DOI: 10.21005/AAPZ2016.37.1.04

FOLIA POMERANAE UNIVERSITATIS TECHNOLOGIAE STETINENSIS
Folia Pomer. Univ. Technol. Stetin., Agric., Aliment., Pisc., Zootech. 2016, 325(37)1, 29–38

Karolina KOZOS, Ireneusz OCHMIAN

THE INFLUENCE OF FERTILISATION UREA PHOSPHATE ON GROWTH AND YIELDING BUSH OF TWO HIGHBUSH BLUEBERRY CULTIVARS (*V. CORYMBOSUM*)

WPŁYW NAWOŻENIA FOSFORANEM MOCZNIKA NA WZROST I PLONOWANIE KRZEWÓW DWÓCH ODMIAN BORÓWKI WYSOKIEJ (*V. CORYMBOSUM*)

Department of Horticulture, West Pomeranian University of Technology, Szczecin, Poland

Streszczenie. Na świecie wzrasta zainteresowania uprawą borówki wysokiej. Wzrost popytu wpływa na wysoką cenę owoców. Powodzenie uprawy uzależnione jest od zapewnienia roślinom podłoża o niskim odczynie. W pracy określono wpływu zróżnicowanych dawek (30 i 60 kg N · ha^{-1}) fizjologicznie kwaśnego nawozu fosforanu mocznika (17,7% N, 44,6% P_2O_5) na wzrost i plonowanie krzewów borówki wysokiej. Doświadczenie przeprowadzono w Katedrze Ogrodnictwa Zachodniopomorskiego Uniwersytetu Technologicznego w Szczecinie na plantacji borówki wysokiej. Krzewy posadzono w glebie zakwalifikowanej do pyłów piaszczystych, o zawartości substancji organicznej na poziomie 4,1–4,2%. Jesienią mierzono wysokość krzewów, długość przyrostów jednorocznych, określono liczbę pędów odziomkowych, indeks zazielenienia, wielkość liści oraz plon, wielkość owoców i ich jędrność. Stosowanie fosforanu mocznika wpłynęło na zwiększenie plonu i wielkość owoców obu odmian borówki wysokiej, nie wpłynęło natomiast na wzrost wysokości krzewów i długości pędów jednorocznych. Pobudziło krzewy do wytwarzania pędów odziomkowych i większych liści, o wyższym indeksie zazielenienia, w porównaniu z krzewami nienawożonymi.

Key words: cultivars ‘Brigitta Blue’ and ‘Sunrise’, firmness, height shrubs, weight of 100 fruits.
Słowa kluczowe: jędrność, masa 100 owoców, odmiany ‘Brigitta Blue’ i ‘Sunrise’, wysokość roślin.

INTRODUCTION

At present, the interest in highbush blueberry cultivation is enormous, which is caused by high popularity of these fruits among consumers. An increase in the consumption causes higher prices and, as a result, higher profitability of production of this species. In Europe, Poland is the country with the highest area used for planting highbush blueberry bushes and the greatest producer of fruits (Brazelton 2013). Soils with a low pH value and good availability of nutrients are the best for cultivating highbush blueberry bushes (Ochmian and Kozos 2014), including peaty soils with a stable groundwater level (Moore 1993; Starast et al. 2002). A high demand for highbush blueberry fruits makes farmers use soils which are less appropriate for cultivating this species. These soils, however, need to be prepared in an

Corresponding author – Adres do korespondencji: PhD Ireneusz Ochmian, Department of Horticulture, West Pomeranian University of Technology, Szczecin, Juliusza Słowackiego 17, 71–434 Szczecin, Poland, e-mail: ochir@go2.pl

appropriate manner. If the pH value of the soil is too high, it can be reduced by adding dusty sulphur to the soil. Slow-decomposing organic matter can be also used: fragmented coniferous tree bark, high peat, composted pine sawdust (Ochmian et al. 2008; Ochmian et al. 2009). An alternative method for obtaining an appropriate pH value of the soil is the use of acids or physiologically acidic fertilizers for which the pH of the water used for watering is reduced. Highbush blueberry has a low demand for nutrients, also including nitrogen. Urea phosphate, a fertilizer with a pH value of 1.2 should not be the main method for reducing the pH value of the soil, but rather a substance supporting this process. There is a risk of overfertilizing the plantation, which may damage bushes in winter (Hachiya et al. 2012). In addition, increasing the dose of a fertilizer containing nitrogen, phosphorus and potassium intensifies the vegetative growth and limits yielding at the same time (Koszański et al. 2008; Ruan et al. 2010).

Urea phosphate is a fertilizer which increases the content of assimilable magnesium and phosphorus in the soil (Grata and Krzyśko-Łupicka 2008), increases the content of mineral forms of nitrogen, especially N-NH_4 (Grata 2013). It also causes a reduction in the pH value of the peat substrate (Hodge et al. 1994; Krzbietke and Benedycka 2006). This is a compound which is completely soluble in water (Nowak and Kotula 1998), which also has disinfecting properties (Grata et al. 1999).

The aim of the study was to determine the influence of physiologically acidic fertilizer, urea phosphate, on the growth and yield of highbush blueberry bushes.

MATERIAL AND METHODS

The studies were carried out in the Laboratory of Orcharding at the Department of Horticulture, West Pomeranian University of Technology in Szczecin in the years 2013–2015.

The research was conducted at a production plantation specialized in the cultivation of highbush blueberry.

The bushes were planted in 2008 in soil classified as sandy silts (PN-R-04033) with the organic matter content of 4.1–4.2% and the organic carbon content of 1.61–1.63%. The soil was characterized by a low content of P and it was rich in K and Mg. As a result of being set aside for a long time, a natural process of acidification occurred to the pH value of 5.2–5.3. The bushes were watered using a drip-line, the intensity of watering was determined using soil extensomters. Sward was kept between the rows.

Scheme of the experiment

3 doses of the urea phosphate fertilizer **–** control without fertilizing (0 UP), 30 kg N (1/2 UP), 60 kg N (1 UP).

The fertilizer was sprinkled in four doses:

– beginning of vegetation (bud break – first leaves),
– end of blossom,
– first decade of June,
– end of June.

2 cultivars: ‘Sunrise’, ‘Brigitta Blue’.

Characteristics of the fertilizer

- chemical formula: $CO(NH_2)\cdot H_3PO_4$;
- content of mineral ingredients: N 17.7%, P_2O_5 44.6%;
- pH value of a 10% solution: ~1.2;
- EC 34 µS · cm;
- very good solubility in water.

Characteristics of cultivars

Sunrise – spreading bushes with a loose structure, height up to 150 cm. 'Sunrise' is an early season high-bush blueberry cultivar which ripens with Duke, 10 and 20 July. 'Sunrise' originated from a cross of G-180 x ME-US-6620 in 1974 and was selected in 1978 in Weymouth. Although considered a highbush blueberry, 'Sunrise' does have some lowbush ancestry. 'Sunrise' fruit are medium blue, medium in size, have good firmness, and have a very good picking scar. Notable characteristics of 'Sunrise' include the following: no susceptibility to red ringspot virus exhibited in an area with high pressure for the disease, fruit are firm and appear to maintain good quality over time.

'Brigitta Blue' – 1977 Australian release. Bearing large flavorful sky-blue, firm, fruits late in the blueberry season – they ripen in August. They ship and store well. This cultivar from Australia has been introduced to numerous other parts of the world including the United States, Chile and Europe. The high plants are dense and upright. Highbush blueberry 'Brigitta Blue' flourishes in moist well drained acidic soil in full to partial sun.

The experiment was carried a randomised sub-block design (3 blocks, 10 plants in each block). The following parameters were measured in autumn: the height of the bushes, the length of one-year growths (without shoots growing on roots), the number of one-year shoots growing on roots. Prior to the first harvest of fruits, the index of leaf greenness was measured, using the Chlorophyll Meter SPAD-502 (Minolta, Japan) apparatus. In autumn, the foliage area was measured using the Delta Image Analysis System (Delta-T Devices LTD, England) scanner connected to the computer.

Fruits were harvested manually from all the shrubs covered by the experiment, and prepared the aggregate sample on which measurements. Physical features of fruits (fruit size, firmness), were measured on fresh berries immediately after the harvest were performed on fresh fruits. The fruit weight was measured with RADWAG WPX 4500 electronic scales (0.01 g accuracy). Fruit diameter, firmness and puncture resistance of the skin was measured with a FirmTech2 apparatus (BioWorks, USA) of 100 randomly selected berries from three replicate was expressed as a gram-force causing fruit surface to bend 1 mm.

Considerable differences were observed in the weather in the individual years and significant deviations of these values from the mean values of the multi-year period (Table 1). The year 2015 was characterized by lower temperatures in the spring as compared to 2014 and 2013. The temperatures were much higher in the fruit ripening months as compared to the multi-year period. Precipitation varied over the years and in individual months. Exceptionally little precipitation was observed in 2015, especially in the fruit ripening period – in August and September.

Table 1. Weather conditions during the vegetative season (April–October) in the years 2013–2015 with reference to a multi-year period (1951–2012)
Tabela 1. Przebieg warunków pogodowych w okresie wegetacyjnym (kwiecień–październik) w latach 2013–2015 w odniesieniu do wielolecia (1951–2012)

Month – Miesiąc								Mean Średnia
	IV	V	VI	VII	VIII	IX	X	
Year – Rok	Temperature – Temperatura [°C]							
2015	8.7	12.5	15.6	18.6	21.1	14.1	–	15.1
2014	10.8	13.4	16.3	21.3	17.5	15.4	11.8	15.2
2013	8.4	14.4	16.9	19.3	18.7	13.0	10.9	14.5
1951–2012	8.0	13.0	16.4	18.2	17.6	13.8	9.2	13.7
	Rainfall – Opad deszczu [mm]							Total Ogółem
2015	29.0	48.0	32.8	62.0	14.7	34.4	–	221
2014	47.5	85.3	26.5	70.8	104.6	80.9	32.8	448
2013	20.8	88.1	112.5	50.4	35.9	43.9	45.8	397
1951–2012	39.7	62.9	48.2	69.6	74.2	58.7	37.3	391

In order to determine the significance of differences, a two-factor analysis of variance was carried out, followed by the assessment of the significance of differences using the Tukey's test. The statistical analyses were performed using the Statistica 12.0 (StatSoft Polska).

RESULTS AND DISCUSSION

The growth of bushes and especially the number of new shoots in the bush provides information about the condition of the plant and has a direct influence on the yield. Regardless of the fertilizer dose used, the growth of bushes from the tested cultivars was at a similar level. The height of the bushes had been changing in particular years of study. Because of the fact the bushes were young at that point of time, the maximum typical heights for the cultivars was not achieved. In the last year of the experiment, bushes had a similar height, regardless of the fertilizer dose, however, they were characterized by much greater dynamics of growth in the years 2013–2015 than plants examined by Wach (2008). Bushes from the 'Sunrise' cultivar which received the full dose of the fertilizer (1 UP) were characterized by the greatest growth in 2014 – by 19 cm, in comparison to 2013 (Table 2). This may have been influenced by precipitation with distribution close to the multi-year period. In the last year of the experiment, the fertilized bushes from the 'Brigitta Blue' and 'Sunrise' cultivars were slightly higher than the control plants. In 2014, the greatest average growth of one-year shoots was found, especially on bushes for which the full dose of the fertilizer was used (38.5 cm 'Sunrise', 45.6 cm 'Brigitta Blue'). In 2015, which was an exceptionally dry and warm year, the shoots were shorter by over ten centimetres as compared to 2014. Fertilization of highbush blueberry stimulates the growth of new shoots (Koszański et al. 2008) and enrichment of the soil with organic matter (Krzewińska et al. 2010). If plants produce few new shoots and they are short, poorer yields will be obtained in the following years (Smolarz 2005).

One-year shoots growing on roots which grow from the base of the bush replace old shoots which are removed during the cutting process – they rejuvenate the plant. In all the years of the research, bushes fertilized with the full dose of the fertilizer produced a larger

number of one-year shoots growing on roots. A higher number of one-year shoots growing of roots were observed in the 'Brigitta Blue' cultivar – the average number for unfertilized plants was 5.7 and for those fertilized with the full dose – 7.2. A similar tendency was observed for 'Sunrise' bushes, however, there were fewer of them – 3.3 and 4.2, respectively.

Table 2. Biometric measurements of bushes from two cultivars of highbush blueberry depending on the fertilizer dose used
Tabela 2. Pomiary biometryczne krzewów dwóch odmian borówki wysokiej w zależności od zastosowanej dawki nawozu

	'Sunrise'				'Brigitta Blue'			
Fertilizer Nawóz (A)	0 UP	1/2 UP	1 UP	Mean Średnia	0 UP	1/2 UP	1 UP	Mean Średnia
Year – Rok (B)	Height shrubs – Wysokość krzewów [cm]							
2015	136ab*	133ab	145b	138A	143ab	148ab	157b	149A
2014	122ab	125ab	136ab	128A	134ab	136ab	145ab	138A
2013	113a	116a	117a	115A	123a	120a	131ab	125A
Mean – Średnia	124A	125A	133A		133A	135A	144A	
Year – Rok	Average length one-year shoots without shoots growing on roots Średnia długość przyrostów jednorocznych bez pędów odziomkowych [cm]							
2015	17.5a	21.4abc	26.2bcd	21.7A	20.4a	25.6ab	29.1b	25.0A
2014	28.8cd	32.3de	38.5e	33.2B	36.4cd	41.0de	45.6e	41.0B
2013	24.2abc	20.7ab	27.0bcd	24.0AB	27.8ab	29.3b	31.2bc	29.4A
Mean – Średnia	23.5A	24.8A	30.6A		28.2A	32.0A	35.3A	
Year – Rok	Total number of one-year shoots growing on roots Liczba pędów odziomkowych							
2015	4.5bcd	5.1cd	6.2d	5.3B	7.6cd	8.3cd	9.5d	8.5B
2014	2.9ab	3.3abc	3.8abc	3.3A	5.1ab	6.3bc	7.4c	6.3AB
2013	2.4a	2.5a	2.7ab	2.5A	4.5ab	3.9a	4.8ab	4.4A
Mean – Średnia	3.3A	3.6AB	4.2B		5.7A	6.2A	7.2A	
Year – Rok	Leaf area – Powierzchnia liścia [cm^2]							
2015	14.3a	15.0a	17.1bcd	15.5A	20.3a	24.1cd	24.7d	23.0A
2014	16.5bc	17.7cd	18.9d	17.7B	22.4bcd	24.6d	24.5cd	23.8A
2013	15.7ab	15.2ab	16.4abc	15.8A	21.2ab	23.7cd	23.4bc	22.8A
Mean – Średnia	15.5A	16.0A	17.5A		21.3A	24.1B	24.2B	
Year – Rok	Green index – Indeks zazielenienia [SPAD]							
2015	45.6ab	47.3bcd	51.7de	48.2AB	49.8cd	54.4de	58.4e	54.2B
2014	48.4b-e	50.6cde	52.9e	50.6B	40.6a	43.0ab	48.5bcd	44.0A
2013	42.2a	44.6ab	46.1abc	44.3A	45.4abc	46.3abc	47.6bc	46.4A
Mean – Średnia	45.4A	47.5AB	50.2B		45.3A	47.9A	51.5A	

*Means followed by the same letter do not differ significantly at P = 0.05 according to Tukey multiple range test – Średnie oznaczonoe tą samą literą nie wykazują istotnych różnic na poziomie α = 0,05, według wielowymiarowego testu Tukeya.

A higher supply of nitrogen to plants activates their growth processes and influences the chlorophyll content in leaves (Blackmer and Schepers 1994). The total chlorophyll content can be assessed on the basis of the green index, which is highly correlated with it (Gregorczyk and Raczyńska 1997; Pacewicz and Gregorczyk 2009). The research conducted has also shown the influence of the fertilization used on the increase in the value of the green index and the size of leaves. This relationship was found in all of the years of the research especially on plants fertilized with a full dose (1 UP). The green index was the highest for Sunrise cultivar leaves in 2014 – the average value from 1UP plants was 52.9.

In that year, the bushes were also characterized by the largest leaf surface area (on average 18.9 cm). 'Brigitta Blue' leaves had the highest value of the green index in 2015 also with full fertilization (58.4). Krzewińska et al. (2010) determined the green index of highbush blueberry at 34.9–51.9, with higher values in autumn. An increase in the green index and the size of leaves after the application of nitrogen to blueberry bushes was also found by Ochmian (2012), and for other cultivated plant species by Jarecki et al. (2013) and Podsiadło and Jaroszewska (2013).

The fertilization used had a significant influence on the increase in the yield and improved fruit quality (Table 3). However, regardless of fertilizer dose used, 30 or 60 kg N, the yields were at a similar level. The full dose of the fertilizer did not have a significant influence on the increase in the unit weight of fruits from both cultivars. The 'Sunrise' cultivar rendered better yields over the three-year period. The year 2014 was exceptional. As a result of application of the complete dose of the fertilizer (1 UP), there was collected 5 kg of fruits by average from the 'Sunrise' bushes, while the 'Brigitta Blue' produced 5.4 kg. In 2015, the yield was lower regardless of the fertilization used. Despite the large size of `Brigitta Blue` bushes, only 2.2 kg of fruits were collected from them. In that year, fruits from both cultivars were also the smallest – on average 254 g for 'Sunrise' and 261 g for 'Brigitta Blue'. This was cause by very little precipitation as compared to the multi-year period, especially in the period of intensive growth of fruits. Additionally, exceptionally high temperatures occurred in this period. Despite profuse watering, plants showed water deficiency and fruits were sunburnt. In studies by other authors, the weight of 100 fruits ranged on average from 122 to 216 g (Glonek and Komosa 2004; Krzewińska et al. 2009; Krzewińska et al. 2010) and depended on the cultivar.

Table 3. Yields and fruit quality of two cultivars of highbush blueberry depending on the fertilizer dose used
Tabela 3. Plonowanie i jakość owoców dwóch odmian borówki wysokiej w zależności od zastosowanej dawki nawozu

	'Sunrise'				'Brigitta Blue'			
Fertilizer Nawóz (A)	0 UP	1/2 UP	1 UP	Mean Średnia	0 UP	1/2 UP	1 UP	Mean Średnia
Year – Rok (B)	Yield – Plon [kg]							
2015	3.4b	4.1bc	4.4cd	4.0B	2.2abc	1.9abc	2.5cd	2.2B
2014	4.0bc	4.8cd	5.0d	4.6B	3.4d	4.8e	5.4e	4.5C
2013	2.3a	2.4a	2.5a	2.4A	1.4ab	1.3a	1.7abc	1.5A
Mean – Średnia	3.2A	3.8B	3.9B		2.3A	2.6AB	3.2B	
Year – Rok	Weight of 100 fruit – Masa 100 owoców [g]							
2015	247a	255ab	259ab	254A	261a	253a	270ab	261A
2014	278bc	294cd	336e	303B	284abc	311cd	328d	308B
2013	304cde	318de	332e	318B	295bcd	309cd	318cd	307B
Mean – Średnia	276A	289AB	309B		280A	291AB	305B	
Year – Rok	Firmness; height axis – Jędrność; w osi wysokości [$G \cdot mm^{-1}$]							
2015	395cd	404d	382bcd	394B	438d	448d	420cd	435B
2014	344a	361ab	377bc	361A	386abc	365ab	354a	368A
2013	383bcd	374abc	365abc	374A	397bc	373ab	381ab	384A
Mean – Średnia	374A	380A	375A		407B	395AB	385A	

* For explanation see Table 2 – Objaśnienia zob. tab. 2.

The fruit firmness determines their usefulness for transport and storage. Various responses of bushes were found to the fertilization used in the individual years of research. In the experiment, the greatest firmness of fruits was found in 2015 (394 G · mm^{-1} – 'Sunrise' 435 G · mm^{-1} 'Brigitta Blue'), which can also be explained by low precipitation as compared to the multi-year period and high temperatures during the pick-up. This may also have been influenced by the size of fruits. Smaller fruits, regardless of the cultivation method, are characterized by greater firmness (Ochmian and Kozos 2014). The increase in firmness is also influenced by the calcium content in fruits and it is reduced by nitrogen-containing fertilizers (Ochmian and Kozos 2015). Fruit firmness also largely depends on the cultivar and it ranged from 363 to 513 G · mm^{-1} (Ochmian et al. 2007, 2015a, b).

CONCLUSIONS

1. Urea phosphate, regardless of the dose, did not have a significant influence on the increase in the height of the bushes and the length of one-year shoots, but it stimulated bushes to produce shoots growing on roots.
2. Bushes fertilized with urea phosphate, regardless of the dose of fertilizer, were characterized by larger leaves with a higher green index, as compared with unfertilized plants.
3. The fertilization used at a dose of 60 kg N · ha^{-1}, influenced an increase in the yield and the size of fruits from both highbush blueberry cultivars.

REFERENCES

Blackmer T.M, Schepers J.S. 1994. Techniques for monitoring crop nitrogen status in corn. Commun. Soil. Sci. Plant. 25, 1791–1800.

Brazelton C. 2013. World blueberry acreage & production. North Am. Blueberry Council. 64–67.

Glonek J., Komosa A. 2004. Wpływ fertygacji makro- i mikroelementami na wzrost i plonowanie borówki wysokiej [The effect of macro- and microelements used in fertigation on growth and yield of highbush blueberry]. Rocz. AR Pozn., Ogrodnictwo 356(37), 61–66. [in Polish]

Grata K. 2013. Ecological effects of urea phosphate on soil diazotrophs in spring. Part II. Ecol. Chem. Eng. A 20(7–8), 819–825.

Grata K., Krzyśko-Łupicka T. 2008. Ekologiczne skutki działania fosforanu mocznika na diazotrofy glebowe w okresie jesiennym. Cz. I [Ecological effects of carbamide phosphate on soil diazotrophs in autumn. Part I]. Ecol. Chem. Eng. S. 15(4), 587–593. [in Polish]

Grata K., Latała A., Krzyśko-Łupicka T., Nabradalik M. 1999. Wpływ fosforanu mocznika z bentonitem na mikroflorę gnojowicy drobiowej [Effect ef urea phosphate with bentonite on microflora of poultry manure]. Med. Weter. 55(8), 546–549. [in Polish]

Gregorczyk A., Raczyńska A. 1997. Badania koleracji między metodą Arnona a pomiarami zawartości chlorofilu za pomocą chlorofilometru [Study of the correlation between Arnon's method and measurements of chlorophyll content using a chlorophyll meter]. Zesz. Nauk. AR Szczec. 181, 119–123. [in Polish]

Hachiya T., Watanabe C.K., Fujimoto M., Ishikawa T., Takahara K., Kawai-Yamada M., Uchimiya H., Uesono Y., Terashima I., KNoguchi K. 2012. Nitrate addition alleviates ammonium toxicity without lessening ammonium accumulation, organic acid depletion and inorganic cation depletion in *Arabidopsis thaliana* shoots. Plant. Cell. Physiol. 53, 577–91.

Hodge C.A., Faulkner L.C., Motes T.W. 1994. Solubulity of metallic – salt in acid nutrients in acid fertilizer solutions of urea phosphate, urea sulfate and urea nitrate. Fert. Res. 39(1), 71–75.

Jarecki W., Buczek J., Bobrecka-Jamro D. 2013. Wpływ nawożenia azotem na wielkość plonu ziarna pszenicy twardej (*Triticum durum* Desf.) [Influence of nitrogen fertilization on yield of durum wheat (*Triticum durum* Desf.)]. Fragm. Agron. 30*,* 68–75. [in Polish]

Koszański Z., Rumasz-Rudnicka E., Friedrich S. 2008. Wpływ nawadniania i nawożenia NPK na budowę anatomiczną i morfologiczną oraz plonowanie borówki wysokiej (*Vaccinium corymbosum* L.) [Anatomy, morphology and yield of highbush blueberry (*Vaccinium corymbosum* L.) under the influence of irrigation and mineral fertilization]. Acta Agrophys. 11(3), 677–684. [in Polish]

Krzbietke S., Benedycka Z. 2006. Wpływ fosforanu mocznika na właściwości fizykochemiczne substratu torfowego w warunkach laboratoryjnych [The influence of urea phosphate on the physicochemical properties of peat substrate under laboratory conditions]. Acta Agrophys. 7(4), 969–976. [in Polish]

Krzewińska D., Smolarz K., Tryngiel-Gać A. 2009. Porównanie kilku odmian borówki wysokiej i półwysokiej [Comparative studies of some highbush and half-highbush blueberry cultivars]. Zesz. Nauk. Inst. Sadow. Kwiac. 17, 5–16. [in Polish]

Krzewińska D., Smolarz K., Tryngiel-Gać A., Chlebowska D. 2010. Wpływ sposobu przygotowania gleby na wzrost i owocowanie borówki wysokiej (*Vaccinium corymbosum* L.) odmiany 'Bluecrop' [The effect of some soil cultivation practices on the growth and yield of highbush blueberry cv. 'Bluecrop']. Zesz. Nauk. Inst. Sadow. Kwiac. 18, 71–81. [in Polish]

Moore J.N. 1993. Adapting low organic upland mineral soils for culture of highbush blueberries. Acta Hort. 346, 221–229.

Nowak R., Kotula E. 1998**.** USP a new urea superphosphate fertilizer. Folia Univ. Agric. Stetin., Agricultura 72, 235–237.

Ochmian I., Grajkowski J., Ostrowska K., Mikiciuk G. 2007. Wzrost, plonowanie oraz jędrność dwóch odmian borówki wysokiej (*Vaccinium corymbosum* L.) uprawianej na trzech typach podłoży ogrodniczych [Growth, yielding and fruit firmness of two highbush blueberry cultivars cultivated on three different organic substrates]. Zesz. Nauk. Inst. Sadow. Kwiac. 15, 48–54. [in Polish]

Ochmian, I., Grajkowski, J., Skupień, K. 2008. Effect of substrate type on the field performance and chemical composition of highbush blueberry cv. Patriot. Agric. Food Sci. 19(1), 69–80.

Ochmian I., Grajkowski J., Mikiciuk G., Ostrowska K., Chełpiński P. 2009. Mineral composition of high blueberry leaves and fruits depending on substrate type used for cultivation. J. Elem. 14(3), 509–516.

Ochmian I. 2012. The impact of foliar application of calcium fertilizers on the quality of highbush blueberry fruits belonging to the 'Duke' cultivar. Not. Bot. Hort. Agrobot. Cluj Napoca 40(2), 163–169.

Ochmian I., Kozos K. 2014. Fruit quality of highbush blueberry (*Vaccinium corymbosum* L.) cv. 'Duke' depending on the method of cultivation. Folia Pomer. Univ. Technol. Stetin*.,* Agric*.,* Aliment., Pisc., Zootech. 312(31), 117–126.

Ochmian I., Kozos K. 2015. Influence of foliar fertilisation with calcium fertilisers on the firmness and chemical composition of two highbush blueberry cultIvars. J. Elem. 20(1), 185–201.

Ochmian I., Kozos K., Chełpiński P., Szczepanek M. 2015a. Comparison of berry quality in highbush blueberry cultivars grown according to conventional and organic methods. Turk. J. Agric. For. 39(2), 174–181.

Ochmian I., Kozos K., Mijowska K. 2015b. Influence of storage conditions on changes in physical parameters and chemical composition of highbush blueberry (*Vaccinium corymbosum* L.) fruit during storage. Bulg. J. Agric. Sci. 21(1), 188–193.

Pacewicz K., Gregorczyk A. 2009. Porównanie ocen zawartości chlorofilu chlorofilometrami SPAD-502 i N-Tester [Comparision values of chlorophyll content by chlorophyll meter Spad-502 and N-tester]. Folia Pomer. Univ. Technol. Stein., Agric., Aliment., Pisc., Zootech. 269(9), 49–46. [in Polish]

PN-R-04033. Gleby i utwory mineralne. Podział na frakcje i grupy granulometryczne. [in Polish]

Podsiadło C., Jaroszewska A. 2013. Wpływ nawadniania i nawożenia azotem i potasem na aktywność fotosyntetyczną wiśni [Effect of irrigation and fertilization of nitrogen and potassium on photosynthetic activity of cherry]. Infrastr. Ekol. Ter. Wiej. 2(1), 93–101. [in Polish]

Ruan J., Haerdter R., Gerendás J. 2010. Impact of nitrogen supply on carbon/nitrogen allocation: a case study on amino acids and catechins in green tea *Camellia sinensis* (L.) O. Kuntze plants. Plant Biol. 12, 724–734.

Smolarz K. 2005. Wpływ cięcia odmładzającego i nawożenia azotem na plonowanie borówki wysokiej odmiany 'Bluecrop' [The effect of rejuvenation pruning and nitrogen fertilization on the yielding of 'Bluecrop' highbush blueberry]. Zesz. Nauk. Inst. Sadow. Kwiac. 13, 83–91. [in Polish]

Starast M., Karp K., Paal T. 2002. The effect of using different mulches and growth substrates on half-highbush blueberry (*Vaccinium corymbosum* x *V. angustifolium*) cultivars 'Northblue' and 'Northcountry'. Acta Hort. 574, 281–286.

Wach D. 2008. Wpływ ściółkowania gleby materiałami organicznymi na wzrost wegetatywny borówki wysokiej (*Vaccinium corymbosum* L.) [Effect of soil mulching with some organic materials on vegetative growth of highbush blueberries (*Vaccinium corymbosum* L.)]. Kora 127(82), 123. [in Polish]

Abstract. An interest in highbush blueberry cultivation is growing in the world. An increase in the demand causes high prices of fruits. The success of cultivation depends on providing soil with a low pH value to the plants. The study specifies the influence of different doses (30 and 60 kg N · ha^{-1}) of physiologically acidic urea phosphate (17.7% N, 44.6% P_2O_5) on the growth and yield of highbush blueberry shrubs. The studies were carried out at the Department of Horticulture, West Pomeranian University of Technology in Szczecin, at a production plantation specialized in the cultivation of highbush blueberry. The bushes were planted in soil classified as sandy silts with the content of organic matter at 4.1–4.2%. The following parameters were measured in autumn: the height of the bushes, the length of one-year growths, the number of one-year shoots growing on roots, the green index, leaf area and yield, fruit weight and firmness. The use of urea phosphate influenced the increase in the yield and size of fruits of both highbush blueberry cultivars, it did not, however, influence the increase in the height of bushes and the length of one-year shoots. It stimulated the plants to produce shoots growing on roots and the formation of larger leaves with a higher green index value as compared to unfertilized plants.