.

Skupień, K. & Oszmianski, J. (2007). The effect of mineral fertilization on nutritive value and biological activity of chokeberry fruits. *Agricultural and Food Science, 16*(1), 46 – 55.

Skupień, K., Ochmian, I. & Grajkowski, J. (2008). Influence of mineral fertilization on selected physical features and chemical composition of aronia fruit. *Acta Agrophysica*, 11(1), 213 – 226.

Sójka, M., Kołodziejczyk, K. & Milala, J. (2013). Polyphenolic and basic chemical composition of black chokeberry industrial by products. *Industrial Crops and Products, 51*, 77 – 86.

Šnebergová, J., Čižková, H., Neradová, E., Kapci, B., Rajchl, A., & Voldřich, M. (2014). Variability of characteristic components of aronia. *Czech Journal Food Science, 32*(1), 25 – 30.

Vračar, Lj. (2001). *Priručnik za kontrolu kvaliteta svežeg i prerađenog voća, povrća i pečurki i osvježavajućih bezalkoholnih pića.* 1 izdanje. Novi Sad: Tehnološki fakultet.

Wangensteen, H., Bräunlich, M., Nikolic, V., Malterud, K., E., Slimestad, R. & Barsett, H. (2014). Anthocyanins, proanthocyanidins and total phenolics in four cultivars of aronia: Antioxidant and enzyme inhibitory effects. *Journal of Functional Food, 7*, 746 – 752.

Wrolstad, E. R., Terry, E. A., Eric, A. D., Penner, M. H., Reid, D. S., Schwartz, S. J., Shoemaker, C.F, & Smith, D. M. (2001). *Handbook of food analytical chemistry - pigments, colorants, flavors, texture and bioactive food components* 1st. edition. Wiley-Interscience.

Wu, X., Gu, L., Prior, R. L. & McKay, S. (2004). Characterization of anthocyanidins in some cultivars of ribes, aronia, and sambucus and their antioxidant capacity. *Journal of Agricultural and Food Chemistry, 52*(26), 7846 – 7856.

Утицај ђубрења на вегетативни раст, принос и квалитет плода ароније (*Aronia melanocarpa* Elliot)

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Сажетак

Аронија (*Aronia melanocarpa* Elliot) је листопадни грм из фамилије *Rosaceae* и нема дугу традицију узгоја у Босни и Херцеговини. Стога, циљ овог истраживања био је да се утврди утицај сорте, те количине и комбинације ђубрива на карактеристике вегетативног раста, приноса и квалитета плода ароније сорте Неро у агроеколошким условима Унско-санског кантона (Босна и Херцеговина). Огледно поље ђубрено комбинацијом минералних и органских азотних ђубрива показало је најбоље резултате у морфометријским особинама плода, приносу и вегетативним карактеристикама раста. Плодови са контролне парцеле су имали највише вредности када су у питању следеће карактеристике: садржај суве материје, садржај пепела, укупна киселост, садржај витамина Ц и садржај укупних фенола. Статистичка анализе показала је да количина и форма ђубрива значајно утиче на већину испитиваних параметара у овом истраживању ($P \leq 0.05$).

Кључне ријечи: аронија, ђубрење, фито-хемијске особине, морфометријске особине

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