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INFLUENCE OF MINERAL FERTILIZATION ON SELECTED PHYSICAL FEATURES AND CHEMICAL COMPOSITION OF ARONIA FRUIT[*]

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A b s t r a c t. *Aronia melanocarpa* (Michx) Elliot, called also black chokeberry, is a species with lower cultivation requirements within the *Rosaceae* family. The purpose of the study was to assess the influence of foliar fertilization with Mn, 'Alkalin' (N, K and Si) and Mn + 'Alkalin' on physical features and chemical composition of chokeberries. All fertilizers applied exerted stimulating effect on weight of 100 fruits and fruit size, however, the lowest yield was observed for Mn treated bushes. Fertilization with 'Alkalin' significantly increased firmness of fruit in comparison to control and other treatments. However, neither Mn nor 'Alkalin', nor the combined fertilization increased total sugar content in chokeberries. On the other hand, fruits of the combined treatment showed the highest saccharose content. The treatment did not affect titratable acidity, soluble solids, nitrate and total polyphenol content. The control berries and fruit of Mn treated plants had significantly higher ability of scavenging DPPH radical compared to that of 'Alkalin' and combined fertilization. The tested fertilizers exerted multi-directional changes in physical properties and chemical composition of chokeberries. However, the differences observed between fruit of fertilized variants and control, even when statistically significant, from the practical point of view were not very high.

K e y w o r d s: *Aronia melanocarpa*, yield, firmness, juice extraction efficiency, phytonutrients

INTRODUCTION

Aronia melanocarpa (Michx) Elliot, black chokeberry, belongs to the *Rosaceae* family and is an indigenous species to eastern North America (Jeppsson 2000a). Native Americans used chokeberries both as food and a natural remedy for cold treatment. Today, chokeberries are also cultivated in Eastern Europe (Benvenuti *et al.*

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2004). In Poland, aronia shrubs meant for fruit production were introduced in the nineteen seventies (Kleparski and Domino 1990). Chokeberries are small, dark violet fruits, but because of their astringency are not favoured as 'table fruits'. Chokeberries are grown mainly for juice production. However, compared with other fruits, chokeberries are more abundant in anthocyanins (Zheng and Wang 2003) and are used as food colorants and as a source of valuable phytonutrients (Slimestad *et al.* 2005). Experiments on animals confirm antioxidative activity of aronia extracts (Matsumoto *et al.* 2004, Valcheva-Kuzmanova *et al.* 2005, Oghami *et al.* 2005).

The agronomic practices (especially fertilization) may affect not only the yield of fruit but the content of phytonutrients as well. In the present experiment, the hypothesis tested was whether the treatment with manganese (Mn), 'Alkalin' (a commercial fertilizer containing N, K and Si) and combined treatment (Mn + 'Alkalin') can influence the yield and physical features of aronia berries (fruit size, weight of 100 fruits, firmness and juice extraction efficiency) as well as chemical composition of chokeberries.

Manganese stimulates photosynthesis and carbohydrate production in leaves (Pearson and Rengel 1997). Deficiency of plant-available Mn occurs in neutral and alkaline reaction soils. Manganese is plant-available in acidic and waterlogged soils (Shi *et al.* 2005). The most rapid and efficient way for prevention and/or correction of Mn deficiency is foliar application of solutions containing inorganic or organic Mn (Papadakis *et al.* 2005). Silicon (Si) is involved in enhancing disease resistance of plants (Carver *et al.*1998). Moreover, Si was found to alleviate Mn toxicity in cucumber plants treated with an excess of Mn (Shi *et al*. 2005). In agronomic practice potassium fertilization has been widely applied to increase sucrose content in sugar beets, starch content in potatoes and grains. However, data in the literature on the effects of mineral fertilization on chemical composition of fruits is not unequivocal (Tomás- Barberán and Espin 2001) and scant particularly for chokeberries (Jeppsson 2000a).

MATERIAL AND METHODS

Experimental

Chokeberry plants were grown in the Experimental Station at Rajkowo near Szczecin, northwest Poland. The plantation was established on grey-brown podsolic soil originated from medium boulder clay. The rooted cuttings of aronia (an unspecified cultivar) were planted in 1995. In October, 2003, the plants were rejuvenated by cutting and only 5 shoots were left per shrub. The fertilization with nitrogen in two doses, 40 kg N ha^{-1} each, was used, whereas, phosphorus and potassium fertilization was not applied because the soil was abundant in these elements (7.3 mg 100 g^{-1} and

48.0 mg 100 g^{-1}, respectively). The soil reaction was neutral (pH ~7.1). Additionally, three fertilizers were applied by foliar spraying: chelate manganese (EDTA-ethylene-diamine-tetraacetic acid; DTPA-diethylene-triamine-pentaacetate) in a dose of 1 g l^{-1}, ‘Alkalin’ fertilizer (N, K and Si) in a dose of 5 ml l^{-1}, and Mn + ‘Alkalin’ (a combined dose). Manganese fertilizer contained 14 g of manganese per 100 g, Alkalin contained 40 g N-NH_2, 360 g K_2O and 15 g SiO_2 l^{-1}. The adjuvant Superam 10 AL (10% salt of alkylbenzensulfonic acid and etoxyalkylphenols) was added by spraying in a dose of 50 ml 100 l^{-1}. The fertilizers were purchased from Intermag, Poland. The sprays were performed on six occasions: on 15th, 22th and 29st of May, 5th, 19th of June, and 3rd of July, 2006. Each treatment was comprised of 5 bushes in three replicates. Control plants were sprayed with Superam 10 AL diluted in distilled water; whereas, basic nitrogen fertilization was applied in the same doses and terms as for treated plants. From florescence to harvest, drip irrigation was performed according to tensiometer indications. Weed control was performed chemically between rows (Kerb + Azotop before vegetative season) and by means of Roundup within rows (before flowering). Because *Aronia melanocarpa* plants are resistant to pathogen diseases ’by nature’, no chemical protection was applied. The fruits for physicochemical analyses, ~2 kg samples, were collected in full ripeness stage on 7th September.

Plant material

Physical features of fruits were measured on fresh berries immediately after the harvest.

Soluble solids, titratable acidity, total polyphenol, DPPH radical scavenging activity, nitrate and nitrite content, were performed on fresh fruits packed in polyethylene bags and stored overnight at 5^{o}C. Dry weight, total sugar and reducing sugar content were determined in frozen chokeberries packed in polyethylene bags and stored at –25^{o}C for 2 months.

Chemicals

All the chemicals used for basic constituent analyses were of analytical grade and purchased from POCh (Gliwice, Poland).

Methods

The yield was measured in kg per bush. The weight of 100 fruit was expressed in g. The fruit diameter and firmness was measured by means of non-destructive device FirmTech 2 combined with a computer (BioWorks, USA). The firmness of 50 randomly selected berries from every replicate was expressed as a gram-force causing fruit surface to bend by 1 mm.

For juice extraction efficiency fruit were homogenized with a blender and heated up to 50^{o}C. Then, after cooling, 3 ml of pectinase (Rapidase Super, BE, NC, USA) per kg of pulp were added. The pulp was left to stand at room temperature for 1 hour. Afterward, the pulp was pressed for 10 min at the final pressure of 300 kPa by means of a laboratory hydraulic press (Oszmiański and Wojdylo 2005).

Dry weight of fruit was determined with a gravimetric method (drying an aliquot of ~5 g of fruit tissue at 105 ^{0}C to constant weight) according to Polish standard (PN-90/A-75101/03).

Soluble solids content was determined with an Abbé refractometer (PN-90/A-75101/02).

Titratable acidity was determined by titration of a water extract of chokeberry homogenate with 0.1 N NaOH to an end point of pH 8.1 (measured with an Orion 720 A pH meter; Orion Research Incorporated, USA) according to PN-90/A-75101/04.

Total sugar and reducing sugar content was determined according to the Loof-Schoorl method. Saccharose content was calculated according to the relationship: saccharose = (total sugar – reducing sugar) × 0.95.

Total polyphenol content in methanol (70%) extracts was estimated according to SINGLETON and ROSSI (1965) with the Folin-Ciocalteu reagent. The data were expressed as mg of gallic acid equivalents (GAE) per 100 g of fruit tissue.

The DPPH$^{\cdot}$ was obtained from Sigma-Aldrich Co. (USA). Scavenging effect of chokeberry fruit on DPPH-radical was determined according to the method of YEN and CHEN (1995) with some modification. The fruits were homogenised with a food processor (Predom Zelmer, Poland) and the juice was squeezed through cheese cloth. Further, the raw juice was centrifuged at 8,000 × g (centrifuge MPW-250, MPW Med. Instruments, Poland) and diluted 400 times in methanol (32.04 g/mol). A 1 ml aliquot of diluted juice was added to 3 ml of methanol and 1 ml of DPPH solution (0.012 g DPPH/100 ml methanol). The mixture was shaken and left at room temperature for 10 min; the absorbance was measured spectrophotometrically at 517 nm. DPPH$^{\cdot}$ percent inhibition was calculated according to ROSSI *et al.* (2003) from the formula: Percent inhibition = 100 – [(A_t/A_r) x 100], where A_t – absorbance of test solution and A_r – absorbance of reference solution.

Nitrate and nitrite content was determined with an ion-selective electrode by means of multi-function computer device CX-741 Elmetron (Zabrze, Polska) and the data expressed as mg $NaNO_3$ and $NaNO_2$ per 100 g of fruit.

Chemical analyses were carried out in three replicates.

Statistical analysis was done by using Statistica software package version 7.1 (Statsoft, Poland). The data were subjected to one-way analysis of variance. Values of $P<0.05$ according to Duncan multiple comparison test for physical features and Tukey test for chemical constituents estimation were considered significant.

RESULTS

The quantitative characteristics of aronia yield and juice extraction efficiency are listed in Table 1. The plants fertilized with Mn yielded worst (4.89 kg per bush), while the combined treatment (Mn + 'Alkalin') increased the yield up to 6.85 kg per bush. On the other hand, each of the treatments caused significant increase in weight of 100 fruits and fruit size compared to the control group. The mass of treated fruit was higher by 12.2-13.2% compared to control; whereas, under Mn treatment fruit diameter enlarged by 23% and under Mn + 'Alkalin' treatment by 26% in comparison to non-treated fruit. Significantly higher firmness of fruit was observed only for 'Alkalin' treated berries (461 G mm^{-1}). Both foliar application of Mn and combined treatment (Mn + 'Alkalin') resulted in fruit with similar firmness to that of control berries (430 G mm^{-1}).

The amount of juice derived from pressed control chokeberries was 86.08%. Foliar application of tested fertilizers used separately increased the value slightly, while the combined treatment (Mn + 'Alkalin') increased juice extraction efficiency significantly up to 87.01%.

Data presenting dry weight, soluble solids, titratable acidity, total sugar, reducing sugar, sucrose, nitrate, nitrite and total polyphenol content, and antiradical activity against $DPPH^{\cdot}$ of aronia fruit are listed in Table 2.

The fruit of Mn treatment showed the greatest dry weight content (20.14%), significantly higher (by 1.22%) than berries of combined fertilization; however, not considerably surpassing control and 'Alkalin'-treated fruit.

Noteworthy, the changes in dry weight content were not concomitant with soluble solids content. The fruit treated with 'Alkalin' had the lowest soluble solids content (14.4 ^{0}Bx), while control chokeberries the highest (15.6%). However, the differences observed for the all treatments were not significant.

Similarly, the tested fertilizers caused no significant changes in total acid content in the berries compared to the control. The acidity of chokeberries ranged from 1.31 g citric acid 100 g^{-1} ('Alkalin') to 1.24 g citric acid 100 g^{-1} (Mn + 'Alkalin').

The highest total sugar content was found in control berries. The fruit sprayed with 'Alkalin' had significantly less total sugar (by 9.1%) and reducing sugar (by 7.9%) than control chokeberries. However, the strongest decrease in total sugar and reducing sugar amount was found in berries of the Mn + 'Alkalin' treatment (by 10.1 and 13.2%, respectively). Further, foliar spraying affected significantly saccharose content. The fruit of combined fertilization showed the highest saccharose content surpassing control fruit by 33.3%, Mn-treated chokeberries by 43.7% and that of 'Alkalin' by 54.2%.

Table 1. Physical features of aronia fruit under tested fertilization

Characteristics*	Control	Manganese	Alkalin	Manganese + Alkalin
Yield (kg/bush)	5.83±0,31 ab	4.89±0,21 b	6.44±0,38 ab	6.85±0,27 a
Weight of 100 fruits (g)	81.7±3,11 b	92.0±3,55 a	91.7±2,92 a	92.5±3,02 a
Fruit size (mm)				
Min – Max	9.84-13.30	12.76-16.23	12.80-15.76	12.99-16.37
Mean	11.64±0,72 b	14.41±0,70 a	14.33±0,68 a	14.75±0,70 a
Firmness (G mm^{-1})				
Min – Max	309-570	342-513	385-581	343-516
Mean	430±38,8 b	422±35,8 b	461±37,2 a	430±31,4 b
Juice extraction efficiency (%)	86.1±0.24 b	86.2±0.14 b	86.6±0.19 ab	87.0±0.25 a

*Mean values marked with the same letter do not differ significantly at $P < 0.05$ according to Duncan multiple range test.

Table 2. Chemical composition and 2, 2-diphenyl-1-picrylhydrazyl radical (DPPH˙) % inhibition of chokeberry fruit for tested variants of fertilization

Characteristics[a]	Control	Manganese	Alkalin	Manganese + Alkalin
Dry weight (%)	19.85±0.25 ab	20.14±0.17 a	19.74±0.53 ab	18.92±0.05 b
Soluble solids (^{0} Bx)	15.6±0.49 a	15.2±1.07 a	14.4±1.96 a	14.5±1.45 a
Titratable acidity (g citric acid 100 g^{-1})	1.29±0.00 a	1.28±0.01 a	1.31±0.01 a	1.24±0.01 a
Total sugar (g 100 g^{-1})	6.91±0.09 a	6.86±0.03 ab	6.28±0.01 b	6.21±0.03 b
Reducing sugar (g 100 g^{-1})	6.58±0.05 ab	6.58±0.05 ab	6.06±0.03 bc	5.71±0.03 c
Saccharose (g 100 g^{-1})	0.36±0.03 b	0.27±0.03 c	0.22±0.03 c	0.48±0.01 a
Nitrate (mg kg^{-1})	62.7±1.21 a	63.0±0.98 a	62.7±1.43 a	64.7±1.07 a
Nitrite (mg kg^{-1})	1.24±0.04 a	1.15±0.03 ab	0.90±0.01 b	1.10±0.01 ab
Total polyphenol (mg gallic acid (100 g^{-1})	1175.6±79.6 a	1174.6±47.2 a	1164.2±83.3 a	1180.7±69.5 a
DPPH˙ % inhibition[b]	41.7±0.78 a	39.3±0.36 a	29.6±1.75 c	32.7±1.12 b

[a] Values are the mean of three determinations ±SD and are expressed per fresh weight. Different letters in the same row indicate significant differences at P< 0.05 according to Tukey multiple range test.

[b] DPPH-radical % inhibition was calculated on the basis of DPPH˙ scavenging activity of chokeberry juice diluted 400 times in reaction mixture consisting of: 1 ml of diluted juice + 3 ml of methanol + 1 ml of DPPH˙ solution.

The use of foliar fertilizers had no statistically significant effect on accumulation of nitrates in aronia fruit. The content of nitrates varied from 62.7 mg kg^{-1} (control and 'Alkalin' treated berries) to 64.7 mg kg^{-1} (fruit under Mn + 'Alkalin'). On the other hand, in comparison to the control (1.24 mg kg^{-1}), the amount of nitrites was significantly lower (0.90 mg kg^{-1}) in fruits harvested from bushes fertilized with 'Alkalin'.

The fertilization tested in the study did not cause significant changes in total polyphenol content in chokeberries. The control berries had 1175.6 mg gallic acid $\cdot(100\ g)^{-1}$ (GAE). The fruit treated with Mn + 'Alkalin' showed an increase by 0.4%, whereas in chokeberries under Mn and 'Alkalin' treatment phenolic content decreased by 0.1 and 1%, respectively.

The chokeberries of control group and treated with Mn presented significantly higher ability of quenching DPPH radical compared to the fruit of combined treatment (by 22 and 17%, respectively) and 'Alkalin'-treated berries (by 29 and 25%, respectively).

DISCUSSION

Yield

In our study, aronia bushes yielded 4.89-6.85 kg fruit per bush. For bushes planted at similar spacing (3 m x 1 m), Żmuda (1992) obtained 2.3-2.5 kg of fruits per bush. On the other hand, Smolarz and Chlebowska (1997) reported the yield of 3.7 kg of chokeberries per bush. In this research, yielding of aronia fruits was dependent on the foliar fertilization applied. The plants sprayed with Mn yielded worst, significantly lower than bushes of combined treatment (Mn + 'Alkalin'). Songin and Śnieg (1996) observed that the use of Mn together with other elements increased the crop of cereals. The authors noticed that the use of potassium as a single fertilizer (K is one of the main components of 'Alkalin') resulted in increase of cereal crop. On the other hand, foliar application of Mn on soybean caused insignificant reduction of the yield (LINK 1).

Weight of 100 fruits

In this experiment, the weight of 100 fruits varied from 81.7 to 92.5 g. According to Jeppsson (2000b), black chokeberry cultivars are generally large-fruited. The mean weight of 50 berries tested by the author in 1995 and 1996 ranged from 31.4 to 99.2 g. Kawecki and Tomaszewska reported the mass of 100 berries varied from 84 to 98 g. According to Smolarz and Chlebowska (1997) and Strik *et al.* (2003), 100 aronia fruits achieved the weight 280 g. In this finding, an essential influence of all the fertilizers on fruit size was observed. The treated fruits were characterized by a very similar mass (91.7-92.5 g), whereas the mass of control fruits was significantly lower (81.7 g). Songin and Śnieg (1996) found that fertilization with Mn and Mn in combination with other elements had a positive effect on the size of grains.

Firmness

In the present study, 'Alkalin' treatment significantly increased the firmness of chokeberries. Most probably, it was the effect of silicon which is one of 'Alkalin' components. Similarly, the use of 'ActiSil', another fertilizer containing silicon, considerably increased firmness of strawberries (Grajkowski *et al.* 2006) and plums (Ochmian *et al.* 2006).

Juice extraction efficiency

The chokeberries treated with Mn and 'Alkalin' gave the highest yield of juice, but they surpassed significantly control berries only. Noteworthy, the efficiency of juice extraction from chokeberries was very high (87.01-86.08%) compared to 77.2% for a mash of apples cv. 'Fuji' and 74.7% for that of 'McIntosh' extracted at the same temperature of 50^{o}C (Gerard and Roberts 2004). High efficiency of aronia juice was due to enzymatic pre-treatment.

Dry weight

The dry weight content determined for aronia fruits in this experiment (18.92-20.14%) is narrower than the scope reported by Kleparski and Domino (1990) –17-to-26%. However, the chokeberries grown in the preceding season (Skupień and Oszmiański 2007) showed much higher dry weight content (26.67-30.76%). In this study, berries of Mn treatment had significantly higher dry weight content compared to the berries of Mn + 'Alkalin' but not to other treatments. On the other hand, in 2005 berries treated with Mn showed the lowest dry weight content. In 2005, the plantation was also watered, but the temperatures in summer were much higher and lasted for a longer period compared to 2006. Thus, probably weather conditions influenced dry weight content in fruits more considerably than the tested fertilizers.

Soluble solids

The treatments applied in the present study caused lowering of soluble solids content by 2.6% (Mn), 7.1% (Mn + 'Alkalin') and 7.7% ('Alkalin') compared to the control fruit. The soluble solids content ranged from 14.4 ^{0}Bx ('Alkalin') to 15.6 ^{0}Bx (control). The values were lower compared to those reported by

Jeppsson (2000a) 16.3-17.8 ^{0}Bx, and to the chokeberries obtained in the preceding season 21.7-24.1 ^{0}Bx (Skupień and Oszmiański 2007). This indicates that seasonal variability exerted stronger effect than tested fertilization. However, neither in 2005 nor in 2006 statistically significant differences between the fruits of particular treatments were observed.

Titratable acidity

Jeppsson (2000a) noted that increased rates of N, P and K fertilization reduced total acidity in chokeberries. In this research, aronia fruit fertilized with 'Alkalin' (N, K and Si) displayed the highest amount of acids and this tendency was also observed in 2005 (Skupień and Oszmiański 2007). However, the range of total acid content in berries grown in the hot summer of 2005 was 0.493-0.548 g citric acid (100 g)$^{-1}$ compared to 1.24-1.31 g citric acid (100 g)$^{-1}$ for the fruit of 2006.

Total sugar, reducing sugar and saccharose

In the present study, contrary to expectations, control berries showed significantly higher amount of total sugar (6.91 g (100 g)$^{-1}$) and reducing sugar (6.58 g (100 g)$^{-1}$) compared to the fruit treated with 'Alkalin' and Mn + 'Alkalin', but not with Mn alone. On the other hand, the combined treatment was conducive to saccharose content. The chokeberries under Mn + 'Alkalin' treatment showed significantly higher amount of saccharose (0.48 g (100 g)$^{-}$1) compared to other fruit. The lowest saccharose content was observed in berries treated with 'Alkalin' alone (0.22 g (100 g)$^{-1}$). Total sugar content estimated in this experiment was similar to the data reported by Kleparski and Domino (1990) 6.2-10.8 g (100 g)$^{-1}$, whereas, aronia fruit grown in 2005 (Skupień and Oszmiański 2007) presented enhanced total sugar and reducing sugar content. Fertilization with 'Alkalin' is recommended to increase sugar content in the yield (the effect of K). Similarly, Mn activates many enzymes involved in sugar synthesis. Manganese shortage results in drastic sugar content decline (Starck 2002). In our experiment, the stimulating effect of these elements was recorded only as far as saccharose content is concerned in the berries under combined fertilization. However, in the previous study, both Mn + 'Alkalin' treated and control berries showed similar amounts of saccharose.

Nitrate and nitrite content

In Poland and other countries there is a lack of regulations on permissible nitrate content in fruits (except for bananas). According to the Polish Ministry of Agriculture (Dz. U., 2003), permissible nitrate content in vegetables meant for feeding babies and young children should not exceed 200 mg $NaNO_3$ kg^{-1}. In our study, aronia fruit showed much lower values, at 62.7-64.7 mg $NaNO_3$ kg^{-1}. Whereas, nitrite content in chokeberries ranged from 0.90 to 1.24 mg $NaNO_2$ kg^{-1}, which is similar to the regulations for fruit juices up to 1 mg $NaNO_2$ kg^{-1}.

Total polyphenol

The fertilization did not affect considerably the total polyphenol content. However, the highest amount of phenolics (1180.7 mg $(100\ g)^{-1}$) was found for berries of Mn + Alkalin combination and the lowest for fruit of 'Alkalin' variant (1164.2 mg $(100\ g)^{-1}$). Benvenuti *et al.* (2004) reported considerably lower total polyphenol content for fresh aronia fruit, at 690.2 mg $(100\ g)^{-1}$. According to reported data total polyphenol content in aronia fruit varies from 40.1 mg GAE g^{-1} to 4210 mg GAE $(100\ g)^{-1}$ (Kähkönen *et al.* 1999, 2001, respectively). High content of polyphenols is due to high activity of L-phenylalanine ammonia-lyase (PAL), a key enzyme in the biosynthesis of phenolic compounds in fruit tissues of several species (Cheng and Breen 1991). Carver *et al.* (1998) reported a higher increase in PAL activity in Si-deprived plants. In our study no significant differences were found between combinations fertilized with 'Alkalin' (Si) and non-'Alkalin' ones.

DPPH radical scavenging activity

On the other hand, statistically significant differences occurred between the variants regarding DPPH radical scavenging ability. Control berries showed the highest activity against $DPPH^{\cdot}$ (41.7% DPPH-radical inhibition). The fruit of the 'Alkalin' variant (with the lowest total polyphenol content) had substantially lower ability of quenching the radical (29.6%) compared to other variants. Matsumoto *et al.* (2004) investigated the chokeberry red pigment fraction at a concentration 25 μg ml^{-1} scavenged > 44 % of DPPH-radicals compared to the control solution. Oszmiański and Wojdylo (2005) determined $DPPH^{\cdot}$ quenching ability for aronia lyophilized fruits at 279.38 μM Trolox (100 g^{-1}) on dry weight basis. Nakajima *et al.* (2004) estimated DPPH-radical scavenging activity of aronia extract as nearly identical to bilberry extract, though weaker than that of Trolox. Benvenuti *et al.* (2004) found chokeberries overrating antioxidant properties of blackberry, raspberry and red currant. Only 2 out of 9 black currant cultivars tested by the authors showed EC_{50} (mg of fruit required to decrease the initial $DPPH^{\cdot}$ concentration by 50%) ≤ than that of aronia fruit.

CONCLUSIONS

1. In this experiment foliar fertilization with Mn, ‘Alkalin’ (N, K and Si) and Mn + ‘Alkalin’ resulted in statistically significant increase of weight of 100 fruit and fruit size compared to the control.
2. The bushes fertilized with ‘Alkalin’ yielded fruit with the highest firmness, whereas, the berries of the combined fertilization (Mn + ‘Alkalin’) showed the highest juice extraction efficiency.
3. The plants fertilized with Mn yielded significantly lower than control bushes and those of other fertilizations.
4. A stimulating effect on saccharose content was observed for Mn+’Alkalin’ fertilized chokeberries.
5. The fruit of Mn-fertilized bushes and control showed higher ability of quenching DPPH-radical than berries obtained from plants fertilized with ‘Alkalin’and Mn+’Alkalin’.
6. The applied fertilization did not affect substantially soluble solids, titratable acidity, nitrate and total polyphenol content in aronia fruit.
7. The lowest nitrite content was found for fruit of ‘Alkalin’ fertilized bushes.
8. Regarding practical approach, yielding and important for juice industry constituents such as soluble solids and acidity, foliar fertilization tested in this experiment did not stimulate these parameters considerably.

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WPŁYW NAWOŻENIA MINERALNEGO NA WYBRANE CECHY FIZYCZNE I SKŁAD CHEMICZNY OWOCÓW ARONII

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S t r e s z c z e n i e. *Aronia melanocarpa* (Michx) Elliot, nazywana również aronią czarnoowocową, w obrębie rodziny *Rosaceae*, jest gatunkiem o niskich wymaganiach agrotechnicznych. Celem badań była ocena wpływu nawożenia dolistnego Mn, 'Alkalinem' (N, K i Si) oraz Mn + 'Alkalinem' na cechy fizyczne i skład chemiczny owoców aronii. Wszystkie zastosowane nawozy spowodowały wzrost masy 100 owoców i ich wielkości, chociaż najniższy plon uzyskano z krzewów nawożonych Mn. Nawożenie 'Alkalinem' spowodowało istotny wzrost jędrności owoców w porównaniu do kontroli oraz pozostałych kombinacji doświadczenia. Jednakże, ani nawożenie Mn, ani 'Alkalinem', ani obydwoma nawozami łącznie nie wpłynęło na wzrost zawartości cukrów ogółem. Z drugiej strony, owoce nawożone Mn i 'Alkalinem' łącznie odznaczały się największą zawartością sacharozy. Badane zabiegi nawozowe nie spowodowały istotnych zmian w zawartości kwasów ogółem, ekstraktu ogólnego, azotanów i polifenoli ogółem w owocach. Owoce z krzewów kontrolnych oraz nawożonych Mn wykazywały istotnie większą zdolność zmiatania rodników DPPH w porównaniu do owoców uzyskanych z krzewów nawożonych 'Alkalinem' oraz Mn i 'Alkalinem' łącznie. Badane nawozy spowodowały wielokierunkowe zmiany we właściwościach fizycznych i chemicznych owoców aronii. Jednakże, różnice obserwowane pomiędzy owocami z poszczególnych wariantów nawozowych i owocami kontrolnymi, nawet jeżeli były statystycznie istotne, to z praktycznego punktu widzenia nie były bardzo znaczące.

S ł o w a k l u c z o w e: *Aronia melanocarpa*, plon, jędrność, wydajność soku, składniki odżywcze