UDC 631.147:634.711
615.322:634.711
615.279
Acta Agriculturae Serbica, 27 (54), 143–148, 2022
doi: 10.5937/AASer2254143M
Publisher: Faculty of Agronomy Čačak
www.afc.kg.ac.rs

Yield and fruit quality of 'Meeker' raspberry from conventional and organic cultivation systems

Senad Murtić[1*], Jasmin Fazlić[2], Amina Šerbo[1], Mirza Valjevac[1], Imran Muharemović[1], Fahrudin Topčić[1]

[1] *Department of Plant Physiology, Faculty of Agriculture and Food Sciences, University of Sarajevo, Zmaja od Bosne 8, 71000 Sarajevo, Bosnia and Herzegovina*
[2] *Family Farming, Osoje village, 31300 Prijepolje, Serbia*

**Corresponding author: murticsenad@hotmail.com*

Received 31 May 2022; Accepted 25 October 2022

A B S T R A C T

The aim of this study was to compare the yield and fruit quality characteristics of raspberry (*Rubus idaeus* L.) cultivar 'Meeker' grown in organic and conventional cultivation systems. The total soluble solids, titratable acidity, ascorbic acid content, total phenolic and flavonoid contents and total antioxidant capacity of raspberry fruits were assessed. The analyses showed that raspberry yields per cane were significantly higher in the conventional cultivation system. In contrast, fruits from organic farming had higher antioxidant levels. The findings of this study indicated that organic farming in the study region increased raspberry quality, but decreased yield, as compared to conventional farming.

Keywords: productivity, fruit, chemical composition, bioactive compounds

И З В О Д

Циљ овог рада је био упоредити принос и квалитет плода сорте малине Микер гајене у органском и конвенционалном систему производње. Испитивани параметри квалитета плода малине били су: садржај растворљиве суве материје, укупна киселост, садржај витамина Ц, садржај укупних фенола и флавоноида и укупни антиоксидативни капацитет. Резултати анализа су показали да је принос малине по изданку био значајно већи у конвенционалном систему производње. Супротно томе, плодови малине гајене у органском систему производње имали су већи ниво антиоксиданса у себи. Генерални закључак ове студије је да, у условима овог истраживања, органски систем производње повећава квалитет плодова малине сорте Микер, али смањује принос у односу на конвенционални систем производње.

Кључне речи: родност, плод, хемијски састав, биоактивне компоненте

1. Introduction

Plant production is a fundamental aim of both conventional and organic cultivation systems. However, in organic cultivation systems, all agricultural practices aim to maintain the harmonious balance in the environment including the high crop quality; in conventional cultivation systems, all agricultural practices aim to increase yield and labor efficiency (Kobierski et al., 2020). Unfortunately, high-yielding, conventional cultivation systems are often characterized by the intensive application of chemical fertilizers and pesticides, which cause a large pressure on the environment (Kai and Adhikari, 2021).

Environmental issues and the ones related to agricultural exploitation in particular are capturing more and more of the public's attention; therefore, scientists and environmental engineers are aiming at improving environmental quality through the adoption of sustainable and environmentally safe agro-technical practices that have positive effects on soil fertility (Mugandani et al., 2021).

Cultivation system that can be an alternative to conventional farming, without doubt is organic cultivation system, i.e., organic farming. Organic farming is a system of agricultural practices and principles that increase ecosystem health. This system minimizes the use of many inputs associated with conventional farming, most notably chemical fertilizers, pesticides, growth regulators and genetically modified seeds, and therefore, is becoming more and more popular worldwide (Yadav et al., 2013).

Many people buy and eat organic foods because they believe it is better for them, as well as for the environment. Numerous studies have confirmed that organic foods have lower levels of toxic heavy metals, pesticide residues and other unhealthy substances compared to conventional food products (Mie et al., 2017; Gomiero, 2018; Górska-Warsewicz et al., 2021).

Therefore, the demand for organic food products, especially fruits, is growing every year.

Red raspberries (*Rubus idaeus* L.) are increasingly popular fruits, mainly because of its sweet flavor and freshness (Milinković et al., 2021). Moreover, raspberries, especially those from organic cultivation, are rich sources of phenolic compounds and many other substances with antioxidant properties (Fotirić Akšić et al., 2022). It is therefore not surprising that the global raspberry production has increased 80% in the last 10 years (Žbanova, 2018).

Serbia is one of the biggest raspberry producers (Grčak et al., 2019) with approximately 11,041 ha of plantations (Kljajić, 2017). 'Willamette' is a prevailing cultivar in Serbia, followed by 'Meeker' (Nikolić et al., 2008). 'Meeker' is a mid late raspberry cultivar of high productivity. Its berries are large, bright red, firm, aromatic and of good transportability. It is particularly sensitive to *Phytophthora* root rot and has low tolerance to winter injury (Stojanov et al., 2019; Životić et al., 2019).

Considering the steady increase in 'Meeker' raspberry production in Serbia and Bosnia and Herzegovina in recent years, it is important to improve growing technologies for this cultivar. Up to our knowledge, there are no published reports regarding the influence of cultivation systems on the yield and fruit quality characteristics of this raspberry cultivar. Therefore, the aim of this study was to compare the yield and fruit quality characteristics of raspberry (*R. idaeus* L.) cultivar 'Meeker' grown under organic and conventional farming systems.

2. Materials and methods

2.1. Study area and experimental design

The field experiment was conducted during 2021 in a commercial plantation of 'Meeker' raspberry cultivar located in southwestern Serbia (Osoje village, Prijepolje municipality, 480 m above sea level, latitude: 43°20'50'' N, longitude: 19°24'14'' E). The plantation was established in 2015. The experiment was composed of 6 rows, each 20 m long (planting distance was 2.2 m between rows and 0.25 m in the row). Each row was considered as an experimental unit. Accordingly, each cultivation system included three experimental units, with a 2.2 m distance between organic and conventional fields. All data about the operations applied, i.e., the type, dose and application timing of fertilizers, as well as plant protection products are presented in Table 1.

Table 1.
Fertilization and plant protection regime used for conventional and organic raspberry cultivation systems

Cultivation system	Type, dose and timing of fertilizer application	Plant protection
Organic farming	Cow manure – 12 t ha^{-1} (one-time application in February) Bioazot Top – 2 kg ha^{-1} (applied every four weeks during the growing season until mid-harvest)	Cuprablau (fungicide / bactericide) Fitomite (acaricide) Laser (insecticide)
Conventional farming	NPK 7:14:21 – 400 kg ha^{-1} (one-time application in February) KAN (27% N) – 120 kg ha^{-1} (one-time application in March) NPK 8:11:36 –180 kg ha^{-1} (applied in three split doses during the growing season)	Cuprablau (fungicide / bactericide) Calypso 480 SC (insecticide) Confidor 70 WG (insecticide) Abastate (acaricide)

According to the FAO Soil Classification (1998), the soil in the experimental plantation is classified as ranker (humus-silicate soil). This soil develops on silicate rocks or sediments, and is characterized by an umbric horizon.

The soil samples were collected in February 2021, few weeks before the start of the growing season. The chemical analysis of an average soil sample showed that the soil had a slightly acid reaction (pH 5.6), a moderate level of humus (3.1%), a low content of available phosphorus (3.6 mg 100 g^{-1} soil) and a high content of available potassium (32 mg 100 g^{-1} soil). In accordance with these results and the nutrient requirements of raspberry, fertilizer rates were calculated based on plot area for both organic and conventional cultivation system.

In Prijepolje, climate is classified as Dfb (warm-summer humid continental climate) with cold and not so humid winters and warm and humid summers (Kottek et al., 2006).

In sum, the Prijepolje municipality and all Western Serbia have very favorable environmental conditions (soil properties, climate conditions) for raspberry production, which make the Western Serbia region one of the major production areas of red raspberries not only in Serbia but also in Europe.

2.2. Collection, yield estimation and processing of fruit samples

Yield data for each experimental unit were collected by measuring all of the fruits picked from the beginning (24th July) until the end (26th August) of the harvest. Fruits were harvested three times a week and then weighed on an electronic scale (0.01 g accuracy). Yield was expressed as kg per cane.

Sixty healthy fruits were pooled as one replicate from each experimental unit for analytical purposes. The collected fruits were put in plastic bags, transported under refrigerated conditions to the laboratory of the Faculty of Agriculture and Food Sciences, University of Sarajevo, and then stored at -20°C (no more than 1 month) until extraction and analysis.

2.3. Total soluble solids and titratable acidity

Total soluble solids were measured using a PAL-1 digital refractometer (Atago, USA) and expressed as °Brix (ISO, 2003). Titratable acidity was estimated by titrating 10 mL of the raspberry juice against 0.1N NaOH solution using phenolphthalein as indicator (AOAC, 2000) and the results were expressed as g of citric acid per 100 g of fresh mass (%).

2.4. Ascorbic acid content

Ascorbic acid was determined by the 2,6-dichlorophenolindophenol (DCPIP) titration method (AOAC, 2006) as follows: 20 g of fresh raspberry fruit was weighed and homogenized with 20 mL of 1% HCl using a mortar and pestle. The homogenate was filtered through coarse filter paper into a 500 mL volumetric flask and filled to the mark with the oxalic acid. An aliquot of 10 mL was titrated with DCPIP until a light rose pink color persisted for 15 s. The amount of DCPIP required to complete the titration was recorded and this data was used for the calculation of ascorbic acid content, using the formula prescribed by the method. The results were expressed as mg of ascorbic acid per 100 g of fresh mass.

2.5. Preparation of fruit extracts

Prior to the extraction process, all fruit samples were oven-dried at 40°C (3 days), and then ground into fine particles using an electric blender. Thereafter, 1 g of dried and finely ground fruit samples was extracted with 30 mL of 60% ethanol aqueous solution at room temperature for 24 h. After extraction, the obtained extracts were filtered through filter paper into a 50 mL flask and diluted to the mark with extract solution. The prepared extracts were used for the estimation of total phenolics, total flavonoids and total antioxidant activity.

2.6. Total phenolic content

The total phenolic content of fruit extracts was estimated using the Folin-Ciocalteu method (Ough and Amerine, 1988). Briefly, 0.1 mL of extract solution and 6 mL of distilled water were added into a 10 mL volumetric flask. Then, 0.5 mL of Folin-Ciocalteu reagent (previously diluted with distilled water 1:2 v/v) was added and mixed thoroughly. After 10 min, 1.5 mL of 20% sodium carbonate (w/v) was added. Then, the mixture was diluted to the mark with distilled water and incubated in a water bath at 40°C for 30 min. After cooling to room temperature, the absorbance was measured at 765 nm against a reagent blank. Gallic acid was used as the standard for the calibration curve that was plotted at its concentrations in the range of 0–500 mg L^{-1}. Total phenolic content was expressed as mg of gallic acid equivalents (GAE) g^{-1} dry mass.

2.7. Total flavonoid content

The total flavonoid content of fruit extracts was estimated using the aluminum chloride colorimetric method (Zhishen et al., 1999). Briefly, 1 mL of extract solution, 4 mL of distilled water and 0.3 mL 5% $NaNO_2$ was added into a 10 mL volumetric flask. After 5 min, 0.3 mL of 10% $AlCl_3$ and 2 mL of 1 M NaOH was added. Then, the mixture was diluted to the mark with distilled water and incubated at room temperature for 1 h. The absorbance was read at 510 nm against a reagent blank. Catechin was used as the standard for the calibration curve that was plotted at its concentrations in the range of 0–100 mg L^{-1}. Total flavonoid content was expressed as mg of catechin equivalents (C) g^{-1} dry mass.

2.8. Ferric reducing antioxidant power (FRAP) assay

The total antioxidant capacity of fruit extracts was evaluated using the ferric reducing antioxidant power (FRAP) assay (Benzie and Strain, 1996). Briefly, 80 µL extract was mixed with 240 µL distilled and 2080 µL fresh FRAP reagent (FRAP reagent was made by mixing 300 mM acetate buffer , 10 mM 2,4,6-tri(2-pyridyl)-s-triazine and 20 mM $FeCl_3$ in a volume ratio of 10:1:1). Thereafter, the mixture was incubated at 37°C for 15 min in a water bath, after which the absorbance was measured at 595 nm against a reagent blank. $FeSO_4 \times 7 H_2O$ was used as the standard for the calibration curve that was plotted at its concentrations in the range of 0–2000 µmol L^{-1}. Total antioxidant capacity was expressed as µmol Fe^{2+} g^{-1} dry mass.

2.9. Statistical analysis

All experimental measurements were performed in triplicate and the results were expressed as mean values ± standard deviation. A one-way analysis of variance (ANOVA) and the least-significant-difference test (LSD) were performed to evaluate statistical significance between the means using the Microsoft Excel software. Statistical significance was considered at $P < 0.05$.

3. Results

In this study, organically grown raspberries contained significantly higher levels of total soluble solids, total phenolics, total flavonoids, ascorbic acid and total antioxidant capacity than conventionally grown raspberries. On the other hand, raspberry yields were significantly higher in conventional production. No significant differences were found in titratable acidity between organic and conventional raspberry fruits (Tables 2 and 3).

Table 2.
Yield, total soluble solids (TSS) content, titratable acidity (TA) and ascorbic acid (AA) content of 'Meeker' raspberry fruit from two different cultivation systems

Treatment	Yield (kg per cane)	TSS (°Brix)	TA (g 100 g^{-1} FW)	AA (mg 100 g^{-1} FW)
Organic farming	0.40 ± 0.06 b*	12.99 ± 1.5 a	1.37 ± 0.21	30.83 ± 2.2 a
Conventional farming	0.44 ± 0.07 a	11.63 ± 1.7 b	1.45 ± 0.28	24.11 ± 2.6 b
$LSD_{0.05}$	0.035	0.95	-	1.53

* Means followed by different letters indicate significant differences at $P < 0.05$

Table 3.
Total phenolic content (TPC), total flavonoid content (TFC) and total antioxidant capacity (FRAP) of 'Meeker' raspberry fruit from two different cultivation systems

Treatment	TPC (mg g^{-1} DW)	TFC (mg g^{-1} DW)	FRAP (μmol Fe^{2+} g^{-1} DW)
Organic farming	23.71 ± 1.68 a*	7.84 ± 0.59 a	167.35 ± 11.39 a
Conventional farming	21.52 ± 1.23 b	7.37 ± 0.31 b	152.62 ± 2.08 b
$LSD_{0.05}$	1.36	0.43	7.20

* Means followed by different letters indicate significant differences at $P < 0.05$

4. Discussion

Raspberry quality is very complex and includes color, size, shape, taste, texture, nutritional composition and antioxidant properties. There are many factors affecting the nutritional composition and antioxidant properties of raspberry, with cultivation system (soil management, fertilization, pest protection etc.) exerting the most profound effects (Veljković and Glišić, 2008; Skupien et al., 2011).

In this study, the level of total soluble solids was significantly higher in organically grown raspberries. This is highly desirable since soluble solids improve the quality of the fruit by contributing to its flavor and taste. Higher contents of bioactive compounds, i.e., ascorbic acid, total phenolics, and total flavonoids, and, hence, higher values of antioxidant capacity were also found in organically grown raspberry. These results are in line with previous studies (Kazimierczak et al., 2015; Anjos et al. 2020; Hallmann et al., 2020; Copolovici et al., 2021; Ramaiya et al., 2021).

Sarker and Oba (2019) reported that plants tend to produce more bioactive compounds as a protective measure against stress. High concentrations of bioactive compounds in plants are very important for their acclimation and adaptation to stress conditions because most of the bioactive compounds have the ability to neutralize stress-induced reactive oxygen species (Yang et al., 2018; Isah, 2019; Toscano et al., 2019). Thereby, it may be hypothesized that agronomic practices that allow plants to undergo moderate stress, such as the use of organic fertilizers with unbalanced quantities of nutrients, result in products with higher levels of bioactive compounds. The results of this study support this hypothesis.

Plant bioactive compounds are also very important for consumer health. It is well known and scientifically documented that plant bioactive compounds provide protection against many diseases, including diabetes, hypertension and cardiovascular disease (Petrie et al., 2018; Samtiya et al., 2021). Accordingly, issues surrounding food and health are receiving increasing public attention.

In this study, the yield of organically grown raspberry was significantly lower than the yield of conventionally grown raspberry. This is consistent with the results of previous studies (Bodiroga and Sredojević, 2017; Sangiorgio et al., 2021).

The lower productivity of organically grown raspberries is generally associated with sub-optimal agro-climatic conditions, such as drought, nutrient limitation or other constraints that can cause stress in plants (Orsini et al., 2016; Frias-Moreno et al., 2018). Numerous studies have revealed that stress directly affects plant growth and development and leads to a decrease in yield (Earl and Davis, 2003; Fahad et al., 2017).

Unbalanced organic fertilization can also cause stress, and this may be the reason for the lower yield of organically grown raspberries in this study. Namely, nutrients from cow manure and other organic fertilizers are provided more slowly, and are, therefore, made available to the plant under conditions that change from day to day (Quirós et al., 2014). As a result, organically grown plants often face challenges in obtaining an adequate supply of nutrients from fertilizers. Therefore, it is necessary to understand the nutrient status and nutrient release pattern of organic fertilizers before their application (Conti et al., 2014). Unfortunately, most farmers apply organic fertilizers based on the general recommendations, without prior knowledge of their nutrient status or nutrient release pattern.

Ahmad et al. (2016) reported that the application of chemical fertilizers is a better method to sustain high crop yields because the nutrient status and nutrient release pattern in these fertilizers are well-known. Although chemical fertilizers can increase crop yields quickly, they can also reduce soil fertility after a long period of application. Recent studies have indicated that the excessive use of chemical fertilizers cause harmful effects on the soil chemical, physical and biological properties, which lead to the degradation of its natural fertility (Prashar and Shah, 2016; Bonou-zin et al., 2019). From an environmental point of view, organic fertilizers improve soil structure by creating more air space and increasing soil water retention.

Organic fertilizers also improve the soil biochemical processes, including nutrient cycling and bacterial and fungal activity, thus improving soil fertility (Voltr et al., 2021). Therefore, maintaining or increasing organic matter in agricultural soils is of high importance for maintaining soil productivity and ensuring food safety in the future (Stavi et al., 2016).

5. Conclusions

The results of the present study showed that fertilizer management practices have a large impact on the yield and fruit quality of 'Meeker' red raspberry. Compared with the conventional cultivation system, organic farming enhanced the accumulation of antioxidants in raspberry fruits, but decreased yield. Therefore, organic farming practices can be considered an innovative approach to enhancing the fruit quality of raspberry. Moreover, since organic farming protects the environment, it can be expected to expand considerably in the future.

Declaration of competing interest

The authors declare that they have no conflicts of interest that are relevant to the content of this article.

References

Ahmad, A.A., Radovich, T., Hue, N.V., Uyeda, J., Arakaki, A., Cadby, J., Paull, R., Sugano, J., Teves, G. (2016). Use of Organic Fertilizers to Enhance Soil Fertility, Plant Growth, and Yield in a Tropical Environment. In: Larramendy, M.L., Soloneski, S. (Eds.), *Organic Fertilizers: From Basic Concepts to Applied Outcomes*. InTech, Rijeka, pp. 85-108.

Anjos, R., Cosme, F., Gonçalves, A., Nunes, F.M., Vilela, A., Pinto, T. (2020). Effect of agricultural practices, conventional vs organic, on the phytochemical composition of 'Kweli'and 'Tulameen' raspberries (*Rubus idaeus* L.). *Food Chemistry* 328, 126833.

AOAC (2000). Official methods of analysis of the Association of Official Analytical Chemists: 942.15. Fruits and fruit products - Acidity (Titratable) of Fruit Products. Association of Official Analytical Chemists, Arlington.

AOAC (2006). Official methods of analysis of the Association of Official Analytical Chemists: 967.21. Vitamin C in juices and vitamin preparations. Association of Official Analytical Chemists, Arlington.

Benzie, I.F., Strain, J.J. (1996). Ferric reducing ability of plasma (FRAP) as a measure of antioxidant power: The FRAP assay. *Analytical Biochemistry*, 239, 70-76.

Bodiroga, R., Sredojević, Z. (2017). Economic Validity of Organic Raspberry Production as a Challenge for Producers in Bosnia and Herzegovina. Economic Insights Trends and Challenges, 6(1), 5-15.

Bonou-zin, R.D.C., Allali, K., Fadlaoui, A. (2019). Environmental Efficiency of Organic and Conventional Cotton in Benin. *Sustainability,* 11(11), 3044.

Conti, S., Villari, G., Faugno, S., Melchionna, G., Somma, S., Caruso, G. (2014). Effects of organic vs. conventional farming system on yield and quality of strawberry grown as an annual or biennial crop in southern Italy. *Scientia Horticulturae*, 180, 63-71.

Copolovici, L., Lupitu, A., Moisa, C., Taschina, M., Copolovici, D.M. (2021). The Effect of Antagonist Abiotic Stress on Bioactive Compounds from Basil (*Ocimum basilicum*). *Applied Sciences,* 11, 9282.

Earl, H., Davis, R.F. (2003). Effect of drought stress on leaf and whole canopy radiation use efficiency and yield of maize. *Agronomy Journal,* 95, 688-696.

Fahad, S., Bajwa, A.A., Nazir, U., Anjum, S.A., Farooq, A., Zohaib, A., Sadia, S., Nasim, W., Adkins, S., Saud, S., Ihsan, M.Z., Alharby, H., Wu, C., Wang, D., Huang, J. (2017). Crop Production under Drought and Heat Stress: Plant Responses and Management Options. *Frontiers in Plant Science,* 8, 1147.

FAO (1998). World Reference Base for Soil Resources. Food and Agriculture Organization of the United Nations, World Soil Resources Report No. 84, Rome, Italy.

Fotirić Akšić, M., Nešović, M., Ćirić, I., Tešić, Ž., Pezo, L., Tosti, T., Gašić, U., Dojčinović, B., Lončar, B., Meland, M. 82022). Chemical Fruit Profiles of Different Raspberry Cultivars Grown in Specific Norwegian Agroclimatic Conditions. *Horticulturae.* 8(9), 765.

Frias-Moreno, M.N., Olivas-Orozco, G.I., Gonzalez-Aguilar, G.A., Benitez-Enriquez, Y.E., Paredes-Alonso, A., Jacobo-Cuellar, J.L., Salas-Salazar, N.A., Ojeda-Barrios, D.L., Parra-Quezada, R.A. (2018). Yield, Quality and Phytochemicals of Organic and Conventional Raspberry Cultivated in Chihuahua, Mexico. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 47(2), 522-530.

Gomiero, T. (2018). Food quality assessment in organic vs. conventional agricultural produce: Findings and issues. *Applied Soil Ecology*, 123, 714-728.

Górska-Warsewicz, H., Zakowska-Biemans, S., Stangierska, D., Swiatkowska, M., Bobola, A., Szlachciuk, J., Czeczotko, M., Krajewski, K., Swistak, E. (2021). Factors Limiting the Development of the Organic Food Sector-Perspective of Processors, Distributors, and Retailers. *Agriculture,* 11, 882.

Grčak, D., Grčak, M., Grčak, D., Đekić, V., Aksić, M., Nikolić, K., Gudžić, S. (2019). The Raspberry – An Analysis of Production in the Republic of Serbia from 2006 to 2016. *Acta Agriculturae Serbica,* 24(47), 19-25.

Hallmann, E., Ponder, A., Aninowski, M., Narangerel, T., Leszczynska, J. (2020). The Interaction between Antioxidants Content and Allergenic Potency of Different Raspberry Cultivars. *Antioxidants,* 9(3), 256.

Isah, T. (2019). Stress and defense responses in plant secondary metabolites production. *Biological Research,* 52(1), 39.

ISO (2003). Fruit and vegetable products - Determination of soluble solids - Refractometric method 2173:2003. International Organization for Standardization, Geneva, Switzerland.

Kai, T., Adhikari, D. (2021). Effect of Organic and Chemical Fertilizer Application on Apple Nutrient Content and Orchard Soil Condition. *Agriculture,* 11(4), 340.

Kazimierczak, R., Hallmann, E., Kowalska, K., Rembiałkowska, E. (2015). Biocompounds content in organic and conventional raspberry fruits. *Acta fytotechnica et zootechnica,* 18, 40-42.

Kljajić, N. (2017). Production and export of raspberry from the Republic of Serbia. *Ekonomika,* 63(2), 45-53.

Kobierski, M., Lemanowicz, J., Wojewódzki, P., Kondratowicz-Maciejewska, K. (2020). The Effect of Organic and Conventional Farming Systems with Different Tillage on Soil Properties and Enzymatic Activity. *Agronomy,* 10(11), 1809.

Kottek, M., Grieser, J., Beck, C., Rudolf, B., Rubel, F. (2006). World map of the Köppen-Geiger climate classification updated. *Meteorologische Zeitschrift,* 15:259-263.

Mie, A., Andersen, H.R., Gunnarsson, S., Kahl, J., Kesse-Guyot, E., Rembiałkowska, E., Quaglio, G., Grandjean, P. (2017). Human health implications of organic food and organic agriculture: a comprehensive review. *Environmental Health*, 16(1), 111.

Milinković, M., Vranić D., Đurić, M., Paunović, S. (2021). Chemical composition of organically and conventionally grown fruits of raspberry (*Rubus idaeus* L.) cv. Willamette. *Acta Agriculturae Serbica,* 26(51), 83-88.

Mugandani, R., Mwadzingeni, L., Mafongoya, P. (2021). Contribution of Conservation Agriculture to Soil Security. *Sustainability,* 13(17), 9857.

Nikolić, M., Ivanović, M., Milenković, S., Milivojević, J., Milutinović, M. (2008). The state and prospects of raspberry production in Serbia. *Acta Horticulturae,* 777, 243-250.

Orsini, F., Maggio, A., Rouphael, Y., De Pascale, S. (2016). 'Physiological quality' of organically grown vegetables. *Scientia Horticulturae,* 208, 131-139.

Ough, C.S., Amerine, M.A. (1988). Methods for analysis of must and wines. John Wiley & Sons, New York.

Petrie, J.R., Guzik, T.J., Touyz, R.M. (2018). Diabetes, Hypertension, and Cardiovascular Disease: Clinical Insights and Vascular Mechanisms. *Canadian Journal of Cardiology,* 34(5), 575-584.

Prashar, P., Shah, S. (2016). Impact of fertilizers and pesticides on soil microflora in agriculture. In: Lichtfouse, E. (ed), *Sustainable Agriculture Reviews. Cham: Springer,* 331-361.

Quirós, R., Villalba, G., Muñoz, P., Font, X., Gabarrell, X. (2014). Environmental and agronomical assessment of three fertilization treatments applied in horticultural open field crops. *Journal of Cleaner Production,* 67, 147-158.

Ramaiya, S.D., Lee, H.H., Xiao, Y.J., Shahbani, N.S., Zakaria, M.H., Bujang, J.S. (2021). Organic cultivation practices enhanced antioxidant activities and secondary metabolites in giant granadilla (*Passiflora quadrangularis* L.). *PLoS One,* 16(7), e0255059.

Samtiya, M., Aluko, R.E., Dhewa, T., Moreno-Rojas, J.M. (2021). Potential Health Benefits of Plant Food-Derived Bioactive Components: An Overview. *Foods (Basel, Switzerland),* 10(4), 839.

Sangiorgio, D., Cellini, A., Spinelli, F., Farneti, B., Khomenko, I., Muzzi, E., Savioli, S., Pastore, C., Rodriguez-Estrada, M.T., Donati, I. (2021). Does Organic Farming Increase Raspberry Quality, Aroma and Beneficial Bacterial Biodiversity? *Microorganisms,* 9(8), 1617.

Sarker, U., Oba, S. (2019). Salinity stress enhances color parameters, bioactive leaf pigments, vitamins, polyphenols, flavonoids and antioxidant activity in selected Amaranthus leafy vegetables. *Journal of the Science of Food and Agriculture,* 99(5), 2275-2284.

Skupien, K., Ochmian, I., Grajkowski, J., Krzywy-Gawrońska, E. (2011).Nutrients, antioxidants, and antioxidant activity of organically and conventionally grown raspberries. *Journal of Applied Botany and Food Quality,* 84(1), 85-89.

Stavi, I., Bel, G., Zaady, E. (2016). Soil functions and ecosystem services in conventional, conservation, and integrated agricultural systems. A review. *Agronomy for Sustainable Development,* 36, 1-12.

Stojanov, D., Milošević, T., Mašković, P., Milošević, N. (2019). Impact of fertilization on the antioxidant activity and mineral composition of red raspberry berries of cv. 'Meeker'. *Mitteilungen Klosterneuburg,* 69, 184-195.

Toscano, S., Trivellini, A., Cocetta, G., Bulgari, R., Francini, A., Romano, D., Ferrante, A. (2019). Effect of Preharvest Abiotic Stresses on the Accumulation of Bioactive Compounds in Horticultural Produce. *Frontiers in Plant Science,* 10, 1212.

Veljković, B., Glišić, I. (2008). An Analysis of Raspberry Production Conditions in Serbia. *Acta Agriculturae Serbica*, 13(25), 9-16.

Voltr, V., Menšík, L., Hlisnikovský, L., Hruška, M., Pokorný, E., Pospíšilová, L. (2021). The Soil Organic Matter in Connection with Soil Properties and Soil Inputs. *Agronomy,* 11, 779.

Yadav, S.K., Babu, S., Yadav, M.K., Singh, K., Yadav, G.S., Pal, S. (2013). A Review of Organic Farming for Sustainable Agriculture in Northern India. *International Journal of Agronomy,* 2013, 718145.

Yang, L., Wen, K.S., Ruan, X., Zhao, Y.X., Wei, F., Wang, Q. (2018). Response of Plant Secondary Metabolites to Environmental Factors. *Molecules,* 23 (4), 762.

Žbanova, E. (2018). Fruit of raspberry *Rubus idaeus* L. as a source of functional ingredients (review). *Food Processing: Techniques and Technology,* 48 (1), 5-14.

Zhishen, J., Mengcheng, T., Jianming, W. (1999). The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals. *Food Chemistry,* 64, 555-559.

Životić, A., Mićić, N., Žabić, M., Bosančić, B., Cvetković, M. (2019). Precision cane meristem management can influence productivity and fruit quality of floricane red raspberry cultivars. *Turkish Journal of Agriculture and Forestry,* 43, 405-413.