ACTA SCIENTIARUM POLONORUM *Acta Sci. Pol., Hortorum Cultus 11(1) 2012, 205-214*

EFFECT OF FOLIAR FERTILIZATION ON YIELDING AND LEAF MINERAL COMPOSITION OF HIGHBUSH BLUEBERRY (*Vaccinium corymbosum* L.)

Dariusz Wach, Marzena Błażewicz-Woźniak
University of Life Sciences in Lublin

Abstract: Foliar fertilization is fairly frequently applied besides to fertilization to the roots. In the years 2003–2005 a study was conducted on the effect of foliar feeding with phosphorus on the yielding and content of mineral element in leaves of highbush blueberry. The experiment was conducted on a production plantation, on 10-year old bushes of 'Bluecrop'. The foliar fertilizer Insol Fos was applied at 4 concentrations: control – 0%; 0.4%, 0.8% and 1.2%, several times at intervals of every week (7×), every 2 weeks (4×), and every 3 weeks (3×). The first treatment was applied at the beginning of the 3rd decade of May and the final one at the beginning of July, minimum 7–10 days prior to the first harvest of berries. Foliar sprays with Insol Fos had a positive effect on the yielding of highbush blueberry, but it had no effect on the weight of 100 fruits. The highest concentration of the fertiliser proved to be the most effective. Irrespective of the concentration applied, in the years of the experiment the best yielding were those plants that were foliar-applied every 2 weeks. Foliar fertilization with the fertilizer Insol Fos had a varied effect on the content of mineral elements in the leaves of highbush blueberry, causing a significant increase in the content of N, P and Mg, and a decrease in the concentration of K and Ca.

Key words: *Ericscese*, fruit yield, phosphorus, macroelements

INTRODUCTION

Fertilization applied to the roots of plants is the basic method of supplying plants with nutrients. If the level of nutrients in the soil environment is insufficient, or it becomes retarded and unavailable to plants, it decreases in yield and deterioration of its quality [Michałojć and Szewczuk 2003]. The availability of nutrients from the soil may be limited even under the conditions of its optimum fertility, e.g. due to incorrect soil reaction, ionic antagonism, or unfavourable weather conditions [Czuba 1993]. Addi-

Corresponding author – Adres do korespondencji: Dariusz Wach, Department of Cultivation and Fertilization of Horticultural Plants, University of Life Sciences in Lublin, ul. Leszczyńskiego 58, 20-068 Lublin, e-mail: dariusz.wach@up.lublin.pl

tional fertilization via ways other than through the roots is a simple, fast and effective method of supplying plants with mineral contents [Wójcik 2004]. In the opinion of many researchers, in future it will be common practice to apply combined fertilization to the roots and via other way [Byszewski and Sadowska 1974, Tukey and Marczyński 1984, Zaniewicz-Bajkowska et al. 2010]. In the cultivation of orchard plants the nutrient most frequently used for extra-root fertilization and for facilitation of absorption of other substances applied on leaves and fruits is nitrogen in the form of urea. Moreover, in the initial period of vegetation it is recommended to apply boron, and in later periods also magnesium, iron, manganese and zinc. Whereas, calcium has a particular importance in the fertilization of apple, pear, cherry and sweet cherry trees [Michałojć 2008]. In the recent decade, studies were conducted on foliar fertilization of various *Vaccinium* cultivars with nitrogen and phosphorus [Szwonek 2003, Smagula and Kreider 2009], boron [Hanson 2000, Wójcik 2005] and calcium [Stuckrath et al. 2009] were conducted.

Highbush blueberry has specific soil requirements. It grows best on light, humus, acid and warm soils [Pliszka 2002]. Compared to other cultivated plants, highbush blueberry has low nutrition requirements [Smolarz 1996]. In acid and very acid soils, preferred by highbush blueberry, phosphorus undergoes retardation and even though chemical analyses of soil indicate high levels of the element, the leaves may have a low content of phosphorus [Wach 1998].

The objective of the study presented here was determination of the effect of foliar fertilization with phosphorus on the yield and content of macroelements in the leaves of highbush blueberry.

MATERIAL AND METHOD

In the years 2003–2005 a study of the effect of foliar fertilization with phosphorus on the yielding and content of mineral elements in leaves of highbush blueberry was conducted. The experiment was conducted on a production plantation established on a soil developed from weakly loamy sand, with pH_{KCl} 3.50 and a low humus content (1.2%). Every year fertilization was applied at doses of 60 kg N, 50 kg K_2O, 10 kg MgO (in the form of sulphates). Phosphorus fertilization was not applied as a high level of phosphorus was determined in the soil.

Ten-year old bushes of 'Bluecrop' were growing at spacing of 2 × 1 m. The rows of the plants were mulched with sawdust, and sward was maintained in the inter-rows. The plantation was irrigated.

The study on the effect of foliar fertilization with phosphorus on the yielding and content of mineral nutrients in leaves of northern highbush blueberry was conducted with the use of the foliar fertilizer Insol Fos with the following composition: amide nitrogen – 3% N; phosphorus (orthophosphate) 24.5% P_2O_5; iron – 0.03% Fe – chelate.

The factors of the experiments were:

– fertilizer concentration: control – 0%; 0.4%; 0.8%; 1.2%

– frequency of application (spraying): weekly (7×); every 2 weeks (4×); every 3 weeks (3×).

The spraying was applied in late afternoon hours, using 4 litres of working liquid for each experimental treatment, till complete wetting of the plants. The first treatment was made in the beginning of the 3rd decade of May, and the last one in the beginning of July, at least 7–10 days before the first harvest of berries. Each experimental treatment had 4 replications, and the experimental unit was a plot with five bushes.

Every year of the experiment determinations of the yield and the weight of 100 berries, individually for every harvest were made. The levels of phosphorus and potassium in the soil were determined with the Egner-Riehm method, the content of magnesium with the method of Schachtschabel, and the pH of the soils was determined in 1 n KCl.

In the first decade of August samples of leaves were taken for nutrient content analysis. The sample was 3rd – 4th – 5th leaf from the tip of annual shoots collected from 20 plants.

The leaf samples were subjected to determination of the contents of:

– total nitrogen, with the Kjeldahl method,

– phosphorus, with the colorimetric method,

– potassium, magnesium and calcium – with the ASA method.

The results were evaluated by analysis of variance. The significance of differences was estimated using the Tukey test of confidence at the significance level of $\alpha = 0.05$.

RESULTS

The climatic conditions prevailing during the period of the experiment are presented in table 1.

Table 1. Mean monthly air temperatures and amount of precipitation in ES Felin in years 2003–2005
Tabela 1. Średnie miesięczne temperatury i sumy opadów w GD Felin w latach 2003–2005

	Year Rok	Month – Miesiąc												
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	mean
Average temperature Średnia temperatura °C	2003	-3.4	-6.2	1.6	6.5	16.3	17.4	19.8	18.9	13.5	5.3	4.9	0.2	7.9
	2004	-5.6	-1.0	2.8	7.9	11.9	15.8	18.1	18.3	12.8	9.8	3.1	1.5	8.0
	2005	0.0	-3.9	-0.1	9.1	13.2	16.0	19.8	16.9	14.9	8.8	2.7	-0.8	8.1
	mean for 1951–2000	-3.6	-2.8	1.0	7.5	13.0	16.5	17.9	17.3	12.9	7.9	2.5	-1.4	7.4
Amount of precipitation Suma opadów mm	2003	23.2	25.0	6.6	40.7	71.4	39.6	98.1	27.0	29.0	50.1	17.0	36.3	464.0
	2004	32.7	52.5	33.9	38.1	38.0	49.9	90.5	48.5	14.2	19.1	58.2	17.1	492.7
	2005	41.6	25.0	48.0	18.6	98.0	55.9	109.8	108.7	18.0	8.6	21.1	54.5	608.4
	mean for 1951–2000	21.7	24.8	25.8	40.6	58.3	65.8	78.0	69.7	52.1	40.3	39.1	31.5	547.7

From May till September 2003 the air temperatures recorded were higher than the long-term average, the warmest month was July. The coldest months were February 2003, January 2004, and February of the last year of the experiment. During the study period the highest annual sum of precipitations was characteristic of the final year of the

experiment, due to the plentiful rainfalls in July, August, May, December, March and January. The monthly sums of precipitation of the month of July were the highest in each of the years of the experiment, their values exceeding the long-term average.

The mean levels of mineral nutrients in the soil (in 100 g of $soil^{-1}$) were presented in table 2. The soil had high level of phosphorous, low of potassium and medium level of magnesium.

Table 2. Soil reaction (pH_{KCl}) and content of nutrient element in layer 0–20 cm in year 2003–2005
Tabela 2. Odczyn gleby (pH_{KCl}) i zawartość składników pokarmowych w warstwie 0–20 cm w latach 2003–2005

Year – Rok	Soil reaction Odczyn gleby	Nutrient – Składnik mg 100 g $soil^{-1}$ – mg100 g $gleby^{-1}$		
	pH_{KCl}	P	K	Mg
2003	3.54	8.5	3.7	2.3
2004	3.48	8.3	2.8	2.7
2005	3.45	8.0	4.4	2.7
Mean – Średnio	3.49	8.3	3.6	2.6

The yielding of highbush blueberry foliar fertilized with Insol Fos in the period of 2003–2005 is presented in table 3. During the period of the experiment an increased in the yielding of highbush blueberry was observed. Irrespective of all the experimental factors, significantly higher yields were obtained in the third and second, as well as in the first year of the study.

The study showed a significant effect of foliar fertilization on the level of yields. Irrespective of the spraying frequency, significantly the highest yield of berries was obtained applying the fertilization with the highest concentration of the fertiliser (1.2%), but no significant differences were obtained between the levels of its concentration. Irrespective of the concentration applied, the best yielding were highbush blueberry bushes foliar application at 2-week intervals.

Foliar fertilization with Insol Fos had no significant effect on the weight of 100 fruits of northern highbush blueberry (tab. 3). Statistical analysis revealed only a combined statistically significant effect of the year of experiment and of fertiliser concentration on the level of the parameter examined. It was only noted that, irrespective of the year of the study, the weight of 100 fruits of foliar-applied bushes of highbush blueberry was higher than the control treatment.

The levels of mineral nutrients in the leaves of highbush blueberry in the years 2003–2005 are presented in tables 4 and 5.

Nitrogen. Statistical analysis showed significant differences between the years of the study, spraying frequency, and concentrations of the fertilizer used for foliar fertilization of northern highbush blueberry. Significantly the highest content of nitrogen was recorded in the leaves of Insol-sprayed blueberry in the second year of the study, and the lowest in the final year. Spraying with Insol Fos had a significant positive effect on the content of nitrogen in the leaves when the treatment was performed at 2 and 3-week

Table 3. Efect of foliar fertilizer Insol Fos on yield and weight of 100 fruits of highbush blueberry

Tabela 3. Wpływ dokarmiania dolistnego nawozem Insol Fos na plon i masę 100 owoców borówki wysokiej

Treatment – Kombinacja		Yield – Plon kg bush^{-1} – kg krzew^{-1}				Weight of 100 friuts Masa 100 owoców, g			
Frequency of spraying Częstotliwość oprysku	Concentration Stężenie %	2003	2004	2005	mean średnio	2003	2004	2005	mean średnio
	0	0.82	1.99	2.48	1.76	143.8	217.8	205.8	189.1
Every week Co tydzień	0.4	1.19	3.47	2.95	2.54	151.0	213.8	210.3	191.2
	0.8	0.77	2.51	2.84	2.04	230.0	218.5	208.5	219.0
	1.2	1.30	3.25	3.02	2.52	212.0	214.3	210.5	212.3
	mean	1.02	2.81	2.82	2.22	184.2	216.1	208.8	203.0
Every 2 weeks Co 2 tygodnie	0.4	1.94	4.66	3.95	3.52	198.0	224.8	220.3	214.3
	0.8	1.35	4.34	4.00	3.23	206.0	200.8	194.5	200.4
	1.2	2.15	3.38	3.50	3.01	197.3	188.5	189.5	191.8
	mean	1.56	3.59	3.48	2.88	186.3	207.9	202.5	198.9
Every 3 weeks Co 3 tygodnie	0.4	0.87	2.10	2.40	1.79	203.8	184.3	200.8	196.3
	0.8	0.46	2.97	2.91	2.11	212.8	180.3	186.7	193.3
	1.2	1.39	3.62	3.58	2.86	209.8	179.0	189.5	192.8
	mean	0.88	2.67	2.84	2.13	192.5	190.3	195.7	192.8
Mean Średnia	0.4	1.33	3.41	3.10	2.62	184.3	207.6	210.4	200.8
	0.8	0.86	3.27	3.25	2.46	216.3	199.8	196.6	204.2
	1.2	1.61	3.42	3.37	2.80	206.3	193.9	196.5	198.9
	mean	1.27	3.37	3.24	2.63	202.3	200.4	201.2	201.3
Mean – Średnia		1.16	3.02	3.05	2.41	187.6	204.8	202.3	198.2
$NIR_{0.05}$ for: – $NIR_{0,05}$ dla:									
Years – Lat (A)					0.61				n.s.
Frequency of spraying – Częst. oprysku (B)					0.61				n.s.
Concentration – Stężenia (C)					0.77				n.s.
A × B					n.s.				n.s.
A × C					n.s.				64.10
B × C					n.s.				n.s.
A × B × C					n.s.				n.s.

intervals, compared to the control and to weekly spraying. Irrespective of the years and the spraying frequency, even the lowest concentration of the fertiliser had a significant effect on the concentration of nitrogen in the leaves of highbush blueberry compared to the control treatment. Moreover, a significant difference was noted between the lowest concentration of the fertiliser and the other concentration levels.

Phosphorus. The content of phosphorus in the leaves of northern highbush blueberry varied significantly between the years of the study. The highest levels of phosphorus were found in blueberry leaves in 2003 and the lowest in the following year. Statistical analysis revealed a significant effect of foliar fertilization with Insol Fos on the concentration of that element in the leaves relative to the control treatment, and no significant differences among the fertiliser concentrations applied and the spraying frequencies.

Table 4. Effect of foliar fertilizer Insol Fos on the N, P and K content in the leaves of highbush blueberry

Tabela 4. Wpływ dokarmiania dolistnego nawozem Insol Fos na zawartość N, P i K w liściach borówki wysokiej

Treatment – Kombinacja		Nutrient in % d.m. – Składnik w % s.m.											
		N				P				K			
Frequency of spraying Częstotliwość oprysku	Concentration Stężenie %	2003	2004	2005	mean	2003	2004	2005	mean	2003	2004	2005	mean
	0	1.84	1.94	1.74	1.84	0.10	0.08	0.08	0.09	0.46	0.40	0.62	0.49
Every week Co tydzień	0.4	1.94	1.90	1.68	1.84	0.14	0.08	0.10	0.11	0.41	0.29	0.55	0.42
	0.8	1.90	1.99	1.79	1.89	0.14	0.09	0.10	0.11	0.46	0.29	0.47	0.41
	1.2	1.89	1.94	1.79	1.87	0.12	0.08	0.09	0.10	0.48	0.36	0.48	0.44
	mean	1.89	1.94	1.75	1.86	0.12	0.08	0.09	0.10	0.45	0.33	0.53	0.44
Every 2 weeks Co 2 tygodnie	0.4	1.94	2.08	1.73	1.91	0.10	0.08	0.10	0.10	0.41	0.36	0.54	0.43
	0.8	1.87	1.94	1.77	1.86	0.10	0.09	0.10	0.10	0.41	0.43	0.57	0.47
	1.2	1.98	2.07	1.77	1.94	0.12	0.08	0.10	0.10	0.41	0.29	0.50	0.40
	mean	1.90	2.01	1.75	1.89	0.11	0.09	0.10	0.10	0.42	0.37	0.56	0.45
Every 3 weeks Co 3 tygodnie	0.4	1.84	1.98	1.72	1.84	0.11	0.10	0.09	0.09	0.39	0.25	0.52	0.39
	0.8	1.92	2.16	1.74	1.94	0.14	0.09	0.10	0.11	0.40	0.37	0.53	0.43
	1.2	1.97	2.09	1.73	1.93	0.13	0.09	0.09	0.10	0.41	0.31	0.52	0.41
	mean	1.89	2.04	1.73	1.89	0.12	0.08	0.09	0.10	0.41	0.33	0.54	0.43
Mean Średnia	0.4	1.91	1.98	1.71	1.87	0.12	0.09	0.10	0.10	0.40	0.30	0.54	0.41
	0.8	1.90	2.03	1.77	1.90	0.13	0.09	0.10	0.10	0.42	0.36	0.52	0.43
	1.2	1.95	2.03	1.76	1.91	0.12	0.08	0.09	0.10	0.43	0.32	0.50	0.42
	mean	1.92	2.01	1.75	1.89	0.12	0.09	0.10	0.10	0.42	0.33	0.53	0.42
Mean – Średnia		1,89	2.00	1.74	1.88	0.12	0.08	0.09	0.10	0.43	0.34	0.54	0.44
$NIR_{0.05}$ for: – $NIR_{0,05}$ dla:													
Years – Lat (A)					0.02				0.01				0.03
Frequency of spraying – Częst. oprysku (B)					0.02				n.s.				n.s.
Concentration – Stężenia (C)					0.03				0.01				0.04
A × B					0.05				0.01				n.s.
A × C					0.06				0.01				n.s.
B × C					0.06				0.01				n.s.
A × B × C					0.12				0.02				n.s.

Potassium. Content of potassium in the leaves on blueberry in the years 2003–2005 are presented in table 4. The lowest potassium concentration was recorded in 2004, and the highest in the final year of the study. Leaves of highbush blueberry foliar-fertilizated with Insol Fos had a significantly lower content of potassium than the control treatment. No significant differences were revealed among the concentrations of Insol Fos (0.4–1.2%). The highest level of potassium was recorded in the leaves of highbush blueberry grown in the control treatment in 2005.

Magnesium. Statistical analysis showed significant differences between the years of the study, fertilizer concentrations, interaction between the years and the frequency of foliar fertilization with Insol Fos, and interaction between the years and the fertilizer concentration. The highest levels of magnesium in blueberry leaves were recorded in

2004 and 2005 compared to 2003. Irrespective of the years of the study and the frequency of spraying, the highest levels of magnesium were found in leaves of plants foliar-sprayed with Insol Fos at concentrations of 0.8 and 1.2%, compared to the lowest concentration of the fertilizer and the control treatment.

Table 5. Effect of foliar fertilizer Insol Fos on Mg and Ca content in the leaves of highbush blueberry

Tabela 5. Wpływ dokarmiania dolistnego nawozem Insol Fos na zawartość Mg i Ca w liściach borówki wysokiej

Treatment – Kombinacja		Nutrient in % d.m. – Składnik w % s.m.							
		Mg				Ca			
Frequency of spraying Częstotliwość oprysku	Concentration Stężenie %	2003	2004	2005	mean	2003	2004	2005	mean
	Kontrola 0	0.11	0.12	0.15	0.12	0.32	0.19	0.29	0.26
Every week Co tydzień	0.4	0.12	0.12	0.13	0.12	0.13	0.18	0.25	0.18
	0.8	0.12	0.14	0.13	0.13	0.15	0.27	0.24	0.22
	1.2	0.12	0.14	0.12	0.13	0.13	0.28	0.21	0.21
	mean	0.12	0.13	0.13	0.12	0.18	0.23	0.24	0.22
Every 2 weeks Co 2 tygodnie	0.4	0.12	0.13	0.13	0.12	0.14	0.17	0.22	0.17
	0.8	0.11	0.12	0.15	0.13	0.12	0.22	0.31	0.22
	1.2	0.13	0.15	0.13	0.14	0.15	0.32	0.26	0.24
	mean	0.12	0.13	0.14	0.13	0.18	0.22	0.27	0.22
Every 3 weeks Co 3 tygodnie	0.4	0.10	0.14	0.13	0.12	0.09	0.26	0.22	0.19
	0.8	0.11	0.14	0.13	0.13	0.11	0.24	0.21	0.18
	1.2	0.13	0.16	0.14	0.14	0.12	0.28	0.24	0.21
	mean	0.11	0.14	0.13	0.13	0.16	0.24	0.24	0.21
Mean Średnia	0.4	0.11	0.13	0.13	0.12	0.12	0.20	0.23	0.18
	0.8	0.11	0.13	0.13	0.13	0.13	0.24	0.25	0.21
	1.2	0.13	0.15	0.13	0.13	0.13	0.29	0.23	0.22
	mean	0.12	0.14	0.13	0.13	0.13	0.24	0.24	0.20
Mean – Średnia		0.11	0.13	0.13	0.13	0.17	0.23	0.25	0.22
$NIR_{0.05}$ for: – $NIR_{0,05}$ dla:									
Years – Lat (A)					0.01				0.02
Frequency of spraying – Częst. oprysku (B)					n.s.				n.s.
Concentration – Stężenia (C)					0.01				0.03
A × B					0.01				r.n.
A × C					0.02				0.06
B × C					n.s.				n.s.
A × B × C					n.s.				n.s.

Calcium. The content of calcium in blueberry leaves increased significantly during the period of the experiment. Leaves of bushes foliar-sprayed with Insol Fos had a significantly lower calcium content than the control plants. Irrespective of the years and the frequency of foliar treatment application, the lowest level of calcium was recorded in the leaves of highbush blueberry sprayed with Insol Fos at concentration of 0.4%.

DISCUSSION

Atmospheric conditions, as environmental factors, have an effect on the properties of cuticular membrane, on the physiological processes of plants and on the properties of the solution, and thus play an important role in the process of absorption of mineral components by the cells of the leaf epidermis [Wójcik 1998].

Although this study was conducted on a plantation that bushes were at full fruit-bearing, it demonstrated a positive effect of extra-root fertilization with the Insol Fos fertilizer on the yielding of highbush blueberry. The average yields per bush in the second and third years of the study exceeded 3 kg, while those obtained in the control treatment were 1.99 and 2.48 kg, respectively. In the experiment involving the evaluation of highbush blueberry cultivars on the same plantation, in the period from 3 to 6 years since planting the mean yield per bush was 1.79 kg of berries [Wach 2008]. Szwonek [2003] conducted an experiment with foliar fertilization of two-year old plants of blueberry cv. 'Bluecrop' with the fertilizer Basfoliar (12-4-6+ micro), applied twice at a concentration of 0.3%. Foliar fertilization of blueberry with Basfoliar, applied twice, can be a substitute for a 100 kg lower dose of fertilisers applied to the soil. Starast et al. [2002] obtained a higher yield and higher weight of fruit of lowbush blueberry under the effect of foliar fertilization. In a study by Smagula and Kreider [2002] foliar fertilization with NPK did not cause any increase in the yielding of low bush blueberry compared to ammonium phosphate fertilization applied to the soil.

Chemical analyses of the blueberry leaves revealed nutrients levels varying in the particular years, determined by the climatic conditions. In the experiment with foliar fertilization with Insol Fos a significant effect of the treatment on the concentration of macroelements in leaves of highbush blueberry was observed. In the study was increased the concentration of N, P and Mg and a decrease in the content of K and Ca in the leaves. In the year with the highest yields and the highest precipitation sums the lowest nitrogen content in leaves was observed, but the highest of potassium and calcium. Gruca and Stojek [1994] demonstrated a decrease in the levels of N, P, K and Ca in leaves under the effect of irrigation. Szwonek [2003], under the effect of foliar spraying with Basfoliar, obtained an increase in the levels of N, P and K and a decrease of concentration of Mg only in the case when a reduced dose of the fertilizer Nitrophoska Perfekt was applied to the soil, which indicates that foliar fertilization may be effective at lower levels of fertilization applied to the soil and thus contribute to environmental protection.

CONCLUSIONS

1. It was found greater differences in yield and mineral concentration in leaves between years of study than foliar fertilization
2. Foliar fertilization with Insol Fos had a significant effect on the concentration of phosphorus in the leaves of highbush blueberry, though no differences were shown within the range of concentrations..

3. Leaves of plants subjected to foliar fertilization were characterised by significantly higher levels of N and Mg and lower content of K and Ca.

4. Foliar spraying with Insol Fos had a positive effect on the yielding of highbush blueberry but it had no effect on the weight of 100 fruits.

REFERENCES

Byszewski W., Sadowska A., 1974. Piśmiennictwo dotyczące dolistnego dokarmiania roślin. Zesz. Probl. Post. Nauk. Roln., 143, 15–41.

Czuba R., 1993. Regeneracyjne nawożenie gleby silnie wyczerpanej ze składników pokarmowych. Roczn. Gleb., 44, 1, 57–64.

Gruca Z., Stojek B., 1994. Wpływ nawożenia i nawadniania na zawartość składników mineralnych w liściach borówki wysokiej. XXXIII Ogólnopolska Konferencja Sadownicza, cz. II, 289–290.

Hanson E.J., 2000. Foliar boron sprays do not affect highbush blueberry productivity. Small Fruits Rev. 1,1, 35–41.

Michałojć Z. M., 2008. Zasady pozakorzeniowego dokarmiania roślin w uprawach ogrodniczych. Konf. Nauk. „Dokarmianie dolistne", 11–12.

Michałojć Z., Szewczuk C., 2003. Teoretyczne aspekty dolistnego dokarmiania roślin. Acta Agrophysica, 85, 9–18.

Pliszka K., 2002 (ed). Borówka wysoka. PWRiL.

Smagula. M., Kreider L., 2009. Effect of timing of N and Phi foliar sprays on lowbush blueberry leaf nutrient concentrations, growth and yield. Acta Hort. 810/2, 733–740.

Smolarz K., 1996. Wpływ wieloletniego nawożenia mineralnego na wzrost i plonowanie kilku gatunków roślin jagodowych. Zesz. Nauk. ISK, Monografie i Rozprawy, 28–53.

Starast M., Karp K., Noormets M., 2002. The effect of foliar fertilisation on the growth and yield of lowbush blueberry in Estonia. Acta Hort. 574, 679–684.

Stuckrath R., Quevedo R., Fuente L. de la, Hernandez A., Sepulveda V., 2009. Effect of foliar application of calcium on the quality of blueberry fruits. J. Plant Nutrit. 31:7, 1299–1312.

Szwonek E., 2003. Dolistne dokarmianie borówki wysokiej odmiany Bluecrop. Konf. Nauk. „Uprawne rośliny wrzosowate" Skierniewice, 22–24 maja. 54–59.

Tukey H.B., Marczyński S., 1984. Foliar nutrition – old ideas rediscovered. Acta Hort., 145, 205–212.

Wach D., 1998. Zawartość składników pokarmowych w liściach kilku odmian borówki wysokiej (*Vaccinium corymbosum* L.) uprawianej na glebie mineralnej o niskiej zawartości próchnicy. VII Konf. Nauk. „Efektywność stosowania nawozów w uprawach ogrodniczych" Lublin, 8–9 czerwca, 247–250.

Wach D., 2008. Estimation of growth and yielding od highbush blueberry (*Vaccinium corymbosum* L.) cultivated on soil developed from weakly loamy sand. Folia Hort. 20/2, 47–55.

Wójcik P., 1998. Pobieranie składników mineralnych przez części nadziemne roślin z nawożenia pozakorzeniowego. Post. Nauk Roln. 1, 49–64.

Wójcik P., 2004. Uptake of mineral nutrients from foliar fertilization. J. Plant Res., 12, Special ed., 201–218.

Wójcik P., 2005. Response of Bluecrop highbush blueberry to boron fertilization. J. Plant Nutrit. 28, 11, 1897–1906.

Zaniewicz-Bajkowska A., Kosterna E., Franczuk J., Rosa R., 2010. Field quality of melon (*Cucumis melo* L.) depending on foliar feeding. Acta Sci. Pol. Hortorum Cultus, 9(1), 55–63.

WPŁYW DOKARMIANIA DOLISTNEGO NA PLONOWANIE I ZAWARTOŚĆ SKŁADNIKÓW MINERALNYCH W LIŚCIACH BORÓWKI WYSOKIEJ (*Vaccinium corymbosum* L.)

Streszczenie. Dokarmianie dolistne jest dość często stosowane obok nawożenia dokorzeniowego. W latach 2003–2005 przeprowadzono badania nad wpływem dokarmiania dolistnego fosforem na plonowanie i zawartość składników mineralnych w liściach borówki wysokiej. Doświadczenie przeprowadzono na plantacji towarowej, na 10-letnich krzewach odmiany Bluecrop. Nawóz dolistny Insol Fos zastosowano w 4 stężeniach: kontrola – 0%; 0,4%; 0,8%; 1,2%; kilkakrotnie w odstępach: co tydzień (7×); co 2 tygodnie (4×); co 3 tygodnie (3×). Pierwszy zabieg wykonywano na początku 3 dekady maja, ostatni na początku lipca, przynajmniej na 7–10 dni przed pierwszym zbiorem jagód. Dokarmianie dolistne nawozem Insol Fos wpłynęło dodatnio na plonowanie borówki wysokiej, ale nie miało wpływu na masę 100 owoców. Najefektywniejsze okazało się najwyższe stężenie nawozu. Niezależnie od zastosowanego stężenia w każdym roku badań najlepiej plonowały rośliny dokarmiane co 2 tygodnie. Dokarmianie dolistne nawozem Insol Fos miało zróżnicowany wpływ na zawartość składników mineralnych w liściach borówki wysokiej. Istotnie wzrastała zawartość w liściach N, P i Mg natomiast zmniejszała się koncentracja K i Ca.

Słowa kluczowe: *Ericaceae*, plon owoców, fosfor, makroskładniki

Accepted for print – Zaakceptowano do druku: 25.11.2011