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EFFECT OF POLLINATION MODE ON FRUIT SET IN BLUE HONEYSUCKLE (*Lonicera caerulea* L.)

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ABSTRACT

Honeyberry's popularity has been increasing because of its valuable traits: nutritional value of fruits (a high amount of ascorbic acid, potassium and polyphenolic compounds), early ripening (14 days before strawberry), exceptional hardiness and easy cultivation. However, there is still little known about the pollination biology of this species, which is essential for practical breeding purposes. In this study we evaluated pollen fertility in five cultivars and three breeding clones of this species. The impact of the manner of pollination on the fruit set and forming seeds has also been studied. The highest percentage of viable pollen was found in cultivars 'Duet' and 'Wojtek' (96%), whereas the pollen of 'Chelyabinka' cultivar had the lowest fertility (90%). The percentage of blue honeysuckle fruits obtained from open-pollinated flowers was high (on average 94.7%) compared to isolated flowers (on average 8.6%). The effect of cross-pollination with cv. 'Duet' indicates that the percentage of the fruit set, fruit weight and mass of produced seeds was higher when this cultivar was applied as maternal than paternal form. The number of seeds affected significantly the weight of the fruit in the case when cv. 'Duet' was used as a paternal (correlation coefficient r = 0.45) or maternal form (r = 0.66), while for other methods of pollination this effect was insignificant. These results may be used to the most efficient establishment of plantations as well as for the realization of the breeding program of this valuable species.

Key words: cross-pollination, self-pollination, honeyberry, fruit set

INTRODUCTION

Blue honeysuckle (*Lonicera caerulea* var. *kamtschatica*), also known commercially as haskap or honeyberry, is an early flowering (April–May), temperate fruiting shrub native to northern parts of Europe, Asia and North America. Blue honeysuckle belongs to fruit species with unique biological and chemical properties. Major positive features are extra early ripening, outstanding frost resistance of plants and flowers, and a high content of flavonoids and other bioactive substances [Plekhanova 2000]. A high total polyphenolic content and antioxidant activity are typical of blue honeysuckle berry [Zadernowski et al. 2005, Kusznierewicz et al. 2012] and determines the edible value and health benefits of this plant. The multiple therapeutic effects of *Lonicera* berries include reducing blood pressure, decreasing the risk of heart attack, preventing osteoporosis and anemia, preventing hyperactivity in children, providing curative effect for malaria and gastrointestinal disorders, and slowing the aging process [Svarcowa et al. 2007, Małodobry et al. 2010, Jurikova et al. 2012].

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For a long time berries have been harvested from wild plants in the regions of Russia, China, and Japan. During the past several decades, research in Russia and Japan has resulted in cultivars being selected for commercial production [Thompson and Chaovanalikit 2003]. The evaluation of breeding materials also took place in Romania [Truta et al. 2013] and Estonia [Arus and Kask 2007]. Moreover, a comprehensive program of research on this species is being carried out at the University of Saskatchewan in Canada [Bors 2015]. These works on haskap cultivation have focused largely on the shape, taste and harvest ability of this fruit. However, despite honeysuckle is self-incompatible and requires other genotypes for cross-pollination [Hummer 2006], very little is currently known about its floral biology or pollinator specializations in particular cultivars. Studies of cultivars grown in Poland have found that it produces abundant pollen and nectar that is favored by honey bees and bumble bees, as well as a variety of solitary bees [Bożek 2007].

Information on the manner of pollination, pollen germination, ovule fertilization, as well as other important aspects of anthesis will help refine and optimize the pollination strategy for this crop and ultimately help growers to maximize commercial yield. The determination of percent fruit set is a tool which every grower would benefit from. Percent fruit set refers to the percentage of blossoms which end up forming fruits.

The purpose of this study was to examine the effects of the manner of pollination on the percentage and weight of fruit set, as well as the number and weight of formed seeds in the honeyberry fruit. The influence of pollen fertility on these processes in particular genotypes was also tested. Investigated cultivars and clones planted in Department of Genetics and Horticultural Plant Breeding collection were chosen due to their good fruit quality and suitability to Polish climatic conditions.

MATERIALS AND METHODS

The research material consisted of a diverse group of genotypes including breeding clones ‘Clone Nr 9’, ‘P’ and ‘T2’, cultivars of Polish origin ‘Duet’, ‘Warszawa’, ‘Wojtek’ and Russian origin ‘Chelyabinka’ and ‘Volshebnitsa’. Cultivars ‘Chelyabinka’ and ‘Volshebnitsa’ (selected from open pollinated seedlings of cv. ‘Smolinskaya’) were selected in the South Ural Research Institute of Horticulture and Potato Cultivation [Naugžemys et al. 2011, Król-Dyrek 2017]. ‘Wojtek’ and ‘Duet’ cultivars were selected in the conditions of northern Poland by Zofia and Hieronoim Łukaszewski from seedlings derived from the open pollination of cultivars of this species imported from Russia [Pluta 2015]. The origin of the other genotypes is unknown, probably like most of the cultivars have been selected as seedlings from the open pollination. These plants were obtained from Experimental Station of The Research Institute of Horticulture in Brzezna and grown at the Felin Experimental Station, eastern Poland (N 51°13', E 22°39') since spring 2007. The aim of the experiment was to determine the effect of the method used for pollination of flowers on fruit set (expressed as % of fruit in relation to the pollinated flowers), single fruit weight (g), number of seeds per fruit (pc) and seed weight (mg, per 100 pieces). For this purpose on the plants of each genotype 25 flowers were marked in 4 replicates and remained accessible to pollinating insects throughout the entire flowering period (open-pollinations). The same number of flowers for each genotype was self-pollinated by isolating them with paper bags. Moreover, ‘Duet’ cultivar was used as a maternal and paternal component and cross-pollinated with the rest of clones and cultivars. Each combination of cross-pollination consisted of 25 flowers in 4 replications. Cross-pollinations were made in 2014–2015 while self and open-pollinations in 2014–2016. Those open- and self-pollination effects of tested set of genotypes were assessed as well as cross-pollination effects for cultivar ‘Duet’ used as a maternal and paternal form, according to formula presented by Ubysz-Borucka et al. [1985] for reciprocal crosses. There was also an estimate of yield expressed as the weight of fruit obtained from the pollination of 100 flowers for each method of pollination according to the formula (1): fruit yield = number of fruit set (pc.) × average fruit weight (g). Prior to that, pollen from each genotype was collected and microscopic preparations were made to assess pollen viability. Slides were colored with 2% solution of acetocarmin and glycerin (1 : 1) and examined using the Olympus BX41 microscope under magnification 400×. In every combination 100 grains in 10 fields of vision were analyzed (the microscopic slide). Pollen grains with 75–100% content of cytoplasm were taken as vital. Means for analyzed traits were evaluated for significant differences using Duncan's and t tests with $\alpha = 0.05$. Correlation, multiple regression and cluster analyses were carried out to determine the relationship between the analyzed characteristics and genotypes. Statistical analyses were performed using Statistica 13.1 [2017] software (StatSoft Polska).

RESULTS

The analysis of the effect of the method of pollination on fruit set in blue honeysuckle clearly indicates the negative consequences of self-pollination process (tab. 1.) Although the pollen viability was high – on average 93.7% (the highest in the 'Duet' cultivar, the lowest in the 'Chelyabinka' cultivar), the selfed genotypes formed only from 1 to 20% of fruit (on average 8.6%). In this respect they differed significantly in relation to open-pollination and cross-pollination of cultivar 'Duet'. The use of this method of pollination caused a decrease in fruit set on average by 90% compared to the open-pollination. The most extreme effects of inbreeding depression occurred in two cultivars ('Chelyabinka', 'Warszawa') and two advanced clones ('T2', 'Nr 9'). On the other hand, the share of fruit-bearing flowers resulted from open-pollination was high and ranged from 86 to 100%. Only two of the tested cultivars ('Volshebnitsa' and 'Chelyabinka') were characterized by significantly lower percentage of fruit set. Analyzed characteristics in cross-pollination depended on the use of cultivar 'Duet' as a paternal or maternal component. Significantly higher results were obtained when this cultivar was regarded as a maternal (49.3%) than as a paternal form (37.9%) and therefore most of the reciprocal effects are positive. Among them, those statistically significant involved combinations of cross-pollination of the maternal cultivar 'Duet' with the cultivar 'Wojtek' as well as 'Nr 9' and 'T2' clones.

Table 1. Percentage of fruit set after self-, open- and cross-pollination

Cultivar/ Clone	Pollen viability	Method of pollination			Cross-pollination with cv. Duet as		
		open- -pollination	self- -pollination	% of decreased	paternal form	maternal form	reciprocal effects
Clone Nr 9	94.8a*	97.0a	3.0d	96.9	45.0b	75.0a	15.0**
Clone P	93.0a	98.0a	15.0b	84.7	37.0c	45.0d	4.0
Clone T2	93.2a	96.0a	2.0d	97.9	30.0d	58.0b	14.0**
Chelyabinka	90.1a	88.5b	1.0d	98.8	23.0e	47.0d	12.0
Warszawa	93.0a	100.0a	4.0d	96.0	60.0a	45.0d	–7.5
Wojtek	95.9a	97.0a	20.0a	79.4	22.0e	53.0c	15.5**
Volshebnitsa	93.7a	86.0b	14.0b	83.7	47.0b	22.0e	–12.5
Duet	96.0a	95.0a	10.0c	89.5	–	–	–
Mean for pollination mode	93.7	94.7A	8.6D	90.2	37.9C	49.3B	5.7

[d] Percentage of decrease for self-pollination as compared with open-pollination

* Values in the column marked with the same lowercase letter and in the last row marked with the same capital letter do not significantly differ at $p < 0.05$

** Values are significantly different from zero on the basis of the test t

Table 2. The average fruit weight (g), depending of the way of flower pollination

Cultivar/ Clone	Method of pollination			Cross-pollination with cv. Duet as		
	open-pollination	self-pollination	% of decrease[d]	paternal form	maternal form	reciprocal effects
Clone Nr 9	0.52d*	0.48b	7.7	0.75b	1.04ab	0.15
Clone P	0.41de	0.31bc	24.4	0.36c	1.36a	0.50**
Clone T2	1.21a	0.98a	19.0	1.68a	1.01ab	–0.34**
Chelyabinka	0.17f	0.14c	17.6	0.22c	0.63b	0.21
Warszawa	1.01b	0.19bc	81.2	0.69b	0.49b	–0.10
Wojtek	0.76c	0.36bc	52.6	0.70b	0.66b	–0.02
Volshebnitsa	0.35e	0.17bc	51.4	0.19c	0.72b	0.28**
Duet	0.65c	0.33b	49.2	–	–	–
Mean	0.63B	0.37C	37.9	0.66B	0.85A	0.1

d, *, ** For explanations, see table 1

Table 3. The number of seeds per berry, depending of the way of flower pollination

Cultivar/ Clone	Method of pollination			Cross-pollination with cv. Duet as		
	open-pollination	self-pollination	% of decrease[d]	paternal form	maternal form	reciprocal effects
Clone Nr 9	13.4a*	1.7c	87.3	19.8a	9.6a	–5.1**
Clone P	10.4b	5.5a	47.1	7.8b	13.5a	2.9
Clone T2	8.5bc	1.0d	88.2	12.4ab	10.4a	–1.0
Chelyabinka	8.9bc	2.5b	71.9	8.3b	6.5a	–0.9
Warszawa	11.2ab	2.7b	75.9	9.0b	8.5a	–0.3
Wojtek	6.2cd	3.0b	51.6	4.3b	5.0a	0.4
Volshebnitsa	4.2d	1.5cd	54.3	2.2b	7.7a	2.8
Duet	7.2c	3.0b	58.3	–	–	–
Mean	8.8A	2.6B	68.1	9.1A	8.7A	–0.2

d, *, ** For explanations, see table 1

Table 4. The weight of 100 seeds (mg), depending of the way of flower pollination

Cultivar/ Clone	Method of pollination			Cross-pollination with cv. Duet as		
	open-pollination	self-pollination	% of decrease[d]	paternal form	maternal form	reciprocal effects
Clone Nr 9	206.9b*	186.7a	9.8	203.0c	390.6a	93.8**
Clone P	234.7b	217.0a	7.5	204.2c	344.4a	70.1
Clone T2	436.4a	223.0a	48.9	303.1b	413.4a	55.2
Chelyabinka	177.4b	155.0a	12.6	187.4c	372.8a	92.7**
Warszawa	229.6b	101.4a	55.8	174.8c	388.6a	106.9**
Wojtek	427.2a	228.3a	46.5	423.5a	403.6a	–10.0
Volshebnitsa	198.5b	171.1a	13.8	180.8c	377.3a	98.7**
Duet	447.3a	156.9a	64.9	–	–	–
Mean	297.4B	183.6C	38.3	225.9C	387.1A	80.6

d, *, ** For explanations, see table 1

The negative aspect of self-pollination is also expressed in a decrease in weight of the fruit (tab. 2). Fruits resulting from self-pollination have an average weight of about half as large as those obtained from open-pollination. The highest decrease in the weight of the fruit has been observed in a cultivar 'Warszawa' (81.2%) and the lowest in 'Clone Nr 9' (7.7%). Fruits obtained from cross-pollination of cultivar 'Duet' used as a maternal form had significantly higher fruit weight as compared to other methods of pollination. However, as reciprocal effects for 'Clone T2' suggested, better results can be achieved by treating a cultivar 'Duet' as a pollenizer.

The greatest number of seeds in the fruit was obtained after pollination of 'Clone Nr 9' with pollen from cultivar 'Duet' (tab. 3). Since the opposite cross-pollination was characterized by low levels of this trait, therefore the reciprocal effects proved to be statistically significant. The other cross-pollinations were predominated by low or negative reciprocal effects. Because of this, cultivar 'Duet' is characterized by higher results as pollenizer than the maternal form. However, their mean values were statistically similar and also were not significantly different from those obtained from open-pollination. Fruits obtained from open-pollination were characterized by a high number of seeds in the 'Clone Nr 9', 'P' and cultivar 'Warszawa' and low in cultivars 'Wojtek' and 'Volshebnitsa'. This last cultivar, similarly to 'T2 clone', was characterized by a low level of this characteristic also after self-pollination. Self-pollination resulted in a significant decrease in the number of seeds in the fruits of all the tested genotypes. The average value of this feature decreased by 68.1% compared to open-pollination.

The pollination mode was found to have a significant effect on the seed weight (tab. 4.). The average weight per 100 seeds was 297.4 mg for fruits formed under free insect visitation of the flowers and 183.6 mg from isolated flowers (decrease 38.3%). The highest values of this trait was recorded in the case of cross-pollination where cv. 'Duet' was a maternal form (on average 387.1 mg). In the case of four tested accessions the reciprocal effects proved to be statistically significant.

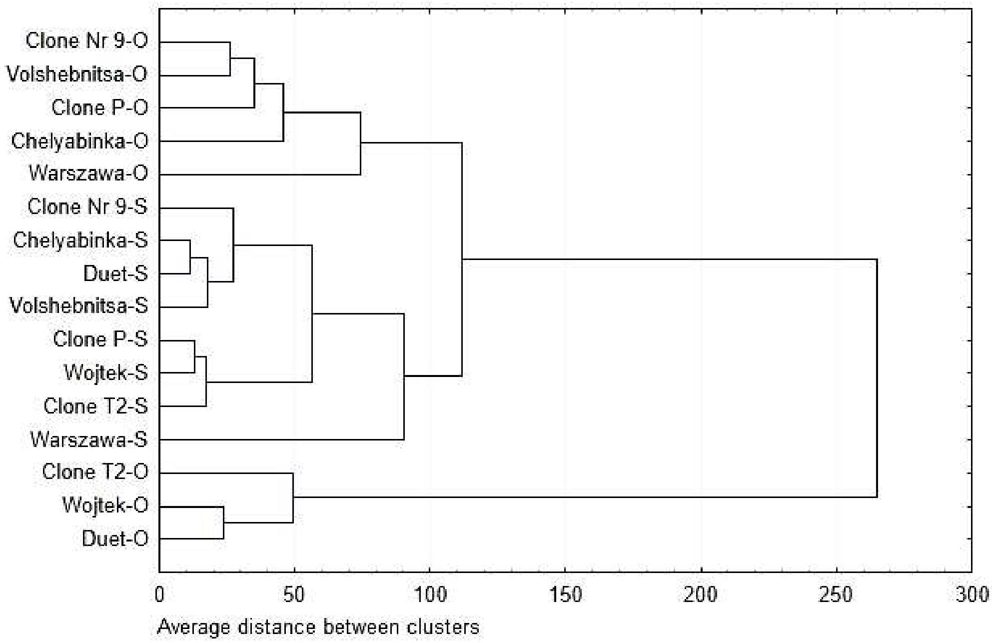

Fig. 1. Dendrogram estimating distance among self-pollinated (name with – S) and open--pollinated (name with – O) genotypes based on pollen viability, percentage of fruit set, fruit weight, number and weight of seeds

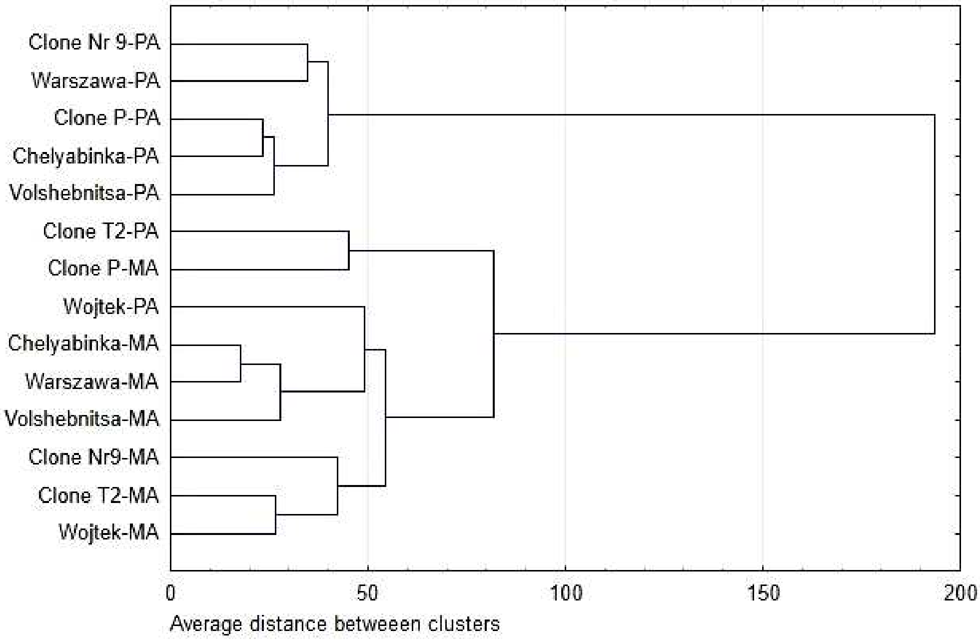

Fig. 2. Dendrogram estimating distance among genotypes treated as maternal (name with – MA) and paternal forms (name with – PA) in cross-pollination with cultivar 'Duet' based on pollen viability, percentage of fruit set, fruit weight, number and weight of seeds

The analysis of clusters in terms of the analyzed properties of genotypes after their open-, self-pollination and cross-pollination of the cultivar 'Duet' revealed their distinctiveness. As can be seen on the dendrogram (fig.1) self-pollinated genotypes were grouped first and they all formed single cluster. On the other hand, subjected to the open-pollination genotypes formed two clusters, one composed of 5 genotypes and the other clearly distinct including of cultivars 'Duet', 'Wojtek' and 'Clone T2'. Similarly distinct clusters were formed by genotypes being maternal or paternal forms in cross-pollination with cultivar 'Duet' (fig. 2). However, in this case 'Clone T2' and cultivar 'Wojtek' as paternal forms were incorporated into the cluster created by the maternal forms.

In the analysis of the relationship between the tested characteristics, it is necessary to indicate those affecting the fruit weight (tab. 5). Among them, the weight and number of seeds correlated positively with this feature in cross-pollination of cultivar 'Duet', but not in self-pollinations. In all combinations of pollinations high correlation coefficient occurred between seed number and seed weight. Moreover, pollen viability significantly affected fruit set in all pollination modes except using cultivar 'Duet" as a parental form. The model of multiple regression for pollen viability, percentage of fruit set, number of seed per fruit and seed weight vs. berry weight was statistically significant for the open-pollinations and use cv. 'Duet' as parental and maternal form, whereas it was irrelevant for self-pollinations. Multiple coefficient of determination explained respectively 61, 81 and 65% of the variability of the variable – the fruit weight. In the regression model the number and the weight of the seeds proved to be statistically significant factors. Multiple regressions produced the equation: for open-pollination, fruit weight = –0.002 (pollen viability) + 0.014 (fruit set) + 0.063 (seed number) + + 0.043 (seed weight); for parental form 'Duet', fruit weight = –0.009 (pollen viability) + 0.004

(fruit set) + 0.089 (seed number) + 0.068 (seed weight); and for maternal form 'Duet', fruit weight = 0.017 (pollen viability) + 0.002 (fruit set) + 0.053 (seed number) + 0.037 (seed weight). The use of the 'Duet' as a pollenizer for the tested cultivars and clones did not affect their yield potential, mainly due to insufficient fruit formation (tab. 6). Average fruit yield obtained from open-pollination of 100 flowers calculated according to the formula 1 (59.66g), was higher than that calculated in the same way for fruit yield after pollination of flowers with the 'Duet' cultivar (25.01g). Also in any combination of cross-pollination where the 'Duet' was a paternal form, the calculated fruit yield was not higher than the mean obtained by open-pollination. However, among the pollenizers tested for this maternal cultivar, the beneficial effect of 'Clone Nr 9' was observed (78.0g – 'Duet' × 'Clone Nr 9' vs. 61.75g for open pollination cv. 'Duet').

Table 5. Effect of pollination mode on the value of the correlation coefficient (r) and regression (b) fruit weight vs. pollen viability, fruit set, number and weight of seeds

Coefficient	Method of pollination		Cross-pollination with cv. Duet as	
	open-pollination	self-pollination	parental form	maternal form
		pollen viability – % fruit set		
Correlation r	0.31*	0.47*	0.03	0.39*
		pollen viability – fruit weight		
	0.13	0.09	0.02	0.07
		pollen viability – number of seeds		
	–0.10	–0.05	0.00	–0.04
		pollen viability – seeds weight		
	0.03	–0.18	0.05	–0.04
		% fruit set – fruit weight		
	0.29	–0.20	–0.16	0.19
		% fruit set – number of seeds		
	0.40*	0.15	0.00	0.05
		% fruit set – seeds weight		
	0.54*	–0.20*	–0.14	0.09
		number of seeds – fruit weight		
	0.15	0.18	0.45*	0.66*
		number of seeds – seeds weight		
	0.70*	0.81*	0.90*	0.91*
		seeds mass – fruit weight		
	0.63*	0.21	0.75*	0.76*
		pollen viability – fruit weight		
Regression b	–0.002	0.037	–0.009	0.017
		% fruit set – fruit weight		
	0.014	–0.017	0.004	0.002
		number of seeds – fruit weight		
	0.063*	0.056	0.089*	0.053*
		seeds mass – fruit weight		
	0.043*	–0.008	0.068*	0.037*

* the asterisk indicates a statistically significant value

Table 6. Fruit yield for the studied genotypes depending on of the way of flower pollination calculated according to formula 1

Cultivar/ Clone	Method of pollination		Cross-pollination with cv. Duet as	
	open-pollination	self-pollination	paternal form	maternal form
Clone Nr 9	50.44	1.44	33.75	78.00
Clone P	40.18	4.65	13.32	61.20
Clone T2	116.16	1.96	50.40	58.58
Chelyabinka	15.04	0.14	5.06	29.61
Warszawa	101.0	0.76	41.40	22.05
Wojtek	73.72	7.20	15.40	34.98
Volshebnitsa	30.10	2.38	8.93	15.84
Duet	61.75	3.30	–	–
Mean	59.66	3.18	25.01	41.90

DISCUSSION

The investigated genotypes of blue honeysuckle had high pollen viability (tab. 1). The same cultivars tested in 2010–2012 by Gawroński et al. [2014] had similar mean pollen fertility, which ranged from 91.9 to 98.4%. High value of this trait was also estimated in honeyberry by Boyarskikh [2017] and Bieniasz et al. [2015].

Based on these results it is clear that both open-pollination and cross-pollination have a positive influence on the percentage of fruit set, their weight, number and weight of seeds. Similar conclusions derive from a study conducted by Bożek [2012], where the percentage of fruit-bearing flowers during self-pollination was low and in the case of 'Atut' cultivar the average was 9.4% whereas for cultivar 'Duet' it was 23.8%. In our study we observed significant decrease (90.2%) in the percentage of fruit set under isolation in comparison with open-pollination, as in the work of Bieniasz et al. [2015] who also emphasized the genotypic diversity in this respect. According to these authors, cultivars such as 'Docz Velikana' and 'Indigo Treat' are characterized by a higher percentage of fruit set resulting from self-pollination. On the other hand, cultivars such as 'Omega' and 'Solowij' do not set fruit when they are selfed. Moreover, as Ehlenfeldt [2001] demonstrated for blueberry, cross-pollination accelerated ripening time and significantly increased fruit weight and seed number. Bors [2008] indicates the necessity to select the pollenizers to obtain a sufficiently high percentage of fruit set. Selection of pollenizer becomes particularly important when cultivar is planted in solid blocks. This may result in a high percentage of self-pollination and, as a consequence, yield reduction. However, the predicted yield potential of the cultivar after selecting the appropriate pollenizer may be reduced due to the possibility of partial self-pollination. The results of research conducted in this study suggest that for cultivar 'Duet' the best pollenizer is a 'Clone Nr 9', while the cultivar 'Duet' is most suitable pollinizer for 'Clone T2' and cv. 'Warszawa'. Average fruit weight for the tested cultivars after open-pollination was lower than that obtained previously for the same genotypes by Gawroński et al. [2014]. Nevertheless, the ranking of cultivars in terms of this characteristic was almost identical. This condition may be caused by mutual shading of crowns, excessive density of the branches, as no pruning was performed and the bushes were in their 8th, 9th and 10th year of vegetation. Szot and Lipa [2013] studies, on the other hand, proved that berries from pruned bushes were characterized by significantly bigger mass of individual fruit. Particularly low mass of fruit is caused by self-pollination and as stated Boyarskikh [2017] and Thompson [2006], such cultivar produces a relatively light crop of smaller than normal berries due to their having very few seeds. However, as was observed by Ehlenfeldt and Martin [2010] in *V. corymbosum*, berries with similar seed numbers varied in weight as much as 39–86% among years, depending on the cultivar. Fruit weight was one of the traits strongly associated with the manner of pollination. In our research the weight of fruit set as a result of open-pollination was almost 72% higher than in the case of self-pollination. In Bożek [2012] study, fruits formed from isolated flowers had about 45–50% lower weight, than those developed from flowers accessible to pollinating insects. The number and weight of seeds in the studied cultivars and clones also decreased (by 68.1% and 38.3%, respectively) due to the isolation of flowers from pollinators. These features are in agreement with the report of Bożek [2012] in which the flowers of blue honeysuckle, which were isolated to prevent insect foraging, produced multiple fruits, characterized by a significantly lower number of seeds. In the experiment performed by Bieniasz [2007] with highbush blueberry, the mean number of seeds per berry was higher for open-pollination in all cultivars tested. Similarly, a much larger number of seeds were obtained from the fruits produced as a result of cross-pollination in raspberry [Żurawicz 2015].

So far, in literature, information on the relationship between the analyzed characteristics of blue honeysuckle is rare. Hence, the obtained results will be also compared to those obtained in other species. The close relationship between fruit weight and seed number presented in this study was also reported by Kulikova and Boyarskikh [2015] in L. *caerulea* subsp. *altaica* plants. Similar results were observed in blueberry [Isaacs and Kirk 2010], strawberry [Hortyński et al. 1991] and kiwifruit [Sotomayor et al. 2010]. The high value of the correlation coefficient between the number of seeds and their weight was observed in strawberry [Kaczmarska et al. 2008], between fruit weight and seed weight in white crowberry [Oliveira and Dale 2012] and *Sorbus domestica* [Miko and Gazo 2004]. Strik et el. [1996] examined the relationship between the fruit weight and drupelet (seeds) number using the regression analysis in four blackberry genotypes. The regression equations were significant with drupelets number per berry from 0.05 to 0.12, which is close to the results presented in this paper.

CONCLUSION

The results clearly indicate the need to use different genotypes in the cultivar composition of the plantations. This will result in much higher yields as compared to plantations with a significantly reduced number of cultivars. With a limited number of genotypes on the plantation it becomes necessary to select the appropriate pollenizer for obtaining sufficient fruit set and this may be supported by high pollen viability of such cultivar. It would be advantageous if the pollinating cultivar would also have a high productive value. The analysis of the relationship between the characteristics suggests that the implementation of breeding strategy aimed at increasing the weight of the fruit may be realized by increasing the number of seeds per berry.

REFERENCES

Arus, L., Kask, K. (2007). Edible honeysuckle (*Lonicera caerulea* var. *edulis*) – underutilized berry crop in Estonia. N.J.R. Report, 3(1), 33–36.

Bieniasz, M. (2007). Effects of open and self-pollination of four cultivars of highbush blueberry (*Vaccinium corymbosum* L.) on flower fertilization, fruit set and seed formation. J. Fruit Ornam. Plant Res., 15, 35–40.

Bieniasz, M., Dziedzic, E., Słowik, G. (2015). Efektywne zapylenie kwiatów jagody kamczackiej wpływa na wysoką, jakość owoców. In: Konferencja Kamczacka 2015, Hortus Media, Kraków, 39–44.

Bors, B. (2008). Haskap pollination strategy. Available: www.fruit.usask.ca/articles/pollinationstrategy.pdf [date of access:17.07.2017].

Bors, B. (2015). Breeding and selecting haskap for nutraceutical and agronomic suitability. Agriculture Develop-ment Fund, University of Saskatchewan. Available: www.agriculture.gov.sk.ca/apps/adf/20110039.pdf [date of access:17.07.2017].

Boyarskikh, I.G. (2017). Features of *Lonicera caerulea* L. reproductive biology. Selskokhozyaistvennaya Biologiya [Agricultural Biology], 52(1), 200–210.

Bożek, M. (2012). The effect of pollinating insect on fruiting of two cultivates of *Lonicera caerulea* L. J. Agric. Sci., 56(2), 5–11.

Bożek, M. (2007). Pollen productivity and morphology of pollen grains in two cultivars of honeyberry (*Lonicera kamtschatica* (Sevast.) Pojark.). Acta Agrobot., 60, 73–77.

Ehlenfeld, M.K. (2001). Self- and cross-fertility in recently released highbush blueberry cultivars. Hortscience, 36(1), 133–135.

Ehlenfeld, M.K., Martin, R.B. (2010). Seed set, berry weight and yield interactions in the highbush blueberry cultivars (*Vaccinium corymbosum* L.) 'Bluecrop' and 'Duke'. J. Am. Pomol. Soc., 64(3), 162–172.

Gawroński, J., Hortyński, J., Kaczmarska, E., Dyduch-Siemińska, M., Marecki, W., Witorożec, A. (2014). Evaluation of phenotypic and genotypic diversity of some Polish and Russian blue honeysuckle (*Lonicera caerulea* L.) cultivars and clones. Acta Sci. Pol. Hortorum Cultus, 13(4), 157–169.

Hortyński, J.A., Żebrowska, J., Gawroński, J., Hulewicz, T. (1991). Factors influencing fruit size in the strawberry (*Fragaria ananassa* Duch.). Euphytica, 56 (1), 67–74.

Hummer, K.E. (2006). Blue honeysuckle: A new berry crop for North America. J. Am. Pomol. Soc., 60, 3–8.

Isaacs, R., Kirk, A.K. (2010). Pollination services provided to small and large highbush blueberry fields by wild and managed bees. J. Appl. Ecol., 47, 841–849.

Jurikova, T., Rop, O., Mlcek, J., Sochor, J., Balla, S., Szekeres, L., Hegedusova, A., Hubalek, J., Adam, V., Kizek, R. (2012). Phenolic profile of edible honeysuckle berries (Genus *Lonicera*) and their biological effects. Molecules, 17, 61–79.

Kaczmarska, E., Dobrowolska, A.M., Hortyński, J.A. (2008). The influence of pollen viability on set and fruit mass in strawberry (*Fragaria* × *ananassa* Duch.). Acta Agrobotanica, 61(1), 79–84.

Król-Dyrek, K. (2017). Przydatność odmian suchodrzewu jadalnego do uprawy w Polsce w zależności od ich pochodzenia. In: Konferencja Kamczacka 2017, Hortus Media, Kraków, 20–28.

Kulikova, A.I., Boyarskikh, A.I. (2015). Reproductive ability of *Lonicera caerulea* (Caprifoliaceae) in the local area of geological and geophysical heterogenity in the Altai Mountains. Contemp. Probl. Ecol., 8(4), 503–511.

Kusznierewicz, B., Piekarska, A., Mrugalska, B., Konieczka, P., Namieśnik, J., Bartoszek, A. (2012). Phenolic composition and antioxidant properties of Polish blue-berried honeysuckle genotypes by HPLC-DAD-MS, HPLC postcolumn derivatization with ABTS or FC, and TLC with DPPH visualization. J. Agric. Food Chem., 60, 1755–1763.

Małodobry, M., Bieniasz, M., Dziedzic, E. (2010). Evaluation of the field and some components in the fruit of blue honeysuckle (*Lonicera caerulea* var. *edulis* Turcz. Freyn.). Folia Hort. Ann., 22(1), 45–50.

Miko, M., Gazo, J. (2004). Morphological and biological characteristics of fruits and seed of the service tree (*Sorbus domestica* L.), J. Fruit Ornam. Plant Res., 12, 139–146.

Naugžemys, D., Žiliskaitě, S., Kleizaitě, V., Skridaila, A., Žvingila, D. (2011). Assessment of genetic variation among elite and wild germplasm of blue honeysuckle (*Lonicera caerulea* L.). Baltic forestry, 17(1), 8–16.

Oliveira, P.B., Dale, A. (2012). *Corema album* (L.) D. Don, the white crowberry – a new crop. J. Berry Res., 2, 123–133.

Plekhanova, M.N. (2000). Blue honeysuckle (*Lonicera caerulea* L.) – a new commercial berry crop for temperate climate: Genetic resources and breeding. Acta Hort., 538, 159–164.

Pluta, S. (2015). Suchodrzew (jagoda kamczacka) – hit w uprawie krzewów owocowych w Polsce. XI Międzynarodowa Konferencja Sadownicza "Jagodowe trendy 2015", Kraśnik 13–14 lutego 2015, 56–61.

Sotomayor, C., Norambuena, P., Ruiz, R. (2010). Boron dynamics related to fruit growth and seed production in kiwifruit (*Actinidia deliciosa* cv. Hayward). Cien. Inv. Agr., 37(1),133–141.

Statistica 13.1. (2017). StatSoft Polska. Avaible at: www.ststsoft.pl

Strik, B., Mann, J., Finn, C. (1996). Percent drupelet set varies among blackberry genotypes. J. Amer. Hort. Sci. 121(3), 371–373.

Svarcova, I., Heinrich, J., Valentova, K. (2007). Berry fruits as a source of biologically active compounds: The case of *Lonicera caerulea*. Biomed. Pap. Med. Fac. Univ. Palacky Olomouc Czech Repub., 151(2), 163–174.

Szot, I., Lipa, T. (2013). Estimating the fruit quality after application the pruning of blue honeysuckle bushes. Mod. Phytomorphol., 4, 51–54.

Thompson, M.M. (2006). Introducing haskap, Japanese blue honeysuckle. J. Am. Pom. Soc. 60(4), 164–168.

Thompson, M.M., Chaovanalikit, A. (2003). Preliminary observations on adaption and nutraceutical values of blue honeysuckle (*Lonicera caerulea*) in Oregon, USA. Acta Hort., 626, 65–7.

Truta, E., Vochita, G., Rosu, C.M., Zamfirache, M.M., Olteanu, Z., Oprica, L. (2013). Karyotype traits in Romanian selections of edible blue honeysuckle. Turk. J. Biol., 37, 60–68.

Ubysz-Borucka, L., Mądry, W., Muszyński, S. (1985). Podstawy statystyczne genetyki cech ilościowych w hodowli roślin. SGGW-AR, Warszawa.

Zadernowski, R., Naczk, M., Nestorowicz, J. (2005). Phenolic acid profiles in some small berries. J. Agric. Food Chem., 53(6), 2118–2124.

Żurawicz, E. (2015). Cross-pollination increases the number of drupelets in the fruits of red raspberry (*Rubus idaeus* L.). Acta Hortic., 1133, 145–151.