



The influence of humus extract on the quality of raspberry (*Rubus idaeus* L.)

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Abstract

This paper analyzes the influence of foliar fertilizer based on humus extract on some of the elements central to the quality of the Polka raspberry variety in the area of the city of Bihać. The research was conducted in 2015 according to the control and treatment system. A foliar fertilizer based on humus extract was used for the treatment. A total of 12 quantitative and qualitative properties were analyzed: content of total sugars, reducing sugars, invert sugars, sucrose, water content, dry matter, total acidity, vitamin C, total phenols, total flavonoids, antioxidant capacity, and fruit mass. After the analyses were completed, it can be concluded that fruits of raspberry plants treated with humus extract have an almost identical value of total acidity (1.65%) as found in control. However, treatment with a humus extract slightly lowered the content of total phenols and vitamin C. Based on the results obtained, it was shown that the foliar fertilizer based on the humus extract did not have a positive effect on certain chemical and antioxidant properties of the raspberry fruit.

Key words: Polka, fertilizers, biostimulators, humus extract, control

Introduction

The pomological classification categorizes the raspberry in the group of berry fruits, which ranks second in terms of importance, right after the strawberry. Today, Polka is among the leading varieties on the B&H market (Hodžić, 2013). The basic task of each nutrition model applied is the same, namely to achieve the greatest fertilizer efficiency, as well as the rationality and economic justification of its use. When it comes to the three macroelements of plant nutrition, the raspberry uses potassium the most, followed by nitrogen, and then phosphorus (Jerkić, 2010). The aim of this research was to examine the influence of fertilizers with biostimulative effect on the quality traits of raspberry fruits. This research also showed certain differences in the quality of the raspberry fruits treated, and upon conducting a statistical analysis of the results, recommendations and conclusions regarding the use of fertilizer application were made.

Material and Methods

The foliar fertilizer based on a humus extract was applied according to proprietary preparation procedure: 1 kg of humus was placed in a 25 L container , to which 1, 0.1 l of molasses (sugar) is added. The contents were covered with water and subjected to 24-hour oxygenation in order to increase the activity of microorganisms from the humus. The fertilizer extract obtained was used for foliar fertilization during the growing season in a concentration of 4%.



Picture 1: Experimental plantation - the "Ribića Otoka" plot (Source: Katastar.ba, 2023).

The experiment was conducted on a raspberry plantation of the Polka variety in 2015 on the "Ribića Otoka" experimental field located in the

immediate vicinity of the city centre of Bihać. The total area is 9.5 ha, of which 1.5 hectares are planted with raspberries, the Polka variety. The raspberries were grown in a trellis system of free individuals with a type of support commonly called the T-system. According to the basic pedological map, this area is located in the lower parts of the valley along the Una river and is mapped as alluvial-carbonate, sandy soil on sand. Thus, it often alternates briefly with alluvial, carbonate, loamy, and clayey soils. In addition, the soil is characterized by high and quick natural water drainage, so these soils are prone to being very drained and dry (Ičanović, 2016).

Sampling of the raspberry fruit was carried out in full harvest, at the end of July and the beginning of August. Harvesting was carried out within each marked field, whereby the samples from all three fields were treated with humus extract, and combined into one average sample, as well as for the control field. All raspberry fruits were harvested from the plants in the experiment, in order to avoid possible errors caused by various ecological and technological factors during cultivation. The experiment was set up and statistically evaluated according to the split plot scheme, where the main fertilization factor, and the sub-factor a variant of biostimulator application, with three repetitions. All results were analyzed using the usual methods of statistical data processing – the analysis of variance (ANOVA), statistical test of significance influence of applied treatments – the F test and Tukey test. In addition to analysis of variance, the principal component analysis (PCA - Principal Component Analysis) Hotelling was also performed.

Results and Discussion

Results of chemical analysis of raspberry fruit.

Polka raspberry fruits were examined and the results of the average values obtained based on the examined chemical properties were presented. Thereby, a standard deviation in the results of statistical data processing (One-Way ANOVA and Tukey - test) occurred, due to the volume of the results and a large number of individual tables. The results obtained for all the parameters mentioned are shown in three tables (chemical, antioxidant properties, and fruit mass), according to the statistical processing of the data.

Table 1: Average values of chemical properties of the Polka raspberry fruit

Treatment	Total sugars	Reduced sugars	Inverted sugars	Sucrose	Water content	Dry matter content	Total acidity
Humus	5.63 ± 0.33 ^{ab}	4.64 ± 0.28 ^a	1.00 ± 0.13 ^{cb}	0.95 ± 0.12 ^b	86.66 ± 0.25 ^{ab}	13.34 ± 0.25 ^{bc}	1.65 ± 0.09 ^b
Control	5.46 ± 0.28 ^b	4.04 ± 0.24 ^b	1.42 ± 0.21 ^b	1.35 ± 0.20 ^b	86.20 ± 0.27 ^b	13.80 ± 0.27 ^b	1.60 ± 0.09 ^b
ANOVA test	p ≤ 0.05	p ≤ 0.05	p ≤ 0.05	p ≤ 0.05	p ≤ 0.05	p ≤ 0.05	p ≤ 0.05

The content of total sugars sampled in the raspberry fruit treated with the humus extract was slightly higher as compared to the control field, as well as the content of reduced sugars. The content of invert sugars, i.e. sucrose, discovered in the analyzed fruits harvested from fields treated with the humus extract-based fertilizer subjected to analysis was 1%, i.e. sucrose 0.95%, while the fruits from the control field showed a slightly higher content of invert sugars and sucrose, amounting to 1.42% and 1.35%, respectively. According to the Tukey test, significant differences in the content of total sugars and invert sugars were found between the fruits harvested from the fields treated with the humus extract and the control field.

In the research carried out by Skupien et al. (2011), the fruits of the Polka variety grown organically and conventionally at different locations of Western Pomerania (Poland) were analyzed. The content of total sugars at 5.82% was observed. Compared to this research, Nikolić et al. (2008) observed a higher content of invert sugars (6.82%) in the Polka raspberry fruits cultivated conventionally over two experimental years. The same author states that the average sucrose content for the Polka variety was 0.89%, which is lower than the values obtained in this paper. Based on the results of our research, dry matter content of raspberry fruits harvested from the plants treated with the humus extract was 13.34%, while it was 13.80% in the control plants. Grajkowski and Ochmian (2007) investigated the effect of three biostimulators (Atonik SL, Biochikol 020 PC, and Tytanit) on the yield and quality of fruits of the Polka variety. They reported that the dry matter ranged from 10.70% (Atonik SL), over 10.80% and 11.30% (Biochikol 020 PC and control) to 11.60% (Tytanit), which is lower in comparison with our results. When it comes to the average content of total acids in raspberry fruits, lower values were found in the fruits from the control fields (1.60%), compared to the fields treated with the humus extract (1.65%). In the research done by Grajkowski and Ochmian (2007), the content of total acids, depending on the application of biostimulative fertilizers, ranged from 1.68% (Biochikol 020), over 1.70% and 1.79% (control and Tytanit) to 1.82% (Astonik SL).

Antioxidant properties of the raspberry Polka fruit

A slightly higher average content of vitamin C in the fruits of the Polka raspberry variety was registered than in the fruits harvested from the control field 22.18 mg/100 g FW, lower values of vitamin C were found in the fruits treated with the humus extract (22.08 mg/100 g FW).

Based on the Tukey test, no significant differences were observed in the content of Vitamin C between the fruits harvested from the control field and those from the field treated with the humus extract ($p > 0.05$). A significantly higher vitamin C content compared to these studies was published by Grajkowski and Ochmian (2007), where the vitamin C content ranged from 43 mg/100 g FW (Tytanite), over 47.00 and 48.00 mg /100 g FW (Astonik SL and Biochikol 020) and up to 59.00 mg/100 g FW in the fruits obtained from the control field. During the analysis of the fruit of the Polka raspberry varieties grown organically and conventionally, Skupien et al. (2011) reported similar content of vitamin C, as obtained in our research. The content of vitamin C in the Polka variety grown organically was 21.9 mg/100g FW, while it was 25.3 mg/100g FW in the conventional cultivation.

Table 2: Average values of antioxidant properties of the Polka raspberry fruit

Treatment	Vitamin C (mg/100 g FW)	Total phenols content (mg/g DW, presenting as gallic acid)	Total flavonoids content (mg/g DW)	Antioxidant capacity ($\mu\text{mol Fe}^{2+}/\text{g DW}$)
Humus	22.08 \pm 0.10 ^b	11.61 \pm 0.06 ^b	3.93 \pm 0.52 ^b	14.42 \pm 0.20 ^b
Control	22.18 \pm 0.10 ^b	12.25 \pm 0.18 ^{ab}	3.87 \pm 0.07 ^b	14.18 \pm 0.28 ^b
ANOVA	$p \geq 0.05$	$p \leq 0.05$	$p \leq 0.05$	$p \leq 0.05$

Kazimierzczak et al. (2015) examined the content of vitamin C by analyzing the organic freeze-dried raspberry Polka variety, a conventional cultivation method. The results obtained in that study indicated a higher content of vitamin C in the fruit of the Polka variety in organic cultivation (47.80 mg/100g DW), as compared to the conventional cultivation method, where the average value of vitamin C was 42.19 mg/100g DW. Based on the Tukey test, no significant differences were found in the content of total phenols in the fruits harvested from the field treated with the humus extract ($p \leq 0.05$) and the control field. Higher values of the content of total phenols compared to these studies were published by Kazimierzczak et al. (2015). The content of total phenols in that study for the

freeze-dried Polka raspberry under the organic cultivation method was 18.64 mgGAE/g DW, whereas in the conventional cultivation method the content of total phenols was 15.17 mgGAE/g DW. According to Skupien et al. (2011), who conducted a research on fresh fruits of the Polka raspberry variety, the content of total phenols in the organically grown raspberry fruits was 215.8 mg GAE/100g FW, while in the conventionally grown Polka variety, the content ranged between 254.6 – 211.8 mg GAE/100g FW. According to the Tukey test, there were no significant differences in the content of total flavonoids in the fruits harvested from the plants treated with the humus extract and the untreated, control plants ($p > 0.05$).

Upon testing the content of biocomponents in the organically and conventionally grown raspberry fruits, Kazimierczak et al. (2016) reported much lower values for the content of total flavonoids in the fruit of the freeze-dried Polka raspberry variety compared to the results obtained in this study, where the content of total flavonoids was 0.1956 mg/100g DW in the organic production, while it was 0,1621 mg/100g DW in conventional. Based on Benzie and Strain (1996), the antioxidant capacity in the samples of dried raspberry fruit was determined according to the FRAP (Ferric Reducing/Antioxidant Power) method, which is based on the ability of the extract to reduce Fe ions to Fe ions in a 2,4,6-tripyridyl-s-triazine (TPTZ) solution at a lower pH value, which is manifested by a change in the colour of the solution to blue. The values obtained in this study indicate that the FRAP value and, thus, the reduction capacity measured in dry fruits of the Polka variety from the fields treated with the humus extract (14.42 $\mu\text{mol Fe}^{2+}/\text{g DW}$) compared to the control field (14.18 $\mu\text{mol Fe}^{2+}/\text{g DW}$). Based on the Tukey test, no significant differences in the antioxidant activity in the fruits from the fields treated with the humus extract and control fields ($p > 0.05$) were detected. Upon conducting a research of mainly Polish monoecious and dioecious varieties of red raspberry (*Rubus idaeus*), black raspberry (*Rubus occidentalis*), and blackberry (*Rubus fruticosus*) grown conventionally in the central part of Europe during two experimental years, Orzel et al. (2015) reported that the antioxidant activity in the first year of research (2012) was 10.61 $\mu\text{mol Fe}^{2+}/\text{g FW}$, while this value was 8.67 $\mu\text{mol Fe}^{2+}/\text{g FW}$ in the second year (2013).

Average values of the fruit weight of the Polka raspberry variety are shown in Table 3.

Table 3: Average values of the fruit weight of the Polka raspberry variety

Treatment	Fruit weight (g)
Humus	3.36 ± 0.39 ^{ab}
Control	3.11 ± 0.45 ^b
ANOVA	p ≤ 0.05

Higher fruit weight was found in the experimental fields treated with the humus extract (3.36 g) compared to the control field, where it was 3.11 g. Significantly higher values of fruit weight expressed on the weight of 100 fruits were published by Grajkowski and Ochmian (2007). The value of the weight of 100 fruits of the Polka variety ranged from 360.00 g in the control field, over 399.00 g and 400.00 g (Astonik SL and Biochikol 020) to 428.00 g treated with the biostimulative fertilizer called Tytanit. In the research published by Krok and Wieniark (2008), who examined the influence of the application of a biostimulative fertilizer based on algae extract (Goemar BM 86) on the development and quality of the fruit of bisexual raspberry varieties, fresh weight of the Polka variety fruits was in accordance with the values obtained in this research.

Conclusion

Based on the results obtained during the one-year experiment, it can be concluded that the application of a humus extract fertilizer had positive effects on the parameters examined. Although these differences were not significant, higher fruit weight was found in the experimental fields treated with the humus extract as compared to the untreated plants.

The results of this experiment, i.e. the weight of the fruit, leads to a conclusion that applying the humus fertilizer on the leaves gives somewhat better results, and, as such, it can be recommended to raspberry producers in their production.

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Утицај екстракта хумуса на квалитет малине (*Rubus idaeus* L.)

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Сажетак

У раду је анализиран утицај фолијарног гнојива на бази екстракта хумуса на неке од елемената квалитета плода малине сорте Полка, на подручју града Бихаћа. Истраживање је проведено у 2015. години, по систему контрола и третман. За третман је примјењено фолијарно гнојиво на бази екстракта хумуса. Укупно анализирано је 12 квантитативних и квалитативних особина у зависности од утјецајног фактора, а то су: садржај укупних шећера, редукујућих шећера, инвертних шећера, сахарозе, садржај воде, сухе твари, укупне киселости, витамина Ц, укупних феноли, укупних флавоноида и антиоксидативни капацитет и маса плода. Након завршених анализа може се закључити да биљке малине третиране екстрактом хумуса су имале готово идентичну вриједност укупне киселости (1,65%), третмана и контроле. Садржај укупних фенола је био нижи код парцеле третиране екстрактом хумуса у односу на контролни третман, као и садржаја витамина Ц (22,08 mg/100 g свјеже масе). На основу добијених резултата показало се да фолијарно гнојиво на бази екстракта хумуса није имало позитивног ефекта на одређена хемијска и антиоксидативна својства плода.

Кључне ријечи: Полка, гнојива, биостимулатори, екстракт хумуса, контрола

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