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Fruit quality of strawberry cultivars (*Fragaria ananassa* Duch.) affected by mineral and microbiological fertilizers

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Abstract. This study was carried out to evaluate the impact of the genotype and fertilizer on fruit quality of strawberry cultivars 'Clery', 'Joly' and 'Garda'. Three types of fertilizer were applied: M – mineral fertilizers, M+B - combination of microbial and mineral fertilizers, B – microbial fertilizer. Fruits of 'Garda' had significantly higher fruit weight, firmness and titratable acidity (TA), whereas fruits of 'Joly' expressed significantly higher antioxidative capacity compared to the other two cultivars. In all fertilization treatments, fruits of 'Clery' had a high content of soluble solids (SSC), total sugars (TS) and inverted sugars (IS). Among the tested cultivars, 'Garda' can be recommended for more intensive commercial growing because of early ripening time and satisfied outer and inner fruit quality. Taking into account the positive effect of combined application of mineral and microbiological fertilizers on content of soluble solids, total acids, total and invert sugars in the fruit, a partial substitution of mineral fertilizer by biofertilizer could be recommended in nutrient management of strawberries aiming to improve the nutritional fruit quality.

Key words: strawberry, cultivar, fertilization, fruit weight, sugars, titratable acidity, antioxidant capacity

Introduction

Strawberries (*Fragaria ananassa* Duch.) are the most important berries in Serbia, after raspberries. Among berries, strawberries are favored fruits, because of their high nutritional value leading to putative health benefits and unique color, flavor, and taste (Gündüz, 2016; Gündüz & Özbay, 2018). Commercially available strawberry cultivars are changing rapidly and hence constant updating of information is required to quantify important taste- and health-related compounds in fruits from newly released cultivars. In addition to differences among genotypes, numerous works have shown that exogenous factors, such as environmental parameters (viz. light conditions, temperature, irrigation, fertilisation or cultivation systems) can affect the concentration of anthocyanins and antioxidant activity in strawberries and other berry crops (Crespo et al., 2008; Davik et al., 2006; Terry et al., 2007; Wang & Zheng, 2001).

One of the most important cultural practices in modern strawberry production is fertilization. According to Vitousek et al. (1997) and Frink et al. (1999), the process of intensifying agricultural production is based on the application of large quantities of mineral fertilizers. Bockman et al. (1990) point to the fact that more than 50% of the applied mineral fertilizers are not adopted by the plant, but there is a loss of minerals in various ways, which may cause danger to the environment. Barlóg & Grzebisz (2004) state that the main reason for this problem is the low efficiency of mineral fertilizers and their continuous use.

The aim of this paper is to examine the impact of genotypes and fertilizers on the fruit quality of the two economically important strawberry cultivars – 'Clery' and 'Joly', and the promising cultivar 'Garda', in order to provide recommendations for increase of strawberry consumption.

Material and Methods

Experimental design and orchard management. The field experiment was carried out in the experimental strawberry plantation at the Fruit Research Institute, Čačak, located in Čačak (43°54' N latitude, 20°21' E longitude, 242 *m* altitude), in the Western Morava valley (Western Serbia). Strawberries were planted in August 2015 in double rows on beds covered with black polyethylene foil. Plant spacing was 30 × 30 *cm*, and distance between beds was 50 *cm*. Fruit quality of the three Italian strawberry cultivars ('Clery', 'Joly' and 'Garda') were studied in the first (2016) and the second (2017) year after planting. The layout of the experiment was a completely randomized design, with the effect of two factors, cultivar and fertilizer, analyzed. The experiment was conducted in 3 treatments (M – mineral fertilizers; M+B – microbial fertilizer in combination with mineral fertilizer; B – microbial fertilizer) on 60 plants (20 plants in 3 replications) of each cultivar. In addition to the standard cultivation practices, the plants were regularly irrigated according to soil humidity.

The following fertilizer treatments for each cultivar were applied: M – mineral fertilizers (Haifa Chemicals Ltd.) with different formulation ratios, M+B – microbial fertilizer in combination with mineral fertilizer, B – microbial fertilizer consisting of a combination of bacteria of the *Bacillus* genera. Mineral fertilizers were applied according to the phenological stage of the plant, as follows: at the beginning of the growing season, starter fertiliser NPK Poly-Feed Drip 11-44-11 with micronutrients at a rate of 1.0 *g* per plant; during intensive plant growth and flower bud emergence, 2 applications of NPK Poly-Feed Drip 20-20-20 with micronutrients at a 7-day interval, at a rate of 1.5 *g* per plant; during flowering, fruit set, growth and ripening, 5 applications of the complex mineral fertilizer NPK Poly-Feed Drip 16-8-32+2 MgO at 10-day intervals at a rate of 1.0 *g* per plant; during intensive fruit growth and ripening, in addition to the former formulation, 2 applications of Multi-Cal (15.5% N and 26.5% CaO) and Multi-KMg (12% N; 43% K and 2% MgO) at a 10-day interval, at a rate of 1.5 *g* per plant.

In a combined treatment of mineral and microbiological fertilizers, twice the smaller quantities of mineral fertilizers were used than those used in a separate treatment of mineral fertilizers, and half the amount of microbiological fertilizer used in the treatment of microbiological fertilizers. Microbiological fertilization involved soaking strawberry roots in the liquid inoculum consisting of a combination of bacteria of the *Bacillus* sp. at planting, followed by fertigation with 10–12 $l\ ha^{-1}$ of the inoculum 3 times per month during the growing season. The bacterial titer in the inoculum was 20–40 × 106 cm^{-3}.

Fruit quality. To assess the weight, firmness and chemical properties, a sample of 25 fruits per replication was randomly selected in both harvesting seasons. Ripe fruits of selected strawberry cultivars were sampled per each treatment separately in the second harvest. For average fruit weight, a technical scale Adventurer Pro AV812M (Ohaus Corporation, Switzerland) was used, and data are expressed in grammes (*g*). Firmness of fruit is determined by fruit hardness tester PHT-803 (Silverado Company, China), and values are expressed in newtons (*N*). Samples were immediately frozen in liquid nitrogen and stored at -20 °C until chemical analyses. Results are expressed as the mean of 2-year values with three replications for each year.

Soluble solids content (SSC) was determined by refractometer (ATC, Belgium). A drop of homogenized and filtrated sample was placed on the lens and the reading was expressed as % of SSC in the fruit. Titratable acidity (TA) was measured using a burette containing 0.1 N NaOH. Homogenized and filtered samples were titrated using phenolphthalein as an acid-base sensitive colour indicator to achieve the pink endpoint. The sodium hydroxide solution was added drop by drop to the flask and mixed until the colour turned persistent pink for at least 30 s. The total TA of the samples was calculated using the following equation:

V (*ml*) × *N* × 0.268 25 *ml* of sample × 100 = % malic acid equivalent where V (*ml*) is the amount of sodium hydroxide solution used, N is the normality of sodium hydroxide solution, and 0.268 is the milliequivalent factor for malic acid. TA was expressed as % of malic acid equivalent.

Content of total sugars (TS), invert sugars (IS) and sucrose (S) were determined according to the Luff – Schoorl method (Egan et al., 1981). TS, IS, S were expressed in %.

Antioxidant capacity was determined using the DPPH method reported by Brand-Williams et al. (1995) with modifications (Sánchez-Moreno et al., 1998). An aliquot of the fruit phenol extraction was added to DPPH solution in methanol and vortexed. A control sample, containing the same volume of solvent in the place of the extraction, was used to measure the maximum DPPH absorbance. After the reaction was allowed to take place in the dark for 30 min, the absorbance at 515 *nm* was recorded to determine the concentration of the remaining DPPH. The results were expressed as the Trolox equivalent antioxidant capacity per g of fresh weight (*µmol TE/g FW*).

Free radical scavenging activity of plant samples was determined by ABTS radical cation decolorization assay (Re et al., 1999). $ABTS^{\cdot+}$ cation radical was produced by the reaction between 7 mM ABTS in water and 2.45 mM potassium persulfate (1:1), stored in the dark at room temperature for 12–16 h before use. $ABTS^{\cdot+}$ solution was then diluted with methanol to obtain an absorbance of 0.700 at 734 *nm*. After the addition of plant extract to diluted $ABTS^{\cdot+}$ solution, the absorbance was measured at 30 min after the initial mixing. Percent inhibition of absorbance at 734 *nm* was calculated using the equation:

$$ABTS^{\cdot+} \text{ scavenging effect } (\%) = ((AB-AA)/AB) \times 100$$

where, AB is absorbance of ABTS radical + methanol; AA is absorbance of ABTS radical + sample extract/standard. Trolox was used as standard substance. An appropriate solvent blank was run in each assay. The results were expressed as the Trolox equivalent antioxidant capacity per g of fresh weight (*µmol TE/g FW*).

Data analysis. The data obtained in the research was processed applying the Fisher model of variance analysis (ANOVA, F test) and the statistics software package STATISTICA version 8.0 (StatSoft, Inc., Tulsa, OK, USA, 2007). The analyses were performed in three replications and the obtained values were expressed as the means. Sources of variation were three fertilizers and three strawberry cultivars. Means were compared with the LSD test at $P \leq 0.05$.

Results and Disscusion

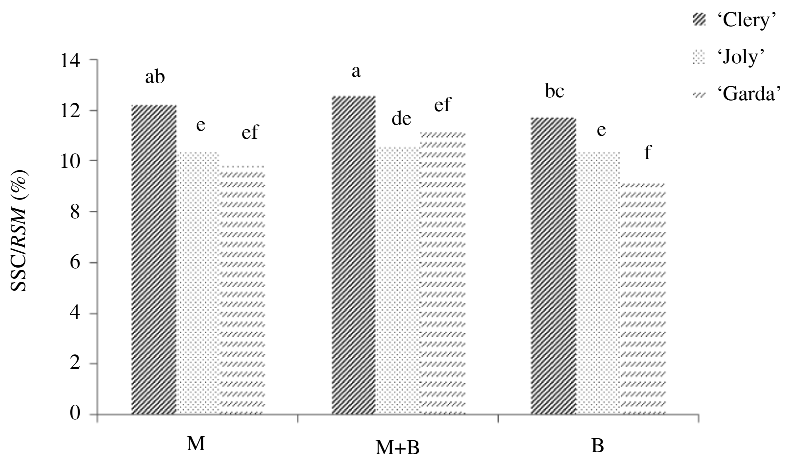
Quality of strawberries depends on their appearance (red colour intensity, fruit size and shape, freedom from defects and decay), firmness and flavour (determined by amounts of sugars, acids, phenols) (Kader, 1991). Fruit size depends on the genotype, ecological factors, cultivation systems, planting age and ripening season. Significant impact of the genotype on the fruit weight was recorded in our research, whereby 'Joly' and 'Garda' (19.5 and 19.8 *g*, respectively) had significantly higher fruit weight compared to the 'Clery' (16.2 *g*) (Tab. 1). On the other hand, fruits of 'Garda' also had a significantly higher fruit firmness (18.3 *N*) compared to the other two cultivars tested. Firmness is a trait that directly affects the quality of strawberry fruit and its susceptibility to physical damages as well as suitability for shipping (Treder, 2004).

Consumer acceptance of strawberry fruits depends to a great extent on the fruit's taste, which is closely related to the content of soluble solids (Tulipani et al., 2008). Quantitative variation in the content of soluble solids may be conditioned by the genetic basis, fruit ripening degree, climatic and other factors (Milivojević et al., 2015). In our study, a significant influence of genotype and fertilizer on the soluble solids content has been recorded. Fruits of 'Clery' had the highest content of soluble solids among the tested cultivars (12.2%), while analyzing the impact of fertilizers, it could be noticed significantly higher soluble solids content in a combined treatment with mineral and microbiological fertilizers (11.4%). Michalska et al. (2017) were noted the highest TSS value for cultivar 'Joly' (13.55%) and lower TSS value for 'Clery' (8.13%), compared to our results.

Tab. 1. The influence of the cultivar and fertilizer on fruit weight, firmness and soluble solids in strawberry fruit
Uticaj sorte i đubriva na masu, čvrstinu i sadržaj rastvorljive suve materije u plodu jagode

Factor *Faktor*		Fruit weight *Masa ploda* (*g*)	Firmness *Čvrstina* (*N*)	Soluble solids *Rastvorljiva suva materija* (%)
Cultivar	'Clery'	16.2 ± 0.5 b	12.3 ± 0.5 b	12.2 ± 0.20 a
Sorta	'Joly'	19.5 ± 0.5 a	13.4 ± 0.9 b	10.4 ± 0.01 b
(A)	'Garda'	19.8 ± 0.7 a	18.3 ± 1.1 a	10.0 ± 0.30 b
Fertilizer	M	17.4 ± 0.9 a	11.4 ± 1.1 a	10.8 ± 0.40 b
Đubrivo	M+B	19.0 ± 0.7 a	12.0 ± 0.4 a	11.4 ± 0.40 a
(B)	B	19.1 ± 0.7 a	13.4 ± 0.4 a	10.4 ± 0.40 c
ANOVA				
A		*	*	*
B		ns	ns	*
A × B		ns	ns	*

Mean of 2-year values with three replications in each year ± standard error are presented. Values within each column followed by the same letter are not significantly different at the p ≤ 0.05 by LSD test/*Rezultati su prikazani kao prosečne vrednosti iz dve godine istraživanja sa tri ponavljanja u svakoj godini ± standardna greška. Vrednosti u svakoj koloni koje su praćene istim malim slovima nisu statistički značajno različite prema LSD testu (p ≤ 0,05)*
* – statistically significant differences at P ≤ 0.05/*statistički značajne razlike za p ≤ 0,05;* ns – non significant difference/*nije statistički značajno*



Values are the mean for 2016 and 2017. The different small letters at the top of columns indicate significant differences among each cultivar/fertilizer interaction at P ≤ 0.05 (LSD test)/*Vrednosti su prikazane kao srednje vrednosti za 2016 i 2017 godinu. Različita mala slova na vrhovima kolona ukazuju na značajne razlike između interakcijskih efekata sorta/đubrivo, na P ≤ 0.05 (LSD test)*

Graph 1. Interaction effect of the cultivar/fertilizer on the content of soluble solids (SSC) in strawberry fruit
Graf. 1. Interakcijski efekat sorta/đubrivo na sadržaj rastvorljive suve materije (RSM) u plodu jagode

Influence of the interaction effect cultivar/fertilizer on the content of soluble solids is shown in Graph 1. The obtained results indicate that 'Clery' yielded the highest soluble solids content in all tested fertilizer treatments, whereas 'Joly' contained significantly lower SSC in the treatment with microbial fertilizer compared to the other tested cultivars (Tab. 2).

Sugars represent the largest part of soluble solids and a basic component in the formation of strawberry fruit flavour. The highest content of total (9.20%), in-

Tab. 2. The influence of the cultivar and fertilizer on chemical properties of strawberry fruit
Uticaj sorte i đubriva na hemijske osobine ploda jagode

Factor *Faktor*		TA *UK* (%)	TS *UŠ* (%)	IS *IŠ* (%)	S *SAH* (%)
Cultivar	'Clery'	0.83 ± 0.01 b	9.20 ± 0.18 a	8.66 ± 0.15 a	0.51 ± 0.07 a
Sorta	'Joly'	0.78 ± 0.00 c	6.88 ± 0.10 b	6.31 ± 0.15 b	0.54 ± 0.08 a
(A)	'Garda'	0.99 ± 0.02 a	6.16 ± 0.26 c	5.87 ± 0.25 b	0.32 ± 0.01 b
Fertilizer	M	0.83 ± 0.02 c	7.47 ± 0.57 b	6.85 ± 0.53 b	0.64 ± 0.08 a
Đubrivo	M+B	0.89 ± 0.04 a	7.79 ± 0.36 a	7.37 ± 0.37 a	0.39 ± 0.03 b
(B)	B	0.88 ± 0.04 b	6.98 ± 0.49 c	6.61 ± 0.47 c	0.34 ± 0.02 b
ANOVA					
A		*	*	*	*
B		*	*	*	*
A × B		*	*	*	*

Mean of 2-year values with three replications in each year ± standard error are presented. Values within each column followed by the same letter are not significantly different at the $p \leq 0.05$ by LSD test/*Rezultati su prikazani kao prosečne vrednosti iz dve godine istraživanja sa tri ponavljanja u svakoj godini ± standardna greška. Vrednosti u svakoj koloni koje su praćene istim malim slovima nisu statistički značajno različite prema LSD testu (p ≤ 0,05)*

* – statistically significant differences at $P \leq 0.05$/*statistički značajne razlike za p ≤ 0,05*; ns – non significant difference/*nije statistički značajno*

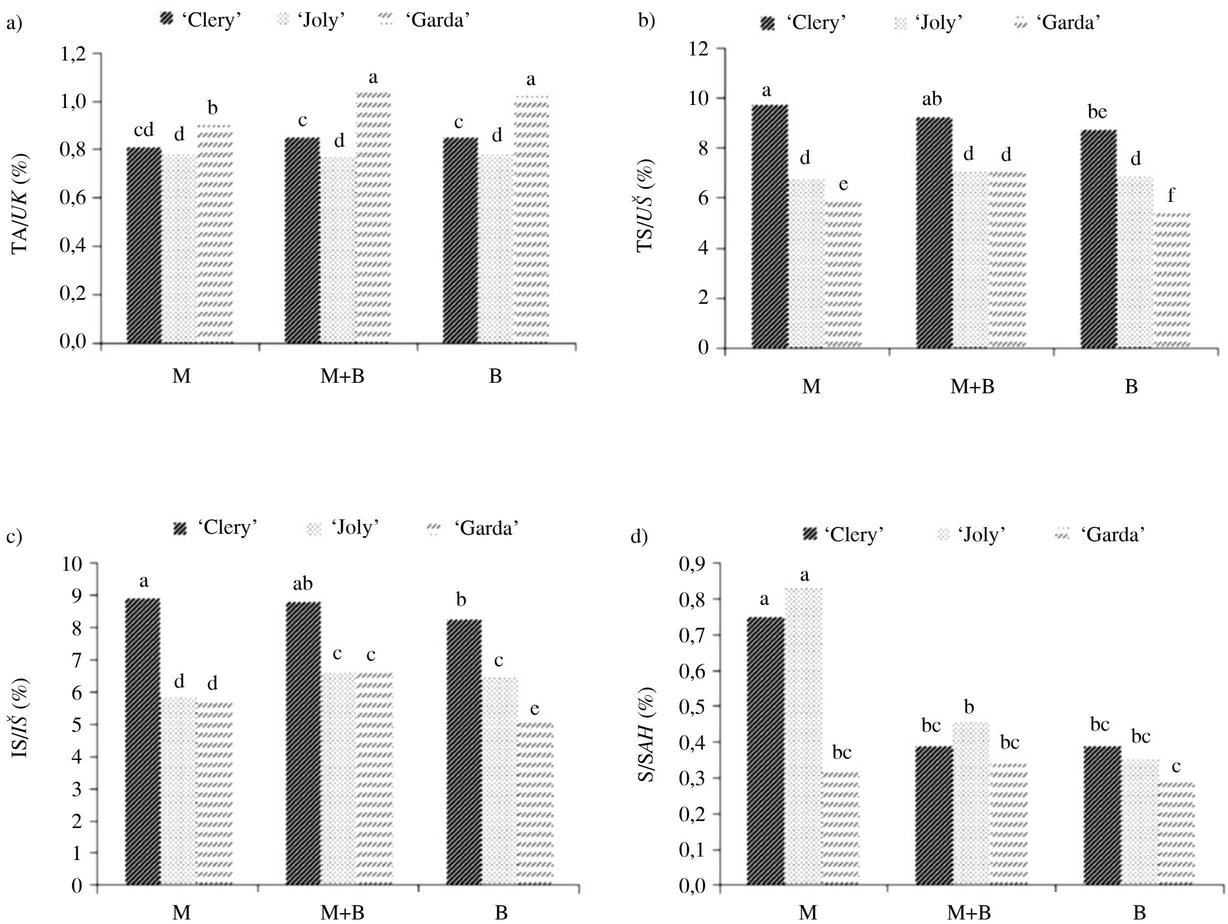
verted sugars (8.66%) and sucrose (0.51%) has been recorded in 'Clery' (Tab. 2). Contrary, Crespo et al., (2010) detected lower level of TS in 'Clery' (4.83%). In the initial stages of fruit development, sucrose is the predominant disaccharide, whereas later, during maturation, sucrose is converted into glucose and fructose, which continues during storage of fruits. Strum et al. (2003) determined the dominant content of glucose and fructose in the fruit of strawberry 'Selva' in relation to sucrose. Additionally, Milivojević et al. (2011) pointed out that fructose is dominant in the structure of total sugars in fruit juice of *Fragaria vesca* L., as well as in two cultivars of garden strawberries; sucrose was detected in small quantites particulary in the fruits of 'Marmolada' and 'Madeleine'. Altogether, glucose, fructose and sucrose account for 99% of total sugar content in strawberries (Nunes et al., 2006).

In all fertilization treatments, 'Clery' had a high content of total sugars and the highest content of invert sugar (Graph 2b). Cultivars 'Clery' and 'Joly' had high sucrose content in treatment with mineral fertilizer (Graph 2d).

Besides sugars, acids represent another important component that participates in the formation of fruit flavour, whereas sugar/acid ratio serves to determine the optimal harvesting time for strawberries (Green, 1971). Acids are also important for the fruit processing because they affect the gelling properties of pectin (Cordenunsi et al., 2002). Fruits of 'Garda' had the highest content of total acids (0.99%) and the lowest sugar content (total sugars, invert sugars and sucrose). The content of TA is in accordance with the study of Michalska et al. (2017). The autors evaluated quality of six strawberry cultivars and detected the same level of TA in fruit of 'Clery' as in our study (0.83%). Variations in organic acid metabolism have been reported for many fruits (Zheng et al., 2009) and several genetic studies have shown that the accumulation of organic acids (i.e., malic acid) is controlled by genes which differ not only between species but also between cultivars (Saradhuldhat & Paull, 2007).

Analyzing the interaction effects, it can be noticed that the highest values of total acids in strawberry fruit were recorded in the interaction of cultivar 'Garda' with mineral and microbiological fertilizers (Graph 2a).

Numerous studies indicate the presence of high concentrations of bioactive substances in strawberry fruit (Manach et al., 2004; Seeram, 2009) and the connection of daily consumption of this fruit and human health. The greatest benefit to human health is attributed to phenolic compounds and vitamin C, due to its antioxidant, anti-carcinogenic, antimutagenic, anti-



Values are the mean for 2016 and 2017. The different small letters at the top of columns indicate significant differences among each fertilizer/cultivar interaction at $P \leq 0.05$ by LSD test/*Vrednosti su prikazane kao srednje vrednosti za 2016 i 2017 godinu. Različita mala slova na vrhu kolona ukazuju na značajne razlike između interakcijskih efekata sorta/đubrivo, na* $P \leq 0.05$ *(LSD test)*

Graph 2. Interaction effect of cultivar/fertilizer on: (a) titratable acidity (TA); (b) total sugars (TS), (c) invert sugars (IS); and (d) sucrose content (S) in strawberry fruit
Graf. 2. Efekat interakcije sorta/đubrivo na sadržaj: (a) ukupnih kiselina (UK); (b) ukupnih šećera (UŠ); (c) invertnih šećera (IŠ); i (d) saharoze (SAH) u plodu jagode

microbial, anti-inflammatory and neuroprotective characteristics (Nile & Park, 2014). Giampieri et al. (2012) stated that vitamin C contributed more than 30% of the total antioxidant capacity of strawberries, followed by anthocyanins, which contributed 25% to 40% of this capacity, with the rest of this capacity contributed by ellagitannins and flavonols.

Earlier conducted studies (Battino & Mezzetti, 2006; Tulipani et al., 2008) have confirmed that genotype has a key role in determining the content of antioxidants in the fruit of strawberry. The results obtained in our study are in agreement with the above stated results, bearing in mind that fruits of 'Joly' expressed about two-fold higher antioxidant capacity in both studied antioxidant tests (29.5 and 30.7 *μmol TE/g FW*) in comparison with the other two cultivars (Tab. 3). In addition to genotype, nutritional value of strawberry depend on many factors, the environment (e.g. temperature, UV-radiation, sunshine duration, soil salinity and nitrogen supply), genotype/environment in-

Tab. 3. The influence of the cultivar and fertilizer on antioxidative capacity of strawberry fruit
Uticaj sorte i đubriva na antioksidativni kapacitet ploda jagode

Factor *Faktor*			DPPH *(μmol TE/g FW)*	ABTS *(μmol TE/g FW)*
Cultivar		'Clery'	17.1 ± 11.8 b	19.4 ± 1.4 b
Sorta		'Joly'	29.5 ± 2.8 a	30.7 ± 0.5 a
(A)		'Garda'	15.9 ± 9.6 b	18.9 ± 1.4 b
Fertilizer		M	20.8 ± 23.0 b	25.3 ± 1.2 a
Đubrivo		M+B	18.4 ± 26.8 c	23.7 ± 2.0 b
(B)		B	23.4 ± 15.9 a	20.0 ± 2.8 c
	'Clery'	M	17.5 ± 3.5 d	24.0 ± 0.3 b
	'Clery'	M+B	12.9 ± 1.9 f	20.0 ± 0.4 cd
	'Clery'	B	20.9 ± 2.9 b	14.2 ± 0.2 e
Cultivar × Fertilizer	'Joly'	M	29.9 ± 1.9 a	29.5 ± 1.0 a
Sorta × Đubrivo	'Joly'	M+B	29.1 ± 7.8 a	31.6 ± 0.7 a
(A × B)	'Joly'	B	29.7 ± 3.6 a	31.0 ± 0.6 a
	'Garda'	M	15.0 ± 1.0 e	22.5 ± 1.4 bc
	'Garda'	M+B	13.3 ± 2.7 f	19.4 ± 0.4 cd
	'Garda'	B	19.6 ± 2.3 c	14.8 ± 2.5 e
ANOVA				
A			*	*
B			*	*
A × B			*	*

Mean of 2-year values with three replications in each year ± standard error are presented. Values within each column followed by the same letter are not significantly different at the $p \leq 0.05$ by LSD test/*Rezultati su prikazani kao prosečne vrednosti iz dve godine istraživanja sa tri ponavljanja u svakoj godini ± standardna greška. Vrednosti u svakoj koloni koje su praćene istim malim slovima nisu statistički značajno različite prema LSD testu (p ≤ 0,05)*

* – statistically significant differences at $P \leq 0.05$/*statistički značajne razlike za p ≤ 0,05*; ns – non significant difference/*nije statistički značajno*

teraction, and also the harvest date (Pelayo-Zaldivar et al., 2005; Capocasa et al., 2008; Cardeñosa et al., 2015; Palmieri et al., 2017). In our research, effect of fertilizer and interaction effect of genotype and fertilizers, significantly increased the antioxidant capacity of strawberry fruit. The multiparametric nature of the antioxidant activity dictates the need of more than one method for the determination (Huang et al., 2005). A positive influence on the antioxidant capacity of the fruit determined by the ABTS test was exhibited by the applied mineral fertilizers, while the microbiological fertilizer showed a positive effect in the DPPH antioxidant test. Interaction effect of the cultivar/fertilizer caused significant differences among the values of antioxidant capacity in cultivars 'Clery' and 'Garda', whereas consistently high antioxidant capacity was recorded in cultivar 'Joly' (Tab. 3).

Conclusion

On the basis of the results obtained in this study, out of the three evaluated cultivars, 'Garda' and 'Joly' can be recommended for further promotion and expansion in strawberry growing regions. 'Garda' characterized by large, very firm fruit and high acids content making this cultivar suitable for fresh and processing markets. In terms of antioxidative content in the fruit, the best results were noted in cultivar 'Joly', which can be recommended to fresh consumption as high nutritional quality strawberry.

Combination of mineral and microbiological fertilizers expressed the positive effect on the content of soluble solids, total acids, total and invert sugars of tested strawberry cultivars. Therefore, a partial substitution of mineral fertilizers by biofertilizers can be recommended in nutrient management of strawberries aiming to improve nutritional fruit quality.

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KVALITET PLODA SORTI JAGODE (*Fragaria ananassa* Duch.) POD UTICAJEM PRIMENE MINERALNIH I MIKROBIOLOŠKIH ĐUBRIVA

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Rezime

U radu su prikazani rezultati dvogodišnjih istraživanja (2016–2017) uticaja sorte i đubriva na kvalitet ploda tri sorte jagode: Clery, Joly i Garda, kako bi se na osnovu dobijenih rezultata dala preporuka za povećanje potrošnje jagode u svežem stanju.

Ogled je postavljen po potpuno slučajnom planu, i proučavan je efekat dva faktora, sorte i đubriva. Primenjena su tri tipa đubriva: M – mineralna đubriva, M+B – kombinacija mineralnih đubriva i mikrobiloškog đubriva, B – mikrobiološko đubrivo. U tretmanu mineralnim đubrivom korišćene su različite formulacije đubriva u skladu sa fenofazama razvoja biljaka, a u kombinovanom tretmanu mineralnim i mikrobiološkim đubrivima primenjene su dvostruko manje količine oba tipa đubriva u odnosu na količine primenjene u samostalnim aplikacijama. Aplicirano mikrobiološko đubrivo bilo je sastavljeno od kombinacije različitih bakterija koje pripadaju rodu *Bacillus*.

Uzorci plodova uzeti u fazi pune zrelosti za analizu mase, čvrstine i sadržaja rastvorljive suve materije, čuvani su na -20°C i korišćeni dalje za ispitivanje hemijskih osobina. Masa ploda je određena merenjem na tehničkoj vagi, čvrstina ploda pomoću penetrometra, a sadržaj rastvorljive suve materije određen je pomoću ručnog refraktometra. Za određivanje ukupnih kiselina i šećera uzorci su najpre homogenizovani i profiltrirani, pa je nakon toga titracijom sa 0,1 N NaOH određen sadržaj ukupnih kiselina (UK), a metodom Luff -Schoorl sadržaj unkupnih (UŠ), invertnih šećera (IŠ) i saharoze (SAH). Merenje antioksidativnog kapaciteta ploda vršeno je pomoću dva testa, DPPH i ABTS.

Značajno veća masa ploda evidentirana je kod sorti Joly i Garda (19,5 *g* i 19,8 *g*) u poređenju sa sortom Clery (16,2 *g*), dok je kod sorte Garda zabeležena i najveća vrednost čvrstine ploda (18,3 *N*). Sorta Clery je imala visok sadržaj rastvorljive suve materije (12,2%), ukupnih i invertnih šećera u plodu (9,20% i 8,66%) u svim tretmanima đubrivima. Značajno viši sadržaj ukupnih kiselina evidentiran je kod sorte Garda (0,99%), dok je sorta Joly imala značajno viši antioksidativni kapacitet ploda (29,5 i 30,7 *μmol TE/g sv.m.plo.*) u poređenju sa ostalim ispitivanim sortama. Takođe, konstantno visok antioksidativni kapacitet ploda zabeležen je kod sorte Joly u svim ispitivanim tretmanima đubrenja.

Sorta Garda se odlikovala krupnim i čvrstim plodovima i visokim sadržajem kiselina, što je čini pogodnom kako za svežu potrošnju tako i za preradu. U pogledu antioksidativnog kapaciteta ploda, najbolje rezultate je pokazala sorta Joly, koja se može preporučiti za potrošnju u svežem stanju kao visokokvalitetna sorta jagode. Sa druge strane, zbog pozitivnog efekta kombinovane primene mineralnog i mikrobiološkog đubriva na sadržaj šećera, može se preporučiti delimična supstitucija mineralnih đubriva mikrobiološkim đubrivima, u cilju unapređenja nutritivnog kvaliteta ploda.

Ključne reči: sorte jagode, đubrivo, masa ploda, šećeri, ukupne kiseline, antioksidativni kapacitet