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The Determination of Plant Nutrient Content of Blueberies Grown in Different Growing Media[A]

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Abstract: The aim of this study was to determine changes in the fruit nutrient content of 10 different blueberry varieties commonly grown in various regions using 3 different growing media (soil (Media 1), peat (Media 2) and commercial cocopeat (Pellemix) (Media 3). In the study, 2-year-old seedlings of Bluegrop, Bluegold, Bluejay, Chandler, Darrow, Duke, Jubilee, Patriot, Brigitta and Elliott varieties were used as well as the yield and mineral nutrient content of berry samples. The study was conducted between 2021 and 2023. According to the results obtained; It was determined that the average yield varied between 561.8 g and 1386.6 g depending on the difference in variety. Blueberry fruits contain the most nitrogen and potassium. Nitrogen content of berries was 80.6 to 221.7 mg 100 g^{-1}, phosphorus content was 16.9 to 25.9 mg 100 g^{-1}, potassium content was 50.3 to 76.5 mg 100 g^{-1}, Ca content was 10.41 to 22.01 mg 100 g^{-1}, Mg content was 5.11 to 10.03 mg 100 g^{-1}, Na content was 2.32 to 7.67 mg 100 g^{-1}, Fe content was 0.390 to 0.592 mg 100 g^{-1}, Mn content was 0.161 to 0.503 mg 100 g^{-1}, Cu content was 0.067 to 0.349 mg 100 g^{-1}, Zn content was 0.166 to 0.329 mg 100 g^{-1}, B content varied between 0.032 and 0.109 mg 100 g^{-1}. Considering the yield and plant nutrient content obtained in the study, it was seen that the organic growing media evaluated as Media 2 gave the best results. Differences of the varieties were evaluated in relation to variety characteristics.

Keywords: Blueberry, growing media, plant nutrients, yield

[A] The study does not require approval from an ethics committee. The article has been prepared according to research and publication ethics.

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Introduction

Blueberry is the general title given to blue-colored fruits, in shrub form, that sheds its leaves in winter. When cultivated in perennial culture, it grows to 2-7 m tall, but when it is cultivated, it is allowed to grow between 1 and 3 m at low height, has a floating root structure and belongs to the rabbiteye blueberry species (Çelik, 2012).

Blueberry fruits are rich in vitamins with high antioxidant activity, anthocyanins and other phenolic compounds such as flavonols, chlorogenic acid and procyanidins (Kalt et al., 2020). The Food and Agriculture Organization (FAO) has confirmed that blueberries are one of the five healthiest foods for humans (Li et al., 2018; Ferron Carrillo et al., 2022). More than half of the total polyphenol content of blueberries is anthocyanins (Kuntz et al., 2017). The anthocyanins responsible for the formation of blue color in blueberries include delphinidin, malvidin, petunidin and peonidin (Pertuzatti et al., 2016). Blueberry fruits contain anticancer, antioxidant, anti-inflammation, anti-obesity and anti-diabetic activities (Jiao et al., 2019). For instance, they are reported to be used in inhibiting the growth of various human cancer cells, including breast, cervical, colon and prostate cancer (Morazzoni et al., 1986; Kalt et al., 2007; Howell, 2009; Folmer et al., 2014). In particular, phenolic compounds that provide health benefits and high antioxidant activity give blueberries the title of a functional food (Milivojević et al., 2016).

Approximately 79% of blueberry production in the world is carried out in America and 20% in Europe (FAO, 2022). Although blueberries grow in the wild in Turkiye, their cultivation has been increasing with the growing commercial importance of blueberries, especially with the development of the soilless production model in recent years. In 2022, 2496 tons of production was achieved in an area of 4197 decares (TUIK, 2023).

The selection of suitable varieties for blueberry cultivation is also important for both cultivation and the market. Studies have been carried out to determine suitable cultivars, cultivar characteristics, and the adaptation of blueberry plants, which have started to be cultivated in different regions (Çelik, 2008; Paprstein et al., 2009; Starst et al., 2009; Ateş, 2011). Morphological and polymorphological characteristics of the varieties were evaluated in the conducted studies (Islam et al., 2019; Pepe et al., 2023).

Blueberry plant varieties require light textured, well drained, sandy-loamy or loamy-silty, strongly acidic soils (pH between 4.2 and 5.5) containing at least 3% organic matter. The most important factor limiting cultivation is soil acidity. Their ability to grow in strongly acidic soils and their need for a temperate or hot climate prevent the cultivation and increase in production areas of these plants in our country and in the world (Çelik, 2012; Pritts and Hancock, 1992).

Recently, studies have been conducted on the characteristics and selection of blueberry growing media (Black and Zimmerman, 2002; Richardson, 2012; Townsend and Robbins, 2010; Ochmian et al., 2010; Eldik, 2015; Kingston et al., 2017; Wang et al., 2017).

However, they need to be able to grow in strongly acidic soils, require a temperate or warm climate, the plants in bush form, the root zone should be constantly moist, not be under excessive water, the soil should be rich in organic matter and the air humidity should be high (Çelik and Seyidoğlu, 2019). These special requirements of blueberries can be overcome by growing them in a soilless culture, that is, in pots. By using special acidic peat in pots, blueberries, which are met with irrigation, fertilization, and other requirements with automatic systems, can be grown both in the open and in greenhouses and pots. Peat is the most important growing medium, whether used alone or mixed with other materials in pots (Schmilewski, 1992). Examples of media used in pots include low pH peat moss, sawdust or conifer sawdust (Ochmian et al., 2010), ground pine bark (Krewer et al., 2002; Mejia et al., 2017; Nicolas et al., 2016), coal ash, compost, and leaf compost or a mixture of materials such as coconut husks and perlite (Black and Zimmerman, 2002). Ready-made blueberry growing media are also commercially available.

With the importance given to the cultivation of blueberries, the product is cultivated both in organic environments and soil conditions. In this study, 10 different varieties that are widely cultivated were taken into consideration, and cultivation was carried out on two organic substrates and a soil with suitable soil properties, and the differences in nutrient content, especially yield, were determined depending on the differences in the growing media.

Materials and Methods

Growing Media

Some physical and chemical properties of the soil and organic growing media used in the study are given in Table 1.

Table 1. Some physical and chemical analysis results of the growing media

	Media 1	**Media 2**	**Media 3**
pH	6.4	6.25	4.41
EC (µmhos/cm)	36.5	439.0	870.0
Lime (%)	0.44		
Texture	Loam		
Organic matter (%)	2.59	78.1	90.8
Total N, %	0.161	0.43	0.76
C:N ratio		109.2	119.5
Water retention capacity		104.9	44.19
Plant-available P (mg kg^{-1})	27.8	36.27	334.1
Exc. K (mg kg^{-1})	255.0	2351	1299
Exc. Na (mg kg^{-1})	107.0	474.6	129.1
Exc. Ca(mg kg^{-1})	6552	1688	3435
Exc. Mg (mg kg^{-1})	498.0	457.0	1309
Available Fe (mg kg^{-1})	16.3	4.25	31.03
Available Cu (mg kg^{-1})	0.34	2.25	0.90
Available Zn (mg kg^{-1})	0.84	7.00	1.90
Available Mn (mg kg^{-1})	12.8	8.60	4.59

Within the scope of the study, soil taken from the region where blueberry cultivation had started was used as the growing medium (Media 1). Two organic media were used in the study. In the study, 60% peat + 15% perlite and 25% cocopeat (Media 2) and 100% cocopeat (Pellemix), which was structured in different sizes by physically treated and widely used in blueberry production (Media 3) were used.

Plant Materials

In the study, 10 different blueberry varieties provided by the seedling producer company (Safir Berry) were used. Seedling varieties that were 2 years old were used in the experiment. The varieties used in the study and their general characteristics are given in Table 2. Seedlings of equal size and form were used.

Table 2. Blueberry varieties used in the experiment and their general characteristics (Çelik, 2023)

Varieties	Berry size	Chilling requirement (hour)	Growing habit	Fruit color	Harvest time	Taste
Bluegrop	Large	800-1000	Upright and strong	Light blue	Early-Mid	Very good
Bluegold	Large	800-1000	Upright	Sky blue	Early-Mid	Very good
Bluejay	Medium	1000	Upright and strong	Light blue	Mid-Early	Good
Chandler	Very large	1000	Widespread and strong	Light blue	Mid-Late	Good
Darrow	Very large	1000	Upright and strong	Light blue	Late	Very good
Duke	Medium	800-1000	Medium widespread and strong	Sky blue	Early	Good
Jubilee	Medium	500	Upright and strong	Sky blue	Middle	Good
Patriot	Large	1000	Widespread and strong	Dark blue	Early	Very good
Brigitta	Large	-	Upright and strong	Light blue	Mid-Late	Very good
Elliott	Medium	1000	Upright and strong	Light blue	Late	Sourish

Greenhouse Experiment

The study was conducted between 2021 and 2023. The greenhouse study was carried out in a 150 m^2 heated glass greenhouse in the Department of Soil Science and Plant Nutrition at Bursa Uludağ University. The study was established in 3 replications. There were 120 seedlings in the experiment. Drained plastic pots with a volume of 25 liters were used in the study. Elemental powder S (200 kg da^{-1}) was used 6 months before planting to bring the pH value of the soil media to the desired level. The amount of S to be used was calculated considering the soil pH and texture (Karimizarchi et al., 2016).

The optimum pH range for blueberry plant growth was reported to be 4.2-5.0 (Çelik, 2008). It was aimed to maintain the pH values between these values during the study. In this context, bringing and maintaining the pH value to the optimum level in organic growing media was ensured by the fertilization program that was applied. The lowest and highest pH and EC values are given in Table 3.

Table 3. The lowest and highest pH and EC values determined periodically in the media

Media	pH		EC, mS cm^{-1}	
	The lowest	The highest	The lowest	The highest
Media 1	4.57	5.88	1.59	4.16
Media 2	2.51	5.53	0.75	3.58
Media 3	3.03	4.43	0.58	3.33

Irrigation and Fertilization

During the study, the irrigation program was created by calculating the field capacity and water retention capacity of the media with an automatic irrigation system. Irrigation treatment; irrigation frequency and the amount of water to be applied were made with an automatic irrigation system that controlled the moisture levels of the growing media. The required nutrients were disolved in water and then supplied by drip irrigation system or foliar application. The irrigation program varied between once every 2 days for 4 minutes, and 3 times a day for 4 minutes depending on the growing season and climate. HNO_3 and H_3PO_4 were used to reduce the pH of the growing media. Water soluble fertilizers were used. Nitrogen was applied in ammonium and nitrate forms. Potassium nitrate, monoammonium phosphate, monopotassium phosphate, magnesium sulphate, calcium nitrate fertilizers were used. Microelements were applied in EDTA form.

Harvesting

In the second year of the study, harvesting started when the blueberry plants reached maturity. In the manual harvest, the fruits collected from each pot were weighed on a scale and recorded. During this process, manual harvesting was done at 5 different times. The first harvest was on June 20, 2023 and the last harvest was on August 15, 2023. The blueberry harvest is between June and September, with peak picking times usually being in July and August. When blueberries are planted, the variety that are picked and the climate when they are picked affect when the berries ripen. The color of the berry plays an important role in making sure that blueberries are picked at the right time. Because not all berries on a bush ripen at the same time, there is a second factor that ensures that blueberries are picked at the perfect time. First, the entire berry should be blue, and second, the blueberries should come off the bush easily.

Plant Nutrient Analysis in Fruit Samples

Fresh samples were homogenized and stored in deep filler and the following analyses were performed after the harvest period. Nitrogen content in fruit samples was determined by a modified Kjeldahl method. The samples burned in a Velp Scientifica DK8 incineration block were distilled in a Velp Scientifica UDK129 model steam distillation device (Bremner, 1965). The homogenized fresh samples were digested in a Multiwave 5000 50Hz microwave oven using HNO_3 and H_2O_2 and the extract obtained was analyzed for P, K, Ca, Mg, Na and available microelements (Cu, Fe, Mn, Zn and B) using an Agilent 5800VDV ICP-OES Spect model ICP OES.

Statistical Analysis

Analysis of variance of the obtained data was performed with the JMP 7 package program. The experiment was established and conducted according to the randomized block design with 3 replications. An LSD test ($p<0.05$; $p<0.01$) was used to compare the differences between the means.

Results and Discussion

Within the scope of the study, when the yield values obtained at the end of the development period of three different growing media and 10 different blueberry varieties were examined; the yield amounts per plant varied between 88.7 g and 1362.5 g (Table 4). According to the medium characteristics, the lowest yield was determined in Media

1 (175.6 g plant^{-1}) and the highest yield per plant was determined in Media 2 (844.8 g plant^{-1}). Depending on the cultivar characteristics, the lowest yield per plant was 283.7 g plant^{-1} in the Duke cultivar and the highest was 563.4 g plant^{-1} in the Chander cultivar. Yields obtained in Media 2 and 3, which were of organic origin, were determined to be higher than the soil media. It is thought that the low yield values in Media 1 may be related to adaptation due to the drying out in the first year and replanting in the soil considered as Media 1.

Çelik and İslam (2010) used eight different blueberry varieties (Toro, Brigitta, Darrow, Patriot, Bluecrop, Bluegold, Chandler and Bluejay) and obtained the highest yield per plant from the Brigitta and Bluegold varieties with 1569.63 g plant^{-1} and 1407.94 g plant^{-1}, respectively, while the lowest yield was obtained from the Chandler variety with 693.35 g plant^{-1}. Akbulut et al. (2013) reported that yield values per plant varied between 87.1 g and 1915 g, depending on the varieties. Starast et al. (2009) reported that the highest yield per plant belonged to the Bluecrop variety, while the yield of the Northblue variety was the lowest in their study conducted with 18 blueberry varieties. It is thought that the yield differences between the studies may be due to the age of the plant, the environment in which it is grown, fertilization practices, and variety characteristics. Aslan (2019) reported that the yield values per plant of blueberry varieties were the highest in the Brigitta and Bluecrop varieties with 5.027 kg and 4.409 kg, respectively, and the lowest in the Jersey and Bluegold varieties with 1.649 kg and 2.310 kg, respectively.

In the evaluation of the nutrient contents of fruit samples, the nutrient values contained in 100 g of fresh fruit per day for adults are generally taken into consideration, and the nutrient values in fresh fruit samples were evaluated by comparing them with the limit values.

Table 4. Yield value and nitrogen contents of fruit samples depending on varieties

Varieties	**Yield, g plant^{-1}**				**N, mg 100 g^{-1}**			
	Media 1	Media 2	Media 3	**Means**	Media 1	Media 2	Media 3	**Means**
Blue Crop	109.4 mn**	985.2 bc	374.6 h-i	**390.0 BCD***	304.3 ab**	143.2 h-k	61.3 m-p	**269.6 B****
Blue Gold	118.3 lmn	798.3 b-e	466.6 g-j	**368.8 CD**	322.1 a	31.1 op	21.9 p	**125.0 C**
Blue Joy	88.7 n	793.2 b-e	313.9 i-n	**323.3 CD**	203.3 d-h	23.8 p	14.7 p	**80.6 D**
Brigitta	107 mn	834.5 bcd	247.3 j-n	**319.2 CD**	185.8 e-ı	73.1 l-p	116.0 j-m	**129.9 C**
Chander	128.9 k-n	1362.5 a	663.6 d-g	**563.4 A**	248.4 b-e	63.5 l-p	38.6 nop	**116.9 CD**
Darrow	153 k-n	732.5 c-f	522.2 f-i	**378.4 CD**	199.0 d-h	92.3 k-o	95.0 k-n	**128.8 C**
Duke	177 k-n	541.8 e-i	329.2 i-n	**283.7 D**	227.5 c-g	73.4 l-p	146.9 h-k	**149.3 BC**
Elliot	256.3 k-n	1046.3 b	673 d-g	**515.7 AB**	280.2 abc	76.5 l-p	65.8 l-p	**140.8 BC**
Jubilee	367.3 h-m	725.4 c-g	388.7 h-k	**394.5 BCD**	232.8 c-f	261.9 a-d	170.4 f-j	**221.7 A**
Patriot	249.8 j-n	627.9 d-h	712 d-g	**430.7 BC**	159.7 hij	125.6 i-l	166.3 g-j	**150.5 BC**
Means	**175.6 C**	**844.8 A**	**469.1 B**		**236.3 A****	**236.2 A**	**96.4 B**	
	LSD $_{Medium}$: 36.82 LSD $_{Variety}$: 177.24 LSD $_{Medium\ x\ Variety}$: 306.8				LSD $_{Medium}$: 20.17 LSD $_{Variety}$: 36.80 LSD $_{Medium\ x\ Variety}$: 63.77			
Small letters were used in comparing medium x varieties of interaction, Capital letters were used in comparing the means, The significance was also reported for the following levels: *p<0.05, **p<0.01								

Nitrogen content of blueberry fruits varied between 14.79 mg and 322.1 mg 100 g^{-1}. Depending on the medium characteristics, the lowest average N content was determined in Media 3 (96.4 mg 100 g^{-1}) and the highest in Media 1 and 2 (236.2 and 236.3 mg 100 g^{-1}). Depending on the cultivar characteristics, the mean N contents varied from the lowest Bluejay (80.6 mg 100 g^{-1}) to the highest Jubilee (221.7 mg 100 g^{-1}). Karlsons et al. (2018) reported that nitrogen content in blueberry fruits varied between 67.5 and 150.0 mg 100 g^{-1}. The high nitrogen content in fruits grown in soil conditions (Media 1) may be related to the increase in nitrogen content of soils and plant uptake due to the lack of drainage conditions. The presence of drainage conditions in organic environments and the ambient N concentration causes the N concentration to remain at lower levels. In addition, blueberries lack root hairs and absorb ammonium-N more efficiently than nitrate N (Throop and Hanson, 1998).

The differences in the phosphorus and potassium content of the fruit due to differences in growth environment and cultivar were found to be statistically significant ($p<0.01$) (Table 5). Phosphorus content of blueberry fruits varied between 12.0 mg and 34.99 mg 100 g^{-1}. Depending on the medium characteristics, the average phosphorus content varied from the lowest in Media 3 (16.71 mg 100 g^{-1}) to the highest in Media 1 (25.52 mg 100 g^{-1}). Depending on the variety characteristics, the average phosphorus content was lowest in the Duke and Brigitta varieties (16.9 and 17.1 mg 100 g^{-1}) and highest in Jubilee (25.9 mg 100 g^{-1}). Karlsons et al. (2018) reported that phosphorus content in blueberry fruits varied between 6.8 and 36.4 mg 100 g^{-1} depending on variety characteristics. It is seen that the phosphorus content of the fruits, depending on the variety difference, is compatible with the fresh fruit content values reported by the researcher. Especially, the high P content of the fruits in the soil environment may be related to the increase in the P content of the soils and plant uptake due to the applications made due to the lack of drainage conditions. This situation can be explained by the low yield and fruit weight per plant and high P content per unit.

Potassium content of fresh blueberry fruits varied between 25.5 mg and 151.4 mg 100 g^{-1}. Depending on the medium characteristics, the average potassium content varied from the lowest in Media 2 (38.2 mg 100 g^{-1}) to the highest in Media 1 (113.1 mg 100 g^{-1}). Depending on the cultivar characteristics, the average potassium content was lowest in the Duke cultivar (50.3 mg) and highest in the Bluegold cultivar (76.5 mg 100 g^{-1}). Karlsons et al. (2018) reported that the potassium content of blueberry fruits varied between 60.0 mg and 180.5 mg 100 $g^{-1,}$ depending on variety characteristics. It is seen that the potassium content of the fruits, depending on the variety difference, is compatible with the fresh fruit content values reported by the researcher. Ekholm et al. (2007) reported that fruit K content varied between 12.65 and 88.5 mg 100 g^{-1} in their study.

The differences in calcium (Ca) and magnesium (Mg) content of blueberry fruits were found to be statistically significant ($p<0.01$) (Table 6). The Ca content of fresh blueberry fruits varied between 8.30 mg and 30.74 mg 100 g^{-1}. Depending on the medium characteristics, the average Ca content varied from the lowest in Media 1 (15.31 mg 100 g^{-1}) to the highest in Media 2 (18.11 mg 100 g^{-1}). Depending on the cultivar characteristics, the average Ca content was lowest in the Brigitta cultivar (10.41 mg) and highest in the Elliot cultivar (22.01 mg 100 g^{-1}). Karlsons et al. (2018) reported that Ca content in blueberry fruits varied between 6.6 mg and 51.6 mg 100 g^{-1} depending on variety characteristics. It is seen that the Ca content of the fruits depending on the variety difference is compatible with the fresh fruit content values reported by the researcher. García-Rubio et al. (2018) reported that the average Ca content of fresh blueberry fruit was 6 mg 100 g^{-1}. Calcium is the plant nutrient most frequently associated with fruit quality, in general, and firmness in particular (Sams, 1999; Stückrath et al., 2008).

The Mg content of fresh blueberry fruits varied between 3.32 mg and 11.48 mg 100 g^{-1}. Depending on the medium characteristics, the lowest average Mg content was determined in Media 3 (6.51 mg 100 g^{-1}) and the highest in Media 1 (10.34 mg 100 g^{-1}). Depending on the cultivar characteristics, the lowest mean Mg content was determined in the Brigitta cultivar (5.11 mg 100 g^{-1}) and the highest in the Jubilee cultivar (10.03 mg 100 g^{-1}). Karlsons et al. (2018) reported that the Mg content in blueberry fruits varied between 4.5 mg and 28.5 mg 100 g^{-1} depending on variety characteristics. It is noted that the Mg content of the fruits, depending on the variety difference, is compatible with the fresh fruit content values reported by the researcher. Ríos de Souza et al. (2014) reported that the average Mg content of fresh blueberry fruits ranged from 4.92 mg 100 g^{-1}, García-Rubio et al. (2018) reported 6 mg 100 g^{-1} and Ekholm et al. (2007) reported that it varied between 6.32 mg and 16.4 mg 100 g^{-1}. Skupien (2004) reported that fresh fruit Mg content varied between 0.16-0.18 g kg^{-1}.

Table 5. P and K contents of fruit samples depending on varieties

Varieties	P, mg 100 g^{-1}				K, mg 100 g^{-1}			
	Media 1	Media 2	Media 3	Means	Media 1	Media 2	Media 3	Means
Blue Crop	23.53 d**	16.88 g-j	17.64 fgh	**19.4 CD****	104.5 d**	42.8 hij	46.0 ghi	**64.4 D****
Blue Gold	29.11 b	17.54 ghı	16.97 g-j	**21.3 B**	149.0 a	34.6 klm	46.0 ghi	**76.5 A**
Blue Joy	23.93 d	14.40 kl	16.14 h-k	**18.2 DE**	119.1 c	41.2 ijk	42.4 ij	**67.6 BCD**
Brigitta	22.33 d	15.26 jkl	13.62 lm	**17.1 E**	103.2 d	40.4i-l	37.6 j-m	**60.4 E**
Chander	34.99 a	12.00 m	13.42 lm	**20.1 BC**	151.4 a	25.5 o	34.3 lm	**70.4 B**
Darrow	26.39 c	15.37 i-l	16.10 h-k	**19.3 CD**	117.1 c	27.2 no	31.8 mno	**58.7 E**
Duke	16.62 g-k	17.98 fgh	16.23 h-k	**16.9 E**	81.9 f	36.2 j-m	32.7 mn	**50.3 F**
Elliot	26.60 c	15.32 i-l	18.53 fg	**20.2 BC**	131.4 b	42.3 ij	31.8 mno	**68.5 BC**
Jubilee	29.68 b	28.06 bc	19.89 ef	**25.9 A**	80.3 f	40.9 i-l	41.0 i-l	**54.1 F**
Patriot	22.05 de	18.57 fg	18.56 fg	**19.7 C**	93.4 e	51.2 g	49.6 gh	**64.7 CD**
Means	**25.52 A****	**17.14 B**	**16.71 B**		**113.1 A****	**38.2 B**	**39.3 B**	
	LSD $_{Medium}$: 0.71, LSD $_{Variety}$: 1.30 LSD $_{Medium\ x\ Variety}$: 2.26				LSD $_{Medium}$: 2.14, LSD $_{Variety}$: 3.92 LSD $_{Medium\ x\ Variety}$: 6.80			
Small letters were used in comparing medium x varieties of interaction, Capital letters were used in comparing the means, The significance was also reported for the following levels: *p<0.05, **p<0.01								

Table 6. Ca and Mg contents of fruit samples depending on varieties

Varieties	Ca, mg 100 g^{-1}				Mg, mg 100 g^{-1}			
	Media 1	Media 2	Media 3	Means	Media 1	Media 2	Media 3	Means
Blue Crop	13.11 jkl**	13.34 i-l	26.33 b	**17.57 C****	11.11 a**	7.13 gh	6.73 hi	**8.32 CD****
Blue Gold	14.42 g-j	12.26 klm	31.83 a	**19.51 B**	11.01 ab	5.49 kl	7.65 fg	**8.05 D**
Blue Joy	14.69 f-j	22.02 c	16.39 fg	**17.71 C**	10.74 ab	9.12 de	8.38 ef	**9.41 B**
Brigitta	12.03 klm	10.90 m	8.30 n	**10.41 F**	7.64 fg	4.36 m	3.32 n	**5.11 G**
Chander	13.61 h-k	16.01 fg	10.43 m	**13.34 E**	11.48 a	4.55 m	4.77 lm	**6.93 EF**
Darrow	15.39 fgh	15.40 fgh	11.59 lm	**14.13 E**	10.20 bc	5.78 jk	6.00 ijk	**7.33 E**
Duke	18.64 e	11.97 klm	15.82 fg	**15.46 D**	8.08 f	5.85 ijk	5.92 ijk	**6.61 F**
Elliot	19.46 de	30.74 a	15.83 fg	**22.01 A**	11.12 a	8.23 f	6.52 hıj	**8.62 C**
Jubilee	16.55 f	27.08 b	14.52 g-j	**19.38 B**	11.07 ab	11.03 ab	8.00 fg	**10.03 A**
Patriot	15.16 f-i	21.37 cd	16.23 fg	**17.60 C**	10.99 ab	9.75 cd	7.88 fg	**9.54 AB**
Means	**15.31 C****	**18.11 A**	**16.73 B**		**10.34 A****	**7.13 B**	**6.51 C**	
	LSD $_{Medium}$: 0.62, LSD $_{Variety}$: 1.16 LSD $^{Medium\ x\ Variety}$: 2.00				LSD $_{Medium}$: 0.28, LSD $_{Variety}$: 0.51 LSD $_{Medium\ x\ Variety}$: 0.87			
Small letters were used in comparing medium x varieties of interaction, Capital letters were used in comparing the means, The significance was also reported for the following levels: *p<0.05, **p<0.01								

The differences in sodium (Na) and iron (Fe) content of blueberry fruits were statistically significant ($p<0.01$) (Table 7). The Na content of fresh blueberry fruits varied between 0.94 mg and 20.1 mg 100 g^{-1}. Depending on the medium characteristics, the lowest average Na content was determined in Media 2 and Media 3 (1.37 mg and 1.47 mg 100 g^{-1}) and the highest in Media 1 (14.1 mg 100 g^{-1}). Depending on cultivar characteristics, the lowest average Na content was determined in the Duke, Darrow and Patriot cultivars (4.16, 4.29 and 4.14 mg 100 g^{-1}) and the highest in the Bluegold cultivar (7.67 mg 100 g^{-1}). The high Na content in the soil environment (Media 1) can be explained by the high soil EC value (Table 3).

The Fe content of fresh blueberry fruits varied between 0.279 mg and 0.616 mg 100 g^{-1}. Depending on the medium characteristics, the lowest average Fe content was determined in Media 2 (0.378 mg 100 g^{-1}) and the highest in Media 3 (0.522 mg 100 g^{-1}). Depending on cultivar characteristics, the lowest average Fe content was determined in the Blue Crop, Blue Gold, BlueJay, Brigitta and Chander cultivars (0.359 mg-0.421 mg 100 g^{-1}) and the highest in the Jubilee and Patriot cultivars (0.592 mg and 0.631 mg 100 g^{-1}).

Table 7. Na and Fe contents of fruit samples depending on varieties

Varieties	Na, mg 100 g^{-1}				Fe, mg 100 g^{-1}			
	Media 1	**Media 2**	**Media 3**	**Means**	**Media 1**	**Media 2**	**Media 3**	**Means**
Blue Crop	16.6 c**	1.34 gh	1.47 gh	**6.46 CD****	0.402 g-k**	0.351 i-m	0.440 fgh	**0.397BCD****
Blue Gold	20.1 a	1.19 gh	1.68 gh	**7.67 A**	0.429 gh	0.342 j-n	0.466 fg	**0.412 BCD**
Blue Joy	17.1 c	1.59 gh	1.96 gh	**6.87 BCD**	0.335 k-n	0.463 fg	0.469 fg	**0.421 BCD**
Brigitta	20.0 a	0.99 h	0.89 h	**7.29 AB**	0.374 h-l	0.317 lmn	0.496 ef	**0.397 BCD**
Chander	16.6 c	1.00 h	1.34 gh	**6.31 D**	0.577 cd	0.289 mn	0.301 mn	**0.390 CD**
Darrow	10.7 d	0.94 h	1.27 gh	**4.29 E**	0.324 lmn	0.337 j-n	0.620 bc	**0.428 BC**
Duke	10.0 d	1.26 gh	1.18 gh	**4.16 E**	0.432 fgh	0.436 fgh	0.431 fgh	**0.434 B**
Elliot	18.2 b	1.27 gh	1.58 gh	**7.01 BC**	0.416 ghi	0.279 n	0.446 fg	**0.382 D**
Jubilee	3.09 f	1.92 gh	1.96 gh	**2.32 F**	0.545 de	0.559 cde	0.514 b	**0.592 A**
Patriot	8.87 e	2.17 fg	1.37 gh	**4.14 E**	0.616 bc	0.404 g-j	0.874 a	**0.631 A**
Means	**14.1 A****	**1.37 B**	**1.47 B**		**0.445 B ****	**0.378 C**	**0.522 A**	
	LSD $_{Medium}$: 0.37, LSD $_{Variety}$: 0.65 LSD $_{Medium \times Variety}$: 1.13				LSD $_{Medium}$: 0.02, LSD $_{Variety}$: 0.04 LSD $_{Medium \times Variety}$: 0.07			
Small letters were used in comparing medium x varieties of interaction, Capital letters were used in comparing the means, The significance was also reported for the following levels: *p<0.05, **p<0.01								

Bushway et al. (1983) reported that Fe content in fresh blueberry fruits varied between 0.15 mg and 0.57 mg 100 g^{-1}. Karsons et al. (2018) reported that Fe content of different blueberry varieties varied between 0.23 mg and 0.68 mg 100 g^{-1}.

The differences in manganese (Mn) and copper (Cu) content of blueberry fruits were statistically significant ($p<0.01$) (Table 8). Mn content of fresh blueberry fruits varied between 0.112 mg and 0.909 mg 100 g^{-1}. Depending on the media characteristics, the lowest mean Mn content was determined in Media 2 and 3 (0.227 and 0.239 mg 100 g^{-1}) and the highest in Media 1 (0.592 mg 100 g^{-1}). Depending on the cultivar characteristics, the average Mn content was lowest in the Brigitta cultivar (0.161 mg 100 g^{-1}) and highest in the Jubilee and Elliot cultivars (0.503 and 0.483 mg 100 g^{-1}). Karlsons et al. (2018) reported that Mn content in blueberry fruits varied between 0.14 mg and 4.35 mg 100 g^{-1}, depending on variety characteristics. Bushway et al. (1983) stated that Mn content in fresh blueberry fruits varied between 0.14 mg and 1.52 mg 100 g^{-1}. It is seen that the Mn content of the fruits, depending on the variety difference, is compatible with the fresh fruit content values reported by the researchers.

Table 8. Mn and Cu contents of fruit samples depending on varieties

Varieties	Mn, mg 100 g^{-1}				Cu, mg 100 g^{-1}			
	Media 1	**Media 2**	**Media 3**	**Means**	**Media 1**	**Media 2**	**Media 3**	**Means**
Blue Crop	0.753 c**	0.224 lmn	0.309 ij	**0.428 B****	0.083 h-k**	0.085 h-k	0.181 ef	**0.116 C****
Blue Gold	0.434 g	0.193 mno	0.283 jkl	**0.303 DE**	0.084 h-k	0.694 a	0.270 d	**0.349 A**
Blue Joy	0.410 gh	0.114 p	0.127 p	**0.217 F**	0.077 ijk	0.139 fg	0.072 jk	**0.096 CD**
Brigitta	0.252 jm	0.120 p	0.112 p	**0.161 G**	0.070 jk	0.063 k	0.318 c	**0.150 B**
Chander	0.720 c	0.136 op	0.151 op	**0.336 CD**	0.393 b	0.050 k	0.048 k	**0.164 B**
Darrow	0.547 de	0.139 op	0.167 nop	**0.284 E**	0.071 jk	0.060 k	0.071 jk	**0.067 E**
Duke	0.497 ef	0.364 hi	0.240 klm	**0.367 C**	0.083 h-k	0.057 k	0.070 jk	**0.070 E**
Elliot	0.909 a	0.288 jk	0.253 j-m	**0.483 A**	0.108 g-j	0.084 h-k	0.047 k	**0.079 DE**
Jubilee	0.815 b	0.409 gh	0.286 jk	**0.503 A**	0.124 gh	0.072 jk	0.127 gh	**0.107 C**
Patriot	0.580 d	0.282 jkl	0.468 fg	**0.443 B**	0.118 ghi	0.192 e	0.132 g	**0.147 B**
Means	**0.592 A****	**0.227 B**	**0.239 B**		**0.121 C**	**0.149 A**	**0.133 C**	
	LSD $_{Medium}$: 0.02, LSD $_{Variety}$: 0.04 LSD $_{Medium\ x\ Variety}$: 0.06				LSD $_{Medium}$: 0.01, LSD $_{Variety}$: 0.03 LSD $_{Medium\ x\ Variety}$: 0.05			
Small letters were used in comparing medium x varieties of interaction, Capital letters were used in comparing the means, The significance was also reported for the following levels: *p<0.05, **p<0.01								

Cu content of fresh blueberry fruits varied between 0.047 mg and 0.694 mg 100 g^{-1}. Depending on the growing media characteristics, the lowest average Cu content was determined in Media 1 (0.121 mg 100 g^{-1}) and the highest in Media 2 (0.149 mg 100 g^{-1}). Depending on cultivar characteristics, the average Cu content was lowest in the Darrow and Duke cultivars (0.067 and 0.070 mg 100 g^{-1}) and highest in the Bluegold cultivar (0.349 mg 100 g^{-1}). Karlsons et al. (2018) reported that Cu content in blueberry fruits varied between 0.01 mg and 0.14 mg 100 g^{-1} depending on variety characteristics. Skupien et al. (2004) reported that Cu content in fruit samples varied between 0.17 mg and 0.30 mg kg^{-1}. It was observed that the Cu content of the fruits, depending on the variety difference, was compatible with the fresh fruit content values reported by the researchers.

The differences in zinc (Zn) and boron (B) content of blueberry fruits were statistically significant ($p<0.01$) (Table 9). The Zn content of fresh blueberry fruits varied between 0.083 mg and 0.476 mg 100 g^{-1}. Depending on the growing media characteristics, the lowest average Zn content was determined in Media 2 (0.193 mg 100 g^{-1}) and the highest in Media 1 (0.292 mg 100 g^{-1}). Depending on cultivar characteristics, the lowest mean Zn content was determined in the Chandler cultivar (0.166 mg 100 g^{-1}) and the highest in the Bluegold cultivar (0.329 mg 100 g^{-1}). Karlsons et al. (2018) reported that Zn content in blueberry fruits varied between 0.08 mg and 0.30 mg 100 g^{-1} depending on variety characteristics. Skupien et al. (2004) reported that Zn content in fruit samples varied between 1.08 mg and 1.30 mg kg^{-1}. It was observed that the Zn content of the fruits, due to variety differences, was compatible with the fresh fruit content values reported by the researchers.

The B content of fresh blueberry fruits varied between 0.014 mg and 0.151 mg 100 g^{-1}. Depending on the growing media characteristics, the lowest average B content was determined in Media 3 and Media 2 (0.052 mg and 0.055 mg 100 g^{-1}) and the highest in Media 1 (0.079 mg 100 g^{-1}). Depending on the cultivar characteristics, the average B content was lowest in the Patriot and Jubilee cultivars (0.032 and 0.040 mg 100 g^{-1}) and highest in the Bluegold cultivar (0.109 mg 100 g^{-1}). Karlsons et al. (2018) reported that B content in blueberry fruits varied between 0.070 mg and 0.150 mg 100 g^{-1} depending on variety characteristics. Bushway et al. (1983) reported that B content varied between 0.08 mg and 0.14 mg 100 g^{-1}. It was observed that the B content of the fruits, depending on the variety difference, was compatible with the fresh fruit content values reported by the researchers.

Table 9. Zn and B contents of fruit samples depending on varieties

Varieties	Zn, mg 100 g^{-1}				B, mg 100 g^{-1}			
	Media 1	**Media 2**	**Media 3**	**Means**	**Media 1**	**Media 2**	**Media 3**	**Means**
Blue Crop	0.356bcd**	0.135 nop	0.304 d-g	**0.265 C****	0.065 ghi**	0.072 efg	0.060 g-j	**0.109 A****
Blue Gold	0.351 b-e	0.159 mno	0.476 a	**0.329 A**	0.073 d-g	0.069 e-h	0.081 de	**0.082 B**
Blue Joy	0.325 c-f	0.083 p	0.261 ghi	**0.223 D**	0.049 jkl	0.035 mno	0.045 klm	**0.074 C**
Brigitta	0.379 bc	0.093 p	0.105 op	**0.192 DEF**	0.066 fgh	0.031 no	0.023 opq	**0.066 D**
Chander	0.197 klm	0.150 mno	0.152 mno	**0.166 F**	0.052 ijk	0.018 pq	0.029 nop	**0.065 D**
Darrow	0.229 i-l	0.216 i-l	0.192 klm	**0.212 DE**	0.072 efg	0.014 q	0.051 jk	**0.063 D**
Duke	0.203 j-m	0.156 mno	0.201 j-m	**0.187 EF**	0.086 d	0.065 ghi	0.037 lmn	**0.045 E**
Elliot	0.361 bc	0.246 h-k	0.184 lmn	**0.263 C**	0.124 b	0.057 h-k	0.067 fgh	**0.043 E**
Jubilee	0.255 g-j	0.394 b	0.244 h-k	**0.298 AB**	0.151 a	0.108 c	0.116 efg	**0.040 EF**
Patriot	0.271 f-i	0.297 e-h	0.234 i-l	**0.267 BC**	0.057 h-k	0.079 def	0.061 g-j	**0.032 F**
Means	**0.292 A****	**0.193 C**	**0.235 B**		**0.079 A****	**0.055 B**	**0.052 B**	
	LSD $_{Medium}$: 0.02, LSD $_{Variety}$: 0.03 LSD $_{Medium\ x\ Variety}$: 0.05				LSD $_{Medium}$: 0.01, LSD $_{Variety}$: 0.01 LSD $_{Medium\ x\ Variety}$: 0.01			
Small letters were used in comparing medium x varieties of interaction, Capital letters were used in comparing the means, The significance was also reported for the following levels: *p<0.05, **p<0.01								

Conclusion

In this project, 10 different blueberry varieties, which are widely used in garden establishment and growing media, were grown under greenhouse conditions. In the study, two growing media of organic origin, one of which is commercially available, and soil with an appropriate pH value taken from the İnegöl district of Bursa province, were filled into pots and used in the experiment. In the study which was conducted over two years, there was growth and pruning in the first year and harvesting in the second year, and yield values were determined. The yield and chemical properties (nutrient content) of the varieties were evaluated.

In the study, the yield values obtained from Media 1, which included soil and pot conditions, remained low compared to organic growing media. This result is thought to be related to the deterioration of aeration and infiltration properties due to the deterioration of the natural structure of the soil and the relatively high pH values. In determining the areas where blueberry orchards will be established, regions with optimum pH and soil properties for the plant should be preferred. In the study, it was found that the difference between soil and organic media is also related to slower plant growth in soil growing conditions.

In the study, the fact that organic origin media gave better results in terms of yield, showed that blueberry cultivation can be done economically in a certain volume of pot media. Thus, it can be said that blueberry production in open or greenhouse conditions can be evaluated as an alternative product for producers by determining suitable varieties in regions where the climate is suitable in Türkiye.

Media 2 (a mixture of peat and perlite), which was evaluated as an organic medium in the study, can be grown with a priority preference for the Chandler, Bluecrop, Bluegold, and Elliot varieties. In the commercial media (Media 3), which is considered the other organic medium, the Chandler, Elliot, and Patriot varieties came to the forefront in terms of yield, and it is predicted that they may be the reason for preference. When the environments were evaluated, in general it was seen that Media 2 gave better results in terms of the yield parameter. It is recommended that the costs of the growing medium should be taken into account when making a preference for producers.

However, if cultivation is carried out in organic media, it should be taken into account that the properties of organic environments will change over time due to decomposition and disintegration.

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No potential conflict of interest was reported by the author(s).

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