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Original article

Growth-Development, Yield and Quality Characteristics of Aronia Varieties Grown in Pots

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Abstract

This study was carried out to determine the growth, development, yield and some quality characteristics of Nero and Viking Aronia varieties grown in open field and pot in Samsun ecological conditions. Three-year-old Aronia plants were planted in 80-liter pots containing a 1:1:1 (v/v) mixture (barnyard manure+soil+sand) and 5 plants were included in each replication. Number of shoots, flower buds and clusters, berry weight (g), yield (g/plant), firmness (N), number of fruits per cluster, must yield (ml/100g), TSSS (%) and pH values were measured in Aronia cultivars. In addition, monthly shoot growth rate (cm/month) was determined and phenological observations recorded. According to Viking and Nero Aronia varieties, the number of shoots (7.8 and 7.6 pieces), the number of flower buds (22.63 and 22.85 pieces), the number of clusters (45.06 and 44.80 pieces), the weight of berry (0.82 and 0.79 g), the fruit number in the bunch (21.45 and 21.53 pieces), berry firmness (4.90 and 5.35 N), amount of must (49.67 and 54.00 ml/100 g) and TSS (17.07 and 16.47) and pH values (3.65 and 3.52) were found to be close to each other. Bud burst (10 March), flowering (26 April), berry set (12 May) and harvest time (24 August) were also similar in cultivars. It was also revealed that while the shoot length was 97.47 cm and 95.47 cm on March 11, respectively, in Viking and Nero varieties, it reached 124.73 and 120.73 cm in August, five months later.

Keywords: Aronia, Yield, Viking, Nero, *Aronia Melanocarpa*.

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INTRODUCTION

Black chokeberry [*Aronia melanocarpa*, (Michx.) Elliot] or aronia is a small fruit-bearing shrub in the rose family (*Rosaceae*) and native to eastern North America. Aronia is a landscape quality plant with few pests and diseases. Because of this, it is an ideal candidate for organic fruit production. The fruit is typically between 1 and 1.5 cm in diameter, very similar in size to commercial blueberries. In the 19th century, the species was introduced to Europe, and Eastern Europeans discovered that the shrubs could grow in extremely cold climates and that the fruit was healthful. By the early 20th century, Europeans were breeding the plant for fruit production resulting in taller shrubs with larger fruit (Brand, 2008). Aronia, also known as chokeberry is a hardy, vigorous plant native to Eastern North America. Aronia prefers neutral to slightly acidic, well-drained soils located in full sun. Plants are not very drought tolerant and will require supplemental irrigation during periods of rainfall deficit. The purplish-black fruit is approximately 0.635-1.27 cm in size and borne on a medium to large shrub that can be 152.40-304.80 cm tall. The astringent fruit, which is very high in several healthful compounds, is being used in the food industry to add color and/or antioxidants to other juices, such as apple and grape. Aronia fruit is also used in making wine, jam, syrup, yogurt and tea. Aronia is a desirable landscape shrub with seasonal interest: white flowers in the spring, clusters of dark berries in the summer, and reddish fall foliage (Kaiser and Ernst, 2018). The firm, black fruit forms on small clusters with 8-12 fruit per cluster (Snebergrova et al., 2014). Aronia fruits are astringent and astringency causes an unpleasant drying sensation to the mouth, regardless of the amount of juice in the fruit. In addition to aronia, astringency is found in a wide cultivar of unrelated fruit, including green persimmons, seedling pears, Cornelian cherry dogwood, and several other species. Fruit can be astringent and low in acid at the same time. Aronia is very acidic. Most of the time astringency disappears during processing; however, there are times when astringency can be carried into wine, cooked juice, and even jelly. In aronia, astringency nearly disappears at the end of the long harvest period (Brand, 2008; Bolling et al., 2015).

The aronia fruit has nutraceutical qualities, heightening its marketability and sales potential as a value-added product. There is currently great interest in fruits and vegetables that contain high concentrations of flavonoids, considered potent antioxidants (Gu et al., 2004; Pietta, 2000). In a recent study (Wu et al., 2004), aronia was shown to contain high levels of flavonoids including anthocyanins and proanthocyanidins, and has a total oxygen radical absorbance capacity (Ristvey and Mathew, 2011). A number of research institutions and government agencies have promoted the production of aronia as an alternative crop (Finn, 1999; King, 2007; Ristvey and Mathew, 2011). In Eastern Europe where the aronia has been cultivated for many years, fruit products include juices, extracts, coloring agents, and wine (Scott and Skirvin, 2007). Through DNA analysis, Leonard (2011) determined that the present cultivars of Aronia including ‘Viking’ and ‘Nero’, utilized mainly for fruit production in Europe and the United States, are a cross between a black-fruited Aronia and the European Mountain Ash (*Sorbus*

aucuparia). Depending on temperatures, dormant buds swell in late March and begin opening in early April with vegetative growth (leaves) visible first and flower buds showing soon after. The bloom cycle is approximately 10 days. By late May, fruit set begins and potential yield can be determined. Throughout June and July vegetative growth continues, doubling or tripling the size of the plant during the first few establishment years after planting. Throughout June, fruit turn from green to a burgundy color. By mid-July, all fruit are colored burgundy and by harvest time in mid to late August, fruit are a dark purple. Harvest is in mid to late August and/or the end of September when fruit clusters are fully ripened. Mature plants can yield up to 11 kg or more of fruit. Soluble sugar content or Brix of fruit varies between 15% and 22% (Ristvey and Mathew, 2011). Viking is taller and produces higher yields than 'Nero'; but 'Nero' is probably better for growers who must harvest by hand. Most growers have noticed few or no differences between the two varieties regarding fruit quality (Kulling and Rawel, 2008). Kawecki and Tomaszewska (2006) determine the effect of several soil management techniques on development, growth and yield in black chokeberry bushes growing in the province of Warmia and Mazuria in Poland. They stated that the start of vegetative growth, blossoming dates and optimum harvest date varied considerably from year to year, depending on weather conditions. They also found that five-year cumulative yield was highest in bushes mulched with either conifer bark or aged manure, and lowest in bushes either weeded by hand or mulched with black sheet plastic.

Ristvey and Tangren (2008) planted 'Viking' and 'Nero' aronia cultivars and plants were each given one of two N fertility rates amongst rows during the first yield studies. 'Viking' plants, being the most mature when planted, produced enough fruit during the third season to determine if fertility treatments affected yield. 'Viking' plants, each given a total of 24 g N during the period between planting and recorded yield produced an average of 2.2 kg per plant. This was significantly less than plants given 15 grams N which averaged 2.8 kg for next year. They stated that each year harvests have shown no differences in yield by N rate to either 'Nero' or 'Viking' cultivars. In each year, no difference in °Bx was found between N rates and cultivars. Jeppsson (2000) noted that high fertility, while increasing yield, negatively affected anthocyanin content in fruit. According to Ristvey and Mathew (2011) plant density may be between 100 and 200 plants per decares and fertility would not exceed 3 kg N per decares. Dragoja et al. (2012) plant the aronia in acidic and cancerous soils and obtained 4200 g of fruits per plant in the third year. Poyraz Engin and Mert (2019) determine the fruit growth in 'Nero' and 'Viking' aronais and they found that average fruit weight s of 'Nero' reached 1.16, and that of 'Viking' was 1.07 g in the harvest time. This time, values of solid soluble content were measured as 19.6% in 'Nero' and 20.05% in 'Viking'. pH values were measured as 3.72 in 'Nero' and 3.77 in 'Viking' while acidity changed as 0.53 g 100 mL^{-1} in 'Viking' and 0.56 g 100 mL^{-1} in 'Nero' cultivar at the harvest time. Poyraz Engin and Mert (2020) compared the 'Nero' and 'Viking' aronia cultivars and determine the optimum harvest dates of each cultivar for various utilizations. They found that the optimum harvest time for both cultivars was at second week of September. They said that the aronia must be harvest

during the second and third weeks of September for anthocyanin content, antioxidant capacity, and total phenol. They also found that the aronia must be harvest during the first and second weeks of October for dry consumption.

The aim of this study was to determine the phenology, yield and berry characteristics of aronia variety planted in pots and grown under Samsun ecology.

MATERIAL and METHOD

Two cultivars of Aronia (*Aronia melanocarpa* (Michx.) Elliot.) including 'Nero' and 'Viking' were used in this study. Aronia plants were grown in the test area of Ondokuz Mayis University, Agricultural Faculty in Samsun (middle part of Black Sea Region of Turkey) in 2020. The aronia bushes planted 80 liters pot with the mixture farmyard manure+fine soil+peat moss (1:1:1 v/v). The aronia plants are 3 years old. The pots were set up with 2×1 m distances. All plants were fertilized with ozmocote slow released fertilizer for once at the beginning of the study, 50 g/per pot. Since aronia plants are resistant to pathogen diseases (by nature), no chemical protection was applied other than aphids. The trial set up with randomized complete block design with tree replication and 5 plants used in one replication.

Berry and leaf bud and flower cluster phenological stages with coloring of the berry was recorded. Monthly shoot growing in cm were determined from 11 March to 11 August. Shoot number, lateral branch, flower bud number, total yield, average fruit weight over 100 fruits, firmness (N) (1.5 mm probe), berry number per bunch, berry must, TSS, acidity, pH and CIE L^*, a^* and b^* (Minolta CR 410) values also determined. The analyses of titratable soluble solid content (TSS), titratable acidity (TA) and pH values were made at harvest time. The weight of fruit was expressed in grams. For juice extraction, fruits were homogenized with a blender and then were filtered in order to determine TSS, pH and acidity. The rates of TSS were measured by hand-held refractometer, and TA was determined by titration with 0.1 N NaOH to end point of pH 8.1, expressed in percentage of malic acid per 100 mL of juice, and pH values were measured with a digital pH meter in three parallel ways. The analyses were made on fresh berries immediately after harvest.

The experiment was established in random plots with 2 cultivars, 3 replications, and 5 plants in each replication. SPSS 16.0 for Windows statistical package program was used to evaluate the data. One-way ANOVA test was used for analysis, and Duncan ($p<0.01$ and $p<0.05$) test was used for significance levels.

RESULTS and DISCUSSION

All the phenological stages detected took place at the same time for two aronia cultivars (Table 1). Pot grown aronia cultivars under Samsun ecological conditions, bud-bursted on 10 March and full flowering began 26 April. Berry settling took place 12 May and veraison begin 15 June. Aronia berries

were pink at 5 July, dark purple at 12 July and black at 11 August. They harvested at the 24 August when fully ripe and eatable ingredients. According to literature, dormant buds of aronia bushes swell in late March and begin bursting in early April with vegetative growth (leaves) visible first and flower buds showing soon after. By late May, berry set begins and potential yield can be determined. Throughout June, fruit turn from green to a burgundy color. By mid-July, all fruit are colored burgundy and by harvest time in mid to late August, fruit are a dark purple. Harvest is in mid to late August when fruit clusters are fully ripened (Ristvey and Mathew, 2011). Our findings for phenology are similar to the literature. Kawecki and Tomaszewska (2006) also revealed that the start of vegetative growth, blossoming dates and optimum harvest date varied considerably from year to year, depending on weather conditions. The monthly shoot growth is also recorded and 'Viking' is much taller than 'Nero' as Kulling and Rawel (2008) determined. 'Viking' shoots reached to 124.73 cm within 5 months but 'Nero' was near to that length as 120.73 cm (Figure 1). On the other hand, 'Nero' is probably better for growers who must harvest by hand. Most growers have noticed few or no differences between the two varieties regarding fruit quality (Kulling and Rawel, 2008).

Table 1. Phenological stages of aronia cultivars grown in pots (2020)

Variety	Bud Burst	Full Flowering	Berry Set	Veraison	Pink Berry	Dark Purple Berry	Black Berry	Harvest
Viking	10 March	26 April	12 May	15 June	05 July	12 July	11 August	24 August
Nero	10 March	26 April	12 May	15 June	05 July	12 July	11 August	24 August

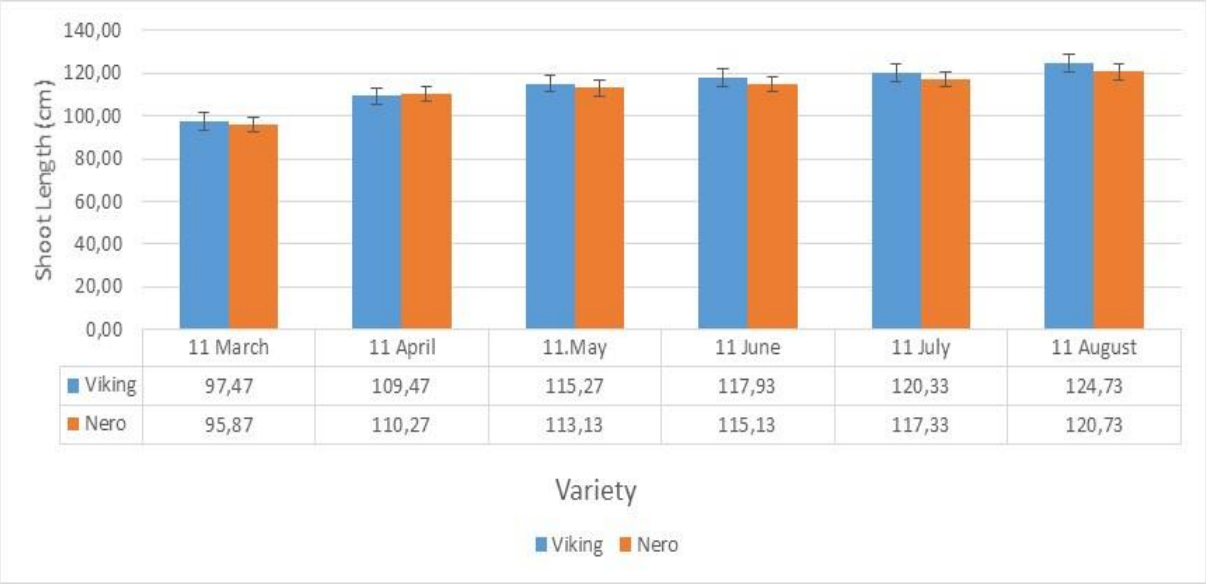

Figure 1. Monthly shoot growing in length of aronia bushes grown in pots (cm)

The shoot number, lateral branches, flower bud and bunch number of the aronia cultivars are close to each other as seen in Table 2. However, 'Viking' cultivar is better than 'Nero' as stated by researcher (Jeppsson, 2000; Kulling and Rawel, 2008; Ristvey and Mathew, 2011; Dragoja et al. 2012; Poyraz Engin and Mert, 2019 and 2020). Our findings as given in Table 2 in favor of 'Viking' variety. And yield of 'Viking' was higher (635.41 g/plant) than 'Nero' (547.74 g/plant). Kawecki and Tomaszewska (2006) found that five-year cumulative yield was highest in bushes mulched with either conifer bark or aged manure, and lowest in bushes either weeded by hand or mulched with black sheet plastic. They also stated that each year harvests have shown no differences in yield by N rate to either 'Nero' or 'Viking' cultivars. According to our results, berry weight (0.83 g), firmness (5.35 N) and berry number per bunch (21.53) of 'Nero' is better than 'Viking' variety (Table 2). Berry weight 0.82-0.83 g we found and these findings are similar with the ones of Ochmian et al. (2012) suggesting that the average fruit weights of 'Nero' and 'Viking' cultivars as 0.9-1.0 g at the harvest time in Poland. Similarly, Jeppsson (2000) found that the fruits of 'Nero' and 'Viking' cultivars weighed from 0.7 to 1.0 g. in Sweden. On the other hand, Strik et al. (2003) obtained fruits that weighed about 2.7 g at the harvest time in Oregon. Poyraz Engin and Mert (2019) determine the fruit growth in 'Nero' and 'Viking' aronia and they found that average fruit weight s of 'Nero' reached 1.16, and that of 'Viking' was 1.07 g in the harvest time. Our results are lower than these findings and this must be affected by pots and smaller root growing areas and climate.

Table 2. Bush, flower bud, bunch and berry characteristics and yield of aronia cultivars grown in pots

Variety	**Shoot Number**	**Lateral Branch**	**Flower Bud**	**Bunch Number**	**Yield (g/bush)**	**Berry weight (g)**	**Firmness (N)**	**Berry number per bunch**
Viking	7.80	7.33	22.63	45.07	635.41 a	0.82	4.90	21.45
Nero	7.60	7.20	22.85	44.80	547.74 b	0.83	5.35	21.53
Signif.	*NS*	*NS*	*NS*	*NS*	*0.05*	*NS*	*NS*	*NS*

NS: non-significant, there are statistical differences between the data has different letter in the column

Berry chemical characteristics are given in Table 3 and there were no significantly differences on all characters determined except for TSS/acidity. 'Viking' Berry length and width, TSS (17.07%) and pH (3.65) are better than 'Nero' but must (54.00 ml/100 g berry) and TSS/acidity (25.05) values of 'Nero' are better than 'Viking' variety Table 3. Kawecki and Tomaszewska (2006) in each year, no difference in °Bx was found between N rates and cultivars. Jeppsson (2000) noted that high fertility, while increasing yield, negatively affected anthocyanin content in fruit. According to Ristvey and Mathew (2011) plant density may be between 100 and 200 plants per decares and fertility would not exceed 3 kg N per decares. Dragoja et al. (2012) plant the aronia in acidic and cancerous soils and obtained 4200 g of fruits per plant in the third year. Poyraz Engin and Mert (2019) determine the fruit growth in 'Nero' and 'Viking' aronia and they found that average fruit weight s of 'Nero' reached 1.16,

and that of 'Viking' was 1.07 g in the harvest time. This time, values of solid soluble content were measured as 19.6% in 'Nero' and 20.05% in 'Viking'. pH values were measured as 3.72 in 'Nero' and 3.77 in 'Viking' while acidity changed as 0.53 g 100 mL^{-1} in 'Viking' and 0.56 g 100 mL^{-1} in 'Nero' cultivar at the harvest time (Poyraz Engin and Mert, 2019). Researchers also revealed that soluble sugar content or Brix of fruit varies between 15% and 22% (Ristvey and Mathew, 2011).

Table 3. Berry chemical and color characteristics of aronia cultivars grown in pots

Variety	**Berry Length (mm)**	**Berry Width (mm)**	**Must (ml/100 g)**	**TSS (%)**	**Acidity (g/100 cc)**	**TSS/ Acidity**	**pH**	***L****	***a****	***b****
Viking	12.19	10.51	49.67	17.07	0.77	22.26 b	3.65	23.18	7.75	7.40
Nero	12.09	9.89	54.00	16.47	0.66	25.05 a	3.61	23.29	7.95	6.04
Signif.	*NS*	*NS*	*NS*	*NS*	*NS*	*0.05*	*NS*	*NS*	*NS*	*NS*

NS: non-significant, there are statistical differences between the data has different letter in the column

These results are similar with the ones of various researchers suggesting that the values of TSS content in aronia fruits amount between 11.3 and 24.3% (Hukkanen et al., 2006). Since the values of soluble solid content in aronia fruits depends on numerous factors: weather, environmental conditions, harvest time and cultivar (Jeppsson, 2000; Strik et al., 2003), the values found in this study are slightly higher than the ones they found, which were between 12.4 and 18.3%. These factors may also explain the discrepancy with the results of Ochmian et al. (2012) suggesting that the values of solible solid content in 'Nero' cultivar measured higher than 'Viking' cultivar in the harvest time. This study showed that this is the case for aronia as well. The results are similar with the ones measured in Germany by Strigl et al. (1995), which were between 3.3 and 3.7 at the harvest time. The values found in this study, however, are slightly higher than the ones measured by Bolling et al. (2015) between 3.15 and 3.45 in the USA. Various researchers reported that the main acids identified were malic acid and citric acid in aronia berries (Kulling and Ravel, 2008). Also Jeppsson and Johansson (2000) pointed out that malic acid was dominating organic acid in aronia berries and they determined as 0.5-1.4 g 100 mL^{-1} in aronia berries. Likewise, Snebergrova et al. (2014) reported that it varies between 0.5 and 1.4 g 100 mL^{-1} in aronia berries. The results found in this research are in the range found by previous researchers. On the other hand, Ochmian et al. (2012) suggested that the values of titratable acidity determined as 0.85 g 100 mL-1 in 'Nero' and 0.80 g 100 mL^{-1} in 'Viking' cultivar at the harvest time. However, this discrepancy may be explained by the early harvest and ecological differences.

CONCLUSIONS

Aronia is an up-and-coming alternative crop in the world. While specific markets have yet to be completely defined, the marketing potential for this crop to be the next "superfood" is very likely. Because of its hardy character, the possibility for organic production with the correct IPM measures and very little input makes this a worthwhile crop to investigate. The pot grown aronia research results

summarized in this paper. This means that aronia could grows both different soil and pot with special mixture. Due to its hardiness for climate, soil, water deficit and pest and disease aronia could move to balcony on pots. This make aronia most popular balcony or house growing berry plants next years. In Turkey, aronia has been shown to tolerate a range of soil types, can be grown with sustainable rates of fertilizer, and is tolerant to many of the pest species that make other fruit crops more difficult to manage. Presently, a move for consumers to "buy local" may bring a renaissance for small farms to sell aronia as value added product. Future research will include the determination of cultural methods that may increase the nutritional value of the fruit to maximize its market value and the determination of processing methods that do not negatively affect the fruit's nutritional value.

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