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Response of Soil Characteristics and Biochemical Composition of Chokeberry (*Aronia melanocarpa* L.) Fruits to Two Cultivation Systems

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ABSTRACT

Cultivation systems, especially mulching, play an important role in modifying soil properties and have a significant effect on the chemical composition of fruits. Therefore, the purpose of this study was to compare two cultivation systems (black plastic mulch and bare soil) and determine the associated response of soil characteristics and biochemical composition of chokeberry (cv. 'Nero') fruits. Soil properties and fruit phytochemical profile were analyzed using established procedures. Antioxidant activity was determined by several methods and cytotoxic activity was evaluated by MTT (3-[4,5-dimethylthiazol-2-yl]-2,5 diphenyltetrazolium bromide) assay. Results indicated that both cultivation systems caused changes in soil physical, chemical, and biological properties. Black plastic mulch led to a greater decrease in clay fractions and most of the agrochemical properties analyzed, and an increase in the numbers of fungi, compared to bare soil. Moreover, mulch was effective in increasing soil temperature and conserving soil moisture by preventing evaporation. This relationship of soil parameters, especially temperature and moisture, under plastic mulch increased the content of certain bioactive phenolic compounds (condensed tannins, gallotannins, and flavonols) and contributed to the strong antioxidant and cytotoxic activity of chokeberry fruits. In contrast, bare soil favored synthesis of other phenolic compounds (total phenols, flavonoids, anthocyanins, flavan-3-ols and phenolic acids). Principal Component Analysis (PCA) revealed the effect of cultivation systems on the biochemical composition of fruits. Results showed that cultivation systems had a significant influence on soil characteristics in the chokeberry orchard as well as on the biochemical composition of chokeberry fruits, which indicates different pathways of metabolite synthesis under various cultivation practices.

Keywords: Bare soil, Bioactive compounds, Black plastic mulch, Soil properties.

INTRODUCTION

Chokeberry (*Aronia melanocarpa* (Michx.) Elliott) is highly appreciated for its ability to adapt to different growing conditions and its unique fruit biological properties. It can thrive in most soils (sandy, clay, acidic or alkaline soils) with minimum water requirements. The most common cultivation system used in chokeberry plantings is bare soil, while in recent years there has been a tendency to intensify production using different types of mulches, especially plastic mulch. Mulches, especially plastic mulch, increase soil temperature by absorbing high amounts of long-wave radiation, reduce temperature fluctuations, facilitate soil moisture retention by blocking rapid evaporation, and suppress weeds (Pandey *et al*., 2016; Paunović *et al*., 2020; Amare and Desta, 2021).

Over the past few years, chokeberries have become increasingly popular for their superior nutritional value. Specifically, chokeberry fruits are a good source of phenolic compounds, especially anthocyanins, flavanols, phenolic acids and flavonols (Kulling *et al*., 2008), which help

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with many chronic diseases, including cardiovascular diseases, cancers, blood pressure, inflammatory disorders, gastrointestinal and neurological diseases (Bräunlich *et al*., 2013; Parzonko *et al*., 2015). By virtue of their very strong biological activity, chokeberry fruits contribute to the antioxidant, anti-inflammatory, antiviral, antidiabetic, antiproliferative, antimicrobial and anticancer activities (Kokotkiewicz *et al*., 2010; Valcheva-Kuzmanova *et al*., 2013). Many epidemiological studies have focused on the biochemical composition of chokeberry fruit, without examining its quality in response to soil properties under different cultivation systems.

With this in mind, the purpose of this investigation was to compare two cultivation systems (bare soil and black plastic mulch) and evaluate their effect on soil properties and the synthesis of bioactive compounds in chokeberry fruits.

MATERIALS AND METHODS

Experimental Design

The present study was conducted in a chokeberry orchard of the cultivar 'Nero' at the Fruit Research Institute, Western Serbia (latitude 43° 54' N, longitude 20° 21' E, altitude 242 m) in 2018–2020. Two cultivation systems were used: bare soil (no mulch treatment) and black plastic mulch treatment. The experiment was laid out in a randomized block design (2 cultivation systems×3 replications×10 bush), giving a total of 60 chokeberry bushes. The orchard was fertilized in accordance with the local practice using 500 kg ha^{-1} of compound NPK (7-14-21) mineral fertilizer in autumn and 300 kg ha^{-1} of Calcium Ammonium Nitrate (CAN) containing 27% of N_{TOT} (two thirds prior to the growing season and one third at the beginning of June). Soil sampling to determine the agrochemical and microbiological properties was performed before chokeberry orchard establishment and at the end of the experimental period (Table 1). The soil before chokeberry orchard establishment was classified as sandy clay loam; the soil was slightly acid, moderately supplied with humus and N, and had high levels of available P_2O_5 and K_2O. Soil textural classes were determined using the textural triangle method of the WRB.

To assess soil properties, samples were randomly collected from three places in each row in the root system at 0–30 cm depth, composited and air-dried in a ventilated room. Agro-chemical characteristics of soil were determined by the following methods: pH of the H_2O and 1MKCl-in (potentiometrically); humus (by the method of Kotzman); total nitrogen (method according to Kjeldahl); readily accessible phosphorus and potassium (AL method, P_2O_5 - colorimetrically, K_2O - photometrically). Soil textural classes were determined using the textural triangle method of the WRB (2014). The microbiological characteristics of the soil were evaluated by counting Colony Forming Units (CFU) using the serial dilution method on an Appropriate Nutrient Medium

Table 1. Soil properties before chokeberry orchard establishment and at the end of the experimental period.

Soil properties		Soil mechanical properties		Soil agrochemical properties				
		Silt (%) (0.02–0.002 mm)	Clay (%) (< 0.002 mm)	pH	Humus (%)	N (%)	P_2O_5 (mg 100 g^{-1})	K_2O (mg 100 g^{-1})
Before orchard establishment		22.30	24.40	5.83	3.77	0.19	25.95	28.25
At the end of the experimental period	Bare soil	21.10	20.80	5.58	2.89	0.14	23.68	26.17
	Black plastic	25.70	19.60	5.37	3.11	0.15	20.07	24.78

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(MPA medium, Czapek's medium, Krasilnikov's medium, Fyodorov's medium). Soil microbiological properties before the experiment and at the end of the experimental period are presented in Figure 1.

During the experiment, soil temperature and water regime in different cultivation systems at a depth of 0–30 cm were determined at ten-day intervals from May (fruit set) to August (fruit maturation). Soil temperature was determined by a soil temperature gauge (Measurement range: −20 to +50°C) (Figure 2), while soil moisture potential expressed as kPa was measured by a WatermarkTM sensors tensiometer (measurement range from 0 – water saturated soil to 200 – extremely dry) (Figure 4). The temperature and moisture of the soil surface were measured by a P330 thermo-hygrometer (measurement range: −40 to +70°C for temperature and 0–99% for moisture) (Figures 3 and 5, respectively). The mean values of soil temperature and moisture during the three-year experimental period are shown in Figures 2-5.

Preparation of Fruit Samples

Chokeberry fruits were sampled at the end of August in the stage of full ripeness. Approximately 10 g of fruits were extracted with 96% ethanol (100.0 mL) using an ultrasonic bath (model B-220, Branson Instruments, Smith-Kline Co., USA). After extraction, the solvent was removed by a rotary evaporator (Devarot, Slovenia) under vacuum and was dried at 30°C to constant weight. The chemical analysis of the fruits included the following parameters: (1) Total phenolic content was assessed using the Folin–Ciocalteu phenol reagent method (Singleton *et al*., 1999); (2) For the determination of total flavonoid content, the samples were measured using a colorimetric assay (Markham, 1989); (3) Total antioxidant activity was assayed by the phosphomolybdenum method (Prieto *et al*., 1999); (4) The method of precipitation of proanthocyanidins with formaldehyde was used to determine condensed tannins, while gallotannins were measured by the potassium iodate assay, as described by Verrmeris and Nicholson (2006); (5) The concentration of anthocyanins was measured using a single pH and pH differential method; (6) The phenolic compounds were analyzed by HPLC (Agilent Technologies, Santa Clara, CA, USA), as described by Mišan *et al*. (2011); (7) DPPH (2,2-diphenyl-1-picrylhydrazyl) assay was conducted according to Kumarasamy *et al*. (2007); (8) ABTS (2.2-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid) assay was evaluated by Delgado-Andrade *et al*. (2005); (9) Hydroxyl radical peroxidation was performed according to Hinneburg *et al.* (2006); (10) Lipid peroxidation was determined using the thiocyanate method

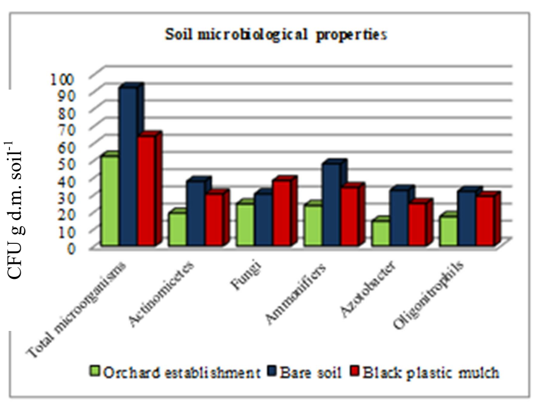

Figure 1. The influence of cultivation systems on soil microbiological properties.

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(Hsu *et al*., 2008), and (11) Cytotoxic activity was evaluated by MTT (3-[4,5-dimethylthiazol-2-yl]-2,5 diphenyltetrazolium bromide) assay (Baviskar *et al*., 2012). The content of polyphenolic compounds was expressed as milligrams per gram of dry extract (mg g^{-1} DW), except for total anthocyanin which was presented as milligrams per gram of fresh weight (mg g^{-1} FW). Antioxidant activity and cytotoxic activity were expressed as IC_{50} values.

Statistical Analysis

Analysis Of Variance (ANOVA, F test) was performed to evaluate the influence of the biochemical composition of chokeberry fruits. Differences between means during the three years of the experiment were compared by LSD test at $P \leq 0.05$ significance levels. Principal Component Analysis (PCA) was applied to investigate relationships between cultivation systems and fruit biochemical composition, using the Statistica 7.0 package (StatSoft, Inc., Tulsa, OK, USA).

RESULTS AND DISCUSSION

After the three-year experiment, in both cultivation systems, there were changes in soil mechanical properties (Table 1). Compared to the soil before chokeberry orchard establishment, bare soil showed a decrease of 3.6% in clay fractions and a decrease of 1.2% in silt, whereas plastic mulch reduced the clay content by 4.8%, but increased the silt content by 3.4%, which favored the formation of more loose and friable soil under mulch. According to Arocena *et al*. (2003) and Inbar *et al*. (2014), an increase in soil temperature causes dehydration of clay in the soil, leading to strong interactions among the clay particles which in turn yield less clay and more silt in the soil. The conclusions of these authors are in agreement with the results obtained in the soil under black plastic, where a higher soil temperature was recorded during the growing season compared to bare soil. However, in both cultivation systems, changes in soil mechanical properties during the experiment did not lead to changes in soil classification.

With regard to soil agrochemical properties, the study demonstrated that cultivation systems significantly influenced the soil pH. At the end of the experimental period, soil pH was lower by 4.28% in bare soil and by 7.89% under plastic mulch. The relatively greater reduction in pH under mulched soil was most likely associated with the decomposition of organic residues and the generation of organic acids due to increased temperature (Dong *et al*., 2015; Pandey *et al*., 2016). Cabilovski *et al*. (2014) found that polyethylene mulch is considerably less gas permeable, which causes higher amounts of CO_2 to remain in the soil and leads to reduce soil pH.

The data shown in Table 1 also revealed a decrease in humus content and N levels in both cultivation systems. Bare soil exhibited a greater reduction in humus content compared to the soil covered with plastic, whereas N content did not differ significantly between the treatments. The contents of humus and N decreased by 23.3% and 26.3%, respectively, under bare soil and by 17.5% and 21.1%, respectively, under plastic mulch, compared to the soil before orchard establishment.

Also, the treatments decreased the content of available P_2O_5 and K_2O. A higher decrease in available P_2O_5 (22.6%) and K_2O (12.3%) was recorded in plastic mulched soil than in bare soil (8.74 and 7.36%, respectively), which is in agreement with the findings of Cuello *et al*. (2015) and Jones *et al*. (2020), who reported a significant reduction in soil nutrients (N, P and K) under plastic mulch. Moreover, Lu and Xu (2014) observed that higher soil temperature under black plastic affects an increase in the rate of nitrogen mineralization through an increase in the decomposition of organic matter in the soil, while Surya *et al*. (2000)

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indicated that higher soil moisture under mulch has significant implications on soil reactions that manage biological nitrogen fixation and nutrient availability.

With respect to microbiological activity, bare soil had a stimulating effect on the numbers of all examined groups of microorganisms, except fungi (Figure 1). The total number of microorganisms was 1.76 times higher in bare soil than in the soil before orchard establishment. The same tendency was observed in the counts of *Azotobacter* (1.71 times) and oligonitrophils (1.85 times), as well as in the populations of actinomycetes and ammonifiers, which increased more than two times (2.24 and 2.02, respectively). Conversely, mulching with plastic was most effective in increasing the number of fungi, which was 1.55 times higher than in the soil before the start of the experiment. These data are consistent with the results of Rickman and Klepper (1980), who observed that mulching creates very favorable conditions for fungal growth and contributes to denitrification by reducing the N content under black plastic.

When bare soil and mulching were compared, lower numbers of all examined groups of microorganisms, except fungi, were determined under plastic mulch, most likely due to high temperatures and higher moisture in mulched soil, confirming the previously established finding by Moreno and Moreno (2008), who reported that plastic mulch results in lower values of soil microbial biomass. Furthermore, numerous studies have reported that plastic mulch blocks organic matter input into the soil, thus negatively affecting the abundance and activity of microorganisms, reducing their many soil benefits (Blouin *et al*., 2013; Jones *et al*., 2020).

In regard to the effect of cultivation systems on soil temperature, the data in Figure 2 reveal a higher soil temperature in the root zone under plastic mulch than in bare soil. Mulching with black plastic increased soil temperature faster, which may be due to the ability of plastic to absorb sunlight and transmit shortwave radiation to deeper soil layers. Also, temperature variations under plastic mulch were lower than in the control treatment. Temperature of the soil under plastic mulch ranged from 17.0 (May) to 22.9°C (August), whereas under bare soil it varied from 14.6 (May) to 19.8°C (August).

At the beginning of the growing season, soil temperature was similar in the two treatments. Starting from May, there was a gradual increase in temperature difference, on average from 1.9 to 4.6°C. The highest temperature difference between bare soil and plastic mulch was recorded throughout July, as the warmest month. During this period, black plastic increased the soil temperature by 4.6 (first ten-day period of July) and 4.2°C (third ten-day period of May). Moreover, a high temperature difference was also observed during the second and third ten-day periods of June (3.7 and 3.9 °C, respectively), while August was characterized by a gradual decrease in soil temperature difference (2.8°C on average). The temperature at the mulch surface was significantly higher than at the bare soil surface (Figure 3). The difference in surface temperature ranged from 2.1 to 5.7°C, the smallest being in May. Thereafter, the increased drying of the soil led to a gradual increase in temperature difference. The largest difference was measured in the second ten-day period in July (5.7°C), and this trend continued in the third ten-day period of July (5.3°C). In the fruit maturation stage at the end of August, the difference in surface temperature was 3.9°C. These results agree with previous studies, in which black plastic mulch had higher thermal conductivity compared to bare soil, resulting in increased temperature in deeper layers of the soil (Pandey *et al*.; 2016; Paunović *et al*., 2020; Liu *et al*., 2021). According to Amare and Desta (2021), plastic mulch directly affects soil temperature and micro-climate around the plant, by modifying the balance between absorbed and reflected radiation transmitted through plastic mulch.

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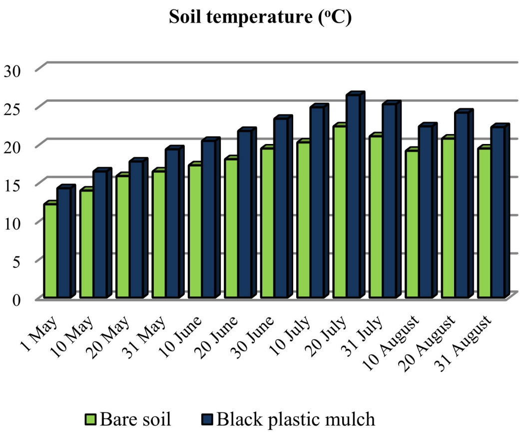

Figure 2. The influence of cultivation systems on soil temperature at 0-30 cm depth.

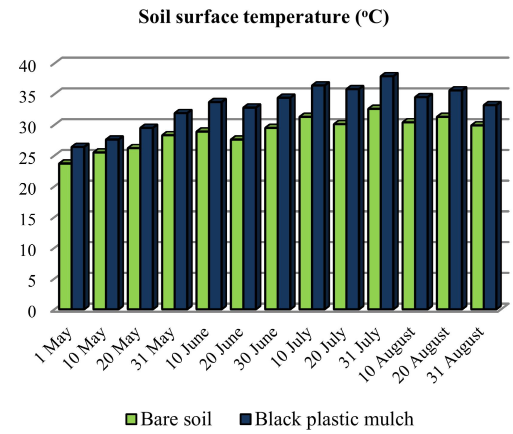

Figure 3. The influence of cultivation systems on soil surface temperature.

The effect of mulch on soil temperature has certain implications for soil moisture, considering that temperature and moisture are dynamic and interdependent variables, as confirmed in our experiment (Figure 4). The presence of mulch helped preserve soil moisture during warmer months compared to bare soil. The present study showed that soil under mulch was adequately wet during May (26.1 kPa) and June (35.8 kPa). Throughout July, as the warmest month, there was a decrease in soil moisture (46.9 kPa on average). Moisture content was lowest in the second ten-day period of July (59.6 kPa), while it gradually increased by 36.2 kPa on average from August. In the same period, the average soil moisture under bare soil varied from 50.6 (May) to 90.5 kPa (August).

The moisture content under bare soil fluctuated more than under plastic mulch. A particularly critical period for plants was the first and second ten-day periods of July (113.7 and 122.5 kPa, respectively) when the soil had an extremely low level of moisture, i.e. about two times lower than the soil under black plastic. However, lower soil moisture was also recorded in August

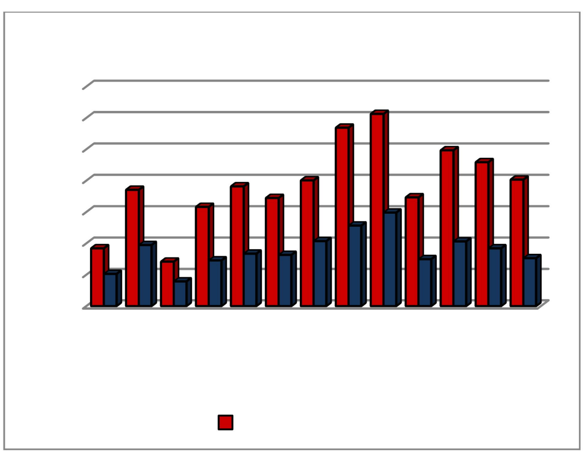

Figure 4. The influence of cultivation systems on soil moisture at 0-30 cm depth

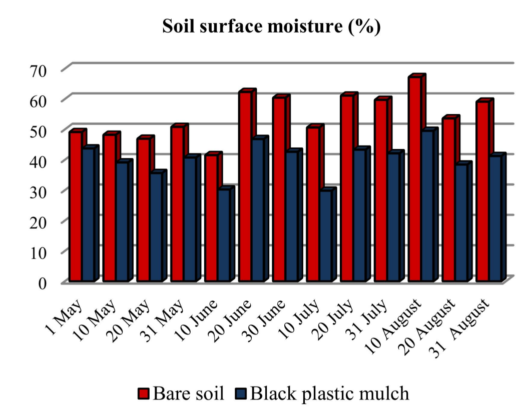

Figure 5. The influence of cultivation systems on soil surface moisture.

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(ranging from 80.6 to 99.3 kPa). Generally, the smallest difference in soil moisture between plastic mulch and bare soil was measured in the first ten-day period of May (16.3 kPa), and the largest in the second ten-day period of July (62.9 kPa). The plants under bare soil needed irrigation from the beginning of May to the end of August, as opposed to the plants under plastic mulch, which underwent a critical period in July. Compared to bare soil, in addition to conserving soil moisture, black plastic contributed to minimize water loss by reducing evaporation from the soil surface and increasing the amount of water stored in the soil profile. Plastic mulch induced lower surface moisture with smaller fluctuations throughout the growing season than the control treatment (Figure 5). During May, the average difference in surface moisture between bare soil and plastic mulch varied from 5.4 to 11.3%. From May, the surface moisture difference increased. The largest difference was recorded in July (18.8% on average), especially in the first ten-day period (20.8%). Throughout the growing season, soil surface moisture under plastic mulch was lower by 14.9% on average compared to bare soil moisture.

Many studies have shown that soil moisture content, infiltration rate, moisture conservation and reduced water evaporation in mulched soil were significantly higher than in the soil without cover (Kuotsu *et al*., 2014; Pandey *et al*.; 2016; Paunović *et al*., 2020).

The effects of cultivation systems were also observed in terms of fruit quality parameters. Soil physicochemical and microbiological properties, especially temperature and moisture relationships, under mulched soil favored the accumulation of condensed tannins, gallotannins and flavonols in chokeberry fruits (Figures 6 and 7).

The contents of condensed tannins and gallotannins were higher by 15.5 and 23.6%, respectively, while the level of flavonols increased by 6.64 (quercetin), 14.1 (myricetin), and 12.7% (kaempferol) compared to bare soil, which indicates that mulch improved the photosynthetic level and accumulation of these compounds in chokeberry. These results can be supported by the findings of Wang *et al*. (2002) and Shiukhy *et al*. (2015), who observed that plastic mulch increased the levels of flavonols, compared to the treatment without mulch. A significantly higher amount of flavonols under black mulch indicates a greater role of elevated temperature and moisture of soil as a catalyst for root activities (Fan *et al.*, 2012; Pandey *et al*., 2016).

In contrast, bare soil had a positive effect on the accumulation of total phenolics,

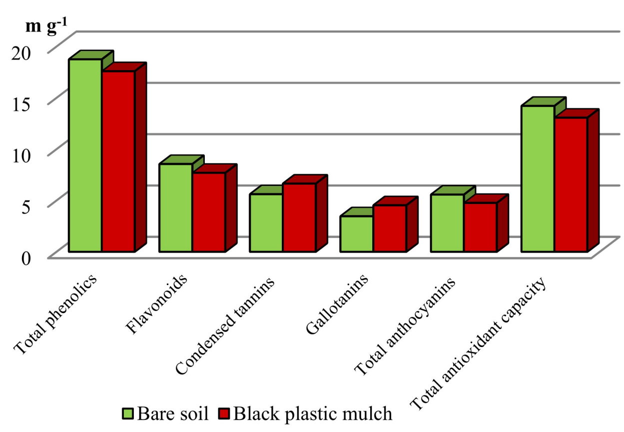

Figure 6. The influence of cultivation systems on the content of polyphenols in chokeberry fruit.

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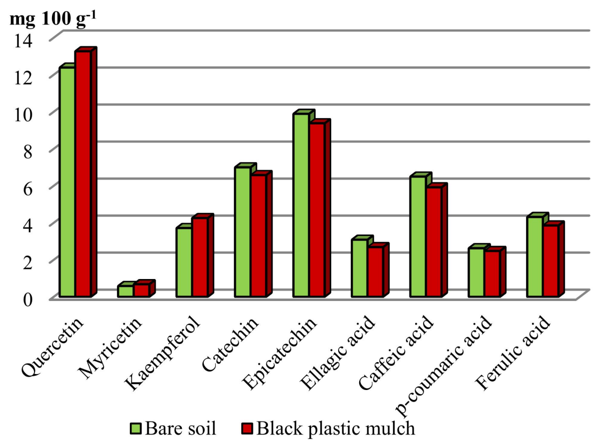

Figure 7. The influence of cultivation systems on the content of flavonols, flavan-3-ols and phenolic acids in chokeberry fruit.

flavonoids, anthocyanins and total antioxidant capacity, which increased by 6.19, 10.1, 14.5 and 8.09%, respectively. Flavonoids accounted for more than 45% of total phenols in chokeberries. The level of caffeic acid as the main phenolic acid was higher by 8.94%, while the amount of dominant flavan-3-ol increased by 5.16% (epicatechin) than plastic mulch. Control treatment had more positive effect on the phenolic compounds analyzed, probably due to lower soil temperature and moisture under bare soil, which favored the synthesis of these compounds. The results are in agreement with the findings of Paunović and Mašković (2020), who observed that lower values of soil temperature and moisture in bare soil were associated with increased levels of phenolics, flavonoids and flavan-3-ols and decreased levels of flavonols, compared to mulch. Also, Melgarejo *et al*. (2012) obtained a higher content of total phenolics in the fruit of plum grown without mulch compared to the treatment with mulch, whereas Wang and Millner (2009) showed that strawberry grown on bare soil had a significantly higher flavonoids content.

Mulching with plastic directly led to an increase in antioxidant and cytotoxic activity of chokeberry fruits, compared to the control. Antioxidant activity (lipid peroxidation, hydroxyl radical, DPPH and ABTS assays) ranged from 38.65 to 62.73 μg mL^{-1}, whereas cytotoxic activity, determined using three different cell lines (Hep2c, RD and L2OB), varied from 14.40 to 37.37 μg mL^{-1} (Table 2).

The results are consistent with the findings of Fan *et al.* (2012), who reported higher antioxidant activity under black plastic, as related to changes in micro-environmental temperature, moisture and soil microflora. In a study by Paunović and Mašković (2020), black plastic induced a high increase in cytotoxic activity, and a decrease in antioxidant activity due to elevated soil temperature and moisture compared to non-mulched treatment. The high antioxidant and cytotoxic activity of chokeberry is mainly attributed to their polyphenolic compounds, including quercetin and caffeic acid, and especially to their high contents of anthocyanins and epicatechin, which are effective in scavenging free radicals.

Principal Component Analysis (PCA) was used to characterize biochemical composition in chokeberry fruits grown under two cultivation systems during three years. Biplot analysis showed a clear separation between bioactive compounds in chokeberry (Figure 8-A). The PCA model

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Table 2. Antioxidant and cytotoxic activity of chokeberry fruit as affected by cultivation systems.[a]

IC_{50} (µg mL^{-1})							
	Antioxidant activity				Cytotoxic activity		
	Lipid peroxidation	Hydroxyl radical	DPPH	ABTS	Hep2 cells	RD cells	L2OB cells
Bare soil	39.59±0.96b	42.89±2.78b	54.35±3.07b	62.73±4.70b	15.55±0.50b	16.20±1.01b	37.37±0.36b
Black plastic	38.65±0.88a	40.44±2.56a	53.41±2.91a	60.88±4.57a	14.40±0.43a	15.53±0.78a	36.32±0.31a

[a] Data represent the means of three replicates±standard error; different letters in each column denote statistically significant differences at P≤ 0.05.

retained two Principal Components (PC), which explained 73.39% of the total variability. The first PC-score (PC1) showed 43.85% of the total variance and had a high contribution in most phenolic acids, all flavonols, epicatechin, anthocyanins and antioxidant activity in the positive direction, and gallotanins and cytotoxic activity in the negative direction. The second PC-score (PC2) contributed 29.54% to the total variance, which was positively related to total phenolics, total antioxidant capacity, catechin, coumaric acid and condensed tannins. As presented in Figure 8B, cultivation systems were discriminated forming three separate clusters depending on the studied year. Cultivation systems in 2017 and 2018 years are well represented in the right part of the factor map, due to their high biochemical composition of fruits. The first group was composed of both cultivation systems in 2018, with a high total antioxidant capacity and total phenolics in chokeberries grown on bare soil, and a high content of condensed tannins in chokeberries grown under black plastic mulch. In 2017, it was observed that fruits grown on the soil mulched with black plastic had higher accumulation of flavonols and a stronger effect on antioxidant activity (lipid peroxidation, hydroxyl radical, DPPH and ABTS), as opposed to the content of total anthocyanins, epicatechin and phenolic acids, which were higher under bare soil. In general, samples from the third group in 2019 showed the lowest contents of bioactive compounds, except chokeberries on plastic mulch, which stood out with a higher content of condensed tannins and greater cytotoxic activity than those under bare soil. Principal Component Analysis confirmed that differences in the nutritional properties of chokeberries were dependent on the cultivation systems, which corresponded to the results described in the section on the biochemical profile of fruits.

CONCLUSIONS

The results of the present research revealed a significant effect of black plastic mulch on the physicochemical and biological properties of the soil. The use of mulch allowed for increased soil temperature and helped conserve water by reducing evaporation from the soil surface, thus a decrease in the need for frequent irrigation during the growing season compared to bare soils. A high soil temperature under plastic mulch caused a decrease in clay fraction and an increase in silt fraction at 0–30 cm depth, which promoted the formation of a loose soil surface. Also, plastic mulch was the most effective in increasing the number of fungi, while it had no stimulating effect on other examined groups of microorganisms, thus contributing to a decrease in soil nutrients. This relationship of physicochemical and microbiological properties of the soil in chokeberries grown under plastic led to an increase in the biosynthesis of some polyphenolics and had a strong influence on the antioxidant and cytotoxic activity of chokeberry fruits. However, due to the interaction between different factors (cultivar, environment, growth locations, etc.), additional research is needed to determine more clearly the effect of plastic mulch on the soil characteristics and biochemical composition of chokeberry fruits.

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واکنش ویژگی‌های خاک و ترکیب بیوشیمیایی میوه های (*Aronia melanocarpa* L. Chokeberry) به دو سامانه کشت

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چکیده

سامانه‌های های کشت به ویژه مالچ پاشی نقش مهمی در اصلاح ویژگی‌های خاک و تأثیر بسزایی در ترکیب شیمیایی میوه ها دارد. بنابراین، هدف از این پژوهش مقایسه دو سامانه کشت (مالچ پلاستیکی سیاه و خاک لخت) و تعیین پاسخ مرتبط با ویژگی‌های خاک و ترکیب بیوشیمیایی میوه‌های chokeberry (cv. 'Nero') بود. ویژگی‌های خاک و مشخصات فیتوشیمیایی (Phytochemical) میوه با استفاده از روش های تعیین شده مورد تجزیه و تحلیل قرار گرفت. فعالیت آنتی اکسیدانی با روش های مختلف و فعالیت سیتوتوکسیک (Cytotoxic) با استفاده از روش MTT ارزیابی شد. نتایج نشان داد که هر دو سامانه کشت باعث تغییر در ویژگی‌های فیزیکی، شیمیایی و بیولوژیکی خاک شدند. مالچ پلاستیکی سیاه منجر به کاهش بیشتر رُس و ویژگی‌های کشاورزی-شیمیایی (Agrochemical) خاک و افزایش تعداد قارچ‌ها در مقایسه با خاک لخت شد. همچنین، مالچ با جلوگیری از تبخیر در افزایش دمای خاک و حفظ رطوبت خاک موثر بود. این رابطه پارامترهای خاک، به ویژه دما و رطوبت، در زیر مالچ پلاستیکی باعث افزایش محتوای برخی از ترکیبات فنلی فعال زیستی (تانن‌های تغلیظ شده، گالوتانن‌ها و فلاونول‌ها) شد و به فعالیت آنتی‌اکسیدانی و سیتوتوکسیک قوی میوه‌های chokeberry کمک کرد. از طرف دیگر، خاک لخت ساخت وسنتز سایر ترکیبات فنلی (فنل کل، فلاونوئیدها، آنتوسیانین ها، فلاوان-۳-اول ها و اسیدهای فنولیک) را ترجیح داد. نیز، تجزیه و تحلیل مؤلفه های اصلی (PCA) اثر سامانه های کشت را بر ترکیب بیوشیمیایی میوه ها نشان داد. نتایج نشان داد که سامانه‌های کشت تأثیر قابل‌توجهی بر ویژگی‌های خاک در باغ chokeberryو همچنین بر ترکیب بیوشیمیایی میوه‌های آن دارند که نشان‌دهنده مسیرهای مختلف سنتز متابولیت‌ها در اثر شیوه‌های مختلف کشت است.

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