ISSN 1644-0692
www.acta.media.pl

ACTA Acta Sci. Pol. Hortorum Cultus, 15(3) 2016, 29-43

THINNING OF APPLE FLOWERS WITH POTASSIUM BICARBONATE (ARMICARB®) IN ORGANIC ORCHARD

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Abstract. Flower or fruit thinning is the most important technique in apple growing for improving fruit quality. In organic fruit production the use of chemical-synthetic thinning agents or plant hormones for crop regulation is forbidden. In Poland the Armicarb® is registered as a fungicide. Being a caustic chemical, Armicarb® damages petals, pistils and anthers and prevents fertilization. In 2013 and 2014 potassium bicarbonate was used twice at the doses 10 and 15 kg·ha^{-1} on trees cv. 'Braeburn Mariri Red'/M.9 T337. The first spraying was done at the beginning of flowering (BBCH 61) and the second at the full bloom (BBCH 65). Trees of cv. 'Šampion'/M.9 T337 in 2014 were sprayed twice at BBCH 61 and 65 at the doses 10 and 15 kg·ha^{-1}, but in 2015 the single application was done. In 2014 and 2015 on trees cv. of 'Gala Must'/M.9 only one spraying with potassium bicarbonate was done at doses: 10,15 and 20 kg·ha^{-1}. Thinning of apple flowers with Armicarb® caused a decrease in the yield, especially of cv. 'Gala Must' and 'Šampion'. However in all cultivars the fruit size distribution was much better than in control. Each variety responded by clear increase in the fruit size after thinning with Armicarb®. Mean fruit mass, the diameter and length of apples after using Armicarb® at all doses were much bigger than in control. Skin of apples was severe russeted after application of Armicarb®. However skin russeting was also affected by the weather. In 2014, at cold temperatures and high precipitation during the period of intensively fruit growth, the skin of apples was more russeted relative to others seasons.

Key words: crop regulation, fruit quality, yield, flower thinning

INTRODUCTION

Apple trees have evolved a system to control fruit load by a process called physiological drop [Bangerth 2000]. In a normal season an apple tree set 5–10% of its blos-

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soms. Under favorable conditions too many flowers develop into fruit and tree cannot feed all of them properly. Overcroping results in a very poor fruit size and leads to a poor crop in the next year. Fruit thinning is one of the important practices in apple tree cultivation for improving fruit quality and the regularity of yielding [Looney 1993]. Fruit thinning is accomplished by hand, mechanical or chemical methods. Chemical thinners are separated into categories as bloom thinners and post bloom thinners. Early blossom thinning is currently used in many apple producing areas to enhance return bloom and to reduce competition for photosynthates between fruitlets [Fallahi and Fallahi 2004].

Organic products are becoming increasingly popular on the world markets of Europe and North America, providing to further intensification of organic production. Growth of organic fruit area exceeds the conventional fruit area and organic fruit area increases faster than other organic crops. There is still a growing consumer response for organic fruit in Europe, but marketing and competition from conventionally produced fruit are getting more competitive [Granatstein et al. 2013]. Consumers expect organic apples to have comparable size and quality to non-organic fruit and thinning is needed to achieve that goal [Weibel et al. 2013]. One of the main challenges in organic apple growing is the regulation of the crop load to: prevent biennial bearing; improve fruit quality and save labor costs for hand thinning [Link 2000]. In organic fruit production the use of chemical synthetic thinning agents or plant hormones for crop regulation is forbidden. In most EU countries and in the US lime sulphur is the standard thinning agent, however in Switzerland it is not allowed due to risks for the operator [Weibel et al. 2012]. In Switzerland a formulated potassium bicarbonate product (Armicarb®) is officially registered for thinning purposes in organic production [Weibel 2008]. In Poland the Armicarb® is registered as a fungicide. Being a caustic chemical, Armicarb® damages petals, pistils and anthers and prevents fertilization. The objective of these trials was to investigate the effect of Armicarb® on the thinning action and fruit quality of apple cultivars: 'Braeburn Mariri Red', 'Šampion' and 'Gala Must'. The cultivars chosen for the experience are very important on European and Polish fruit organic market. Weibel et al. [2013] reported that 'Gala' is the most popular cultivar in organic production (28% market share) and 'Braeburn' is in fourth position (9%) after 'Elstar' (16%) and 'Topaz (11%). Šampion maybe is not so popular in the markets of Western Europe, but it is still a very important cultivar on the Polish market.

MATERIAL AND METHODS

The trials were conducted on the two commercial organic fruit farms of family Lipa and Buła, both situated close to Lublin. The experiments were performed in 2013–2015. Each treatment (tab. 1) was tested on 10 trees (1 tree = replication) of similar height and fruiting intensity, selected from trees distributed along the row. At the beginning of study the experimental material were 6-year-old apple trees of cv. 'Braeburn Mariri Red'/M.9 T337 rootstock, and 4-year-old apple trees of cv. 'Šampion'/M.9 T337 rootstock, planted in commercial orchards in Stryjno (52°6'67"N, 22°83'33"E). In other commercial orchard in Świdnik Mały (51°26'67"N, 22°68'33"E), the experiment was conducted on 12-year-old apple trees of cv. 'Gala Must'/M.9 rootstock. Trees were planted in rows situated in the north-south direction at distance: 3.0 × 0.8 m ('Braeburn Mariri Red'), 3.3 × 1.2 m ('Šampion') and 3.5 × 1.0 m ('Gala Must') and trained as slender spindles.

Table 1. Treatments with Armicarb® tested in 2013–2014

Cultivar	Concentrations ($kg \cdot ha^{-1}$)	Frequency and period of application	Year
'Braeburn Mariri Red'	10	2 × at BBCH 61 and 65	2013, 2014
	15	2 × at BBCH 61 and 65	2013, 2014
'Šampion'	10	2 × at BBCH 61 and 65	2014
	15	2 × at BBCH 61 and 65	2014
	10	1 × at BBCH 61	2015
	15	1 × at BBCH 61	2015
'Gala Must'	10	1 × during flowering period (BBCH 61)	2014, 2015
	15	1 × during flowering period (BBCH 61)	2014, 2015
	20	1 × during flowering period (BBCH 61)	2014, 2015

Table 2. Weather conditions in the period of Armicarb® application

Weather feature	'Braeburn Mariri Red'				'Šampion'			'Gala Must'	
	2013		2014		2014		2015	2014	2015
	BBCH 61	BBCH 65	BBCH 61	BBCH 65	BBCH 61	BBCH 65	BBCH 61	BBCH 61	BBCH 61
Application date	14th of May	16th of May	6th of May	14th of May	25th of April	6th of May	1st of May	29th of April	6th of May
Average temperature	13.2	18.4	8.7	10.2	13.8	8.7	10.2	13.2	15.7
Max temperature	17.7	23.4	14.6	14.2	18.4	14.6	17.3	20.3	20.7
Min temperature	8.9	12.6	2.0	6.2	9.4	2.0	4	7.8	11.3
% relative humidity	77	69	64	89	71	64	72	74	88
Average wind speed (km·h)	10.2	7.8	7.8	9.6	12.2	7.8	7.4	7.2	10.4
Precipitation totals (mm)	0	0	0	0	0	0	0	0	0

Flowering intensity of the trees cv. 'Braeburn Mariri Red'and Šampion used for the experiments was 90–100% and 75% ('Gala Must'). In all studies a single spray was applied with a knapsack sprayer at 1000 l of water per ha, up to "run off". Usually the test agent were applied twice during flowering stage BBCH 61 (at the beginning of flowering, about 10% of flowers open) and BBCH 65 (at full flowering, at least 50% of flower open, first petal falling). Only in the case of 'Gala Must' in 2014 and 2015 and 'Šampion' in 2015 (tab. 1) the spraying was performed once (at the beginning of flowering, about 10% of flowers open). Armicarb® (potassium bicarbonate; $KHCO_3$) was applied at the rates 10 and 15 $kg \cdot ha^{-1}$ ('Braeburn Mariri Red', Šampion') and 10; 15 and 20 $kg \cdot ha^{-1}$ ('Gala Must'). The Armicarb® should not be used with the air temperature below 5°C and above 25°C. Since the test agent is a desiccant, the application was done during warm days (air temperature about 15–20°C) from 8.30 to 9.30 a.m., with no rain announced for the following 24 h (tab. 2). Cultural practices other than thinning were applied in a manner consistent with those of commercial apple orchards.

Crops of the experimental trees were harvested at commercial time. The harvest of apple cv. „Braeburn Mariri Red' in 2013 was conducted in 22nd of October and in 2014 in 28th of October, 'Šampion' in 28th of September in 2014 and in 23rd of September in 2015. Fruit of 'Gala Must' were twice harvested: in 9th and 16th of September in 2014 and 10th and 17th of September in 2015, so the data for 'Gala Must' are an average from two term of harvest.

For each experimental tree the total yield expressed in N° of fruit·tree^{-1} and kg·tree^{-1} was determined. Size distribution – the fruits from every treatment were divided into three class of fruit diameter: <65 mm; 65–75 mm and >75 mm.

A mean sample of 50 fruits per treatment was used to assess the fruit quality: Mean fruit mass was determined with using digital scale (g). Diameter and length of fruits were determined with using digital caliper (mm). Skin colour was specified in 1–5 scale (when 1: no red colour, 2: 1–25% of skin coloured, 3: 26–50% of skin coloured, 4: 51–75% of skin coloured, 5: 76–100% of skin coloured. Skin russeting was identified in scale 1–9 (when 1: no net of russeting, and respectively 2: 1–12.5%; 3: 12.6–25%; 4: 25.1–37.5%; 5: 37.6–50%; 6: 50.1–62.5%; 7: 62.6–75%; 8: 75.1–87.5%; 9: 87.6–100% of skin fruit with russeting. Number of seeds were recorded for each individual fruit from the probe of 25 apples per treatment and determined as total number of seeds, which was divided for number of normal and degenerated seeds. Fruit flesh firmness was measured on two sides of each fruit (the probe of 25 apples per treatment) with a hand held FT 327 penetrometer (EFFEGI, Italy), fitted with an 11.1 mm diameter head. Total soluble solids content (%) were determined using an Abbé refractometer on the probe of 10 apples per treatment. Dry matter content (%) was determined in three replicates per treatment with the oven-drying method. Total sugar content (%) was determined according to the Loof-Schoorl method [Krełkowska-Kułas 1993]. Acidity (%) was determined potentiometrically by titration with 0.1 N NaOH solution and was converted to malic acid [Yermakov et al. 1987].

The data were subjected to analysis of variance and mean separation was by Tukey's test at P = 0.05. Data were analyzed by STATISTICA for Windows version 5.5, Tulsa USA, software.

RESULTS AND DISCUSSION

Armicarb® is a well-known product against scab and scooty blotch on apple [Tamm et al. 2006]. Due to the limited number of preparations registered for fruit thinning, Armicarb® is an interesting candidate for organic apple cultivation. Armicarb® showed quite good thinning effect, when it was used during flowering period. It seems, that this product deteriorates the stigma surface, preventing pollen germination there. The desiccation of the stigma surface could be due to osmotic reactions induced by the high product concentration [Weibel et al. 2008]. In the present research both doses of Armicarb® influenced the significant decrease in total yield of 'Braeburn Mariri Red' determined in N° of fruits·tree^{-1} as compared to the control. However, there was no significant decrease in total yield determined in kg·tree^{-1}. It was caused by distinct increase in mean fruit mass, diameter and length of fruit from trees treated by Armicarb®, as compared to the control (tab. 3). At the both rates of Armicarb® stated significant decreasing in total yield of cv. 'Šampion' determined in N° of fruits·ha^{-1} and kg·ha^{-1}. It was clearly reflected in the quality of the fruit. The mean fruit mass, the diameter and length of fruits were much bigger in the treatments with Armicarb® than in control (tab. 4). In the study on cv. 'Gala' beside the doses of Armicarb® 10 and 15 kg·ha^{-1}, the dose 20 kg·ha^{-1} was additionally applied. Significant decrease in total yield determined in N° of fruits·ha^{-1} and kg·ha^{-1} after using Armicarb® at all used doses was stated. All doses of Armicarb® influenced on significant increasing in mean fruit mass, the diameter and length of fruit as compared to the control (tab. 5).

Table 3. The effect of using Armicarb® on yield and some chemical and physical characteristics of apples cv. 'Braeburn Mariri Red' (mean from two years 2013–2014)

Studied features	Treatment		
	control	Armicarb® 10 kg·ha^{-1}	Armicarb® 15 kg·ha^{-1}
Total yield (N° of fruit·tree^{-1})	126.0 b*	102.7 a	100.6 a
Total yield (kg·tree^{-1})	20.7 a	19.9 a	19.5 a
Mean fruit mass (g)	173.1 a	200.7 b	201.8 b
Diameter of fruits (mm)	71.9 a	75.7 b	75.7 b
Length of fruits (mm)	66.2 a	69.6 b	70.7 b
Skin colour (scale 1–5)	4.82 a	4.85 a	4.83 a
Skin russeting (scale 1–9)	1.09 a	1.40 b	1.34 b
Number of normal seeds (N° of seeds·fruit^{-1})	3.66 a	4.40 ab	5.09 b
Number of degenerated seeds (N° of seeds·fruit^{-1})	1.87 a	1.27 a	1.30 a
Total number of seeds (N° of seeds·fruit^{-1})	5.53 a	5.67 a	6.39 a
Flesh firmness (kG·cm^{-2})	9.78 a	9.88 a	9.77 a
Soluble solids content (%)	12.79 ab	13.11 b	12.27 a
Dry matter content (%)	15.25 a	15.59 a	15.60 a
Sugar content (%)	6.57 b	6.47 b	6.15 a
Acidity (%)	0.56 b	0.53 a	0.57 c

* – means marked with the same letter in a row did not differ significantly at $\alpha = 0.05$

A significant improvement in fruit size, especially of cv. 'Šampion' an 'Gala Must' may result from early reduction of crop load. Based on the results of long term experiment on apple flower and fruit thinning Link [2000] stated that mean fruit weight was negatively correlated with crop load. Armicarb® is blossom thinners, which has a caustic effect on floral parts. Early removal of potential fruit is currently used in many apple producing areas to enhance return bloom. It also results in reduced competition for photosynthates. Many researchers [Bound and Wilson 2004, Stopar 2008, Bound and Klein 2010, Milić et al 2011] found that fruit from the trees, where thinning has been performed at the time of flowering, have a higher quality than fruits from trees where thinning practices were done later. This is due to the fact that after removal of the part of the flowers, these that developed into fruitlets, have better conditions for growth.

Table 4. The effect of using Armicarb® on yield and some chemical and physical characteristics of apples cv. 'Šampion'

Studied features	Treatment		
	control	Armicarb® 10 kg·ha^{-1}	Armicarb® 15 kg·ha^{-1}
Total yield (N° of fruit·tree^{-1})	167.25 b*	97.65 a	101.95 a
Total yield (kg·tree^{-1})	23.46 b	16.44 a	17.17 a
Mean fruit mass (g)	141.87 a	168.79 b	169.61 b
Diameter of fruits (mm)	69.92 a	76.23 b	76.55 b
Length of fruits (mm)	61.95 a	67.30 b	67.40 b
Skin colour (scale 1–5)	3.04 a	4.10 b	4.08 b
Skin russeting (scale 1–9)	1.88 a	2.28 b	2.18 b
Number of normal seeds (N° of seeds·fruit^{-1})	6.1 a	7.9 b	8.1 b
Number of degenerated seeds (N° of seeds· fruit^{-1})	0.1 b	0.0 a	0.0 a
Total number of seeds (N° of seeds·fruit^{-1})	6.2 a	7.9 b	8.1 b
Flesh firmness (kG·cm^{-2})	6.55 a	6.76 b	6.51 a
Soluble solids content (%)	12.45 a	13.70 b	13.53 b
Dry matter content (%)	14,79 a	16,23 c	15,79 b
Sugar content (%)	9.04 a	9.24 a	9.43 a
Acidity (%)	0.35 b	0.30 a	0.29a

* – explanations as in table 3

Table 5. The effect of using Armicarb® on yield and some chemical and physical characteristics of apples cv. 'Gala Must'

Studied features	Treatment			
	control	Armicarb® 10 kg·ha^{-1}	Armicarb® 15 kg·ha^{-1}	Armicarb® 20 kg·ha^{-1}
Total yield (N° of fruit·tree^{-1})	279.80 c	223.95 b	208.65 b	174.4 a
Total yield (kg·tree^{-1})	32.57 c	29.26 b	28.73 b	25.44 a
Mean fruit mass (g)	120.81 a	138.00 b	150.27 c	161.57 d
Diameter of fruits (mm)	64.85 a	68.45 b	69.51 c	70.32 c
Length of fruits (mm)	60.68 a	63.81 b	65.09 bc	65.84 c
Skin colour (scale 1–5)	2.73 a	2.91 a	3.26 b	3.51 b
Skin russeting (scale 1–9)	1.58 a	1.54 a	1.81 b	1.72 ab
Number of normal seeds (N° of seeds·fruit^{-1})	4.5 a	4.7 a	4.9 a	6.1 b
Number of degenerated seeds (N° of seeds·fruit^{-1})	0.4 b	0.4 b	0.13 a	0.2 ab
Total number of seeds (N° of seeds·fruit^{-1})	4.87 a	5.03 a	5.01 a	6.31 b
Flesh firmness (kG·cm^{-2})	7.55 c	7.11 a	7.31 b	7.58 c
Soluble solids content (%)	12.45 b	11.90 a	12.55 b	12.28 b
Dry matter content (%)	14.28 ab	14.03 a	14.50 b	14.92 c
Sugar content (%)	6.89 ab	6.71 a	7.07 b	6.83 a
Acidity (%)	0.270 bc	0.267 ab	0.257 a	0.280 c

* – explanations as in table 3

Fruit size can be viewed as the result of cell number, cell size and intercellular spaces [Goffinet et al. 1995]. Early blossom thinning increases fruit size by enhancing the rate of cell division in the cortical tissue and cell size [Pearson and Robertson 1953]. But cell number is a more important contributor to fruit size than cell size. Bergh [1990] stated that the cell division period lasted 4 weeks after full bloom. A decrease in cell number of fruits from trees thinned after a period of intense cell division was accompanied by larger cell, but these larger cells did not compensate for the reduction in cell numbers, and average size of fruit was reduced [Bergh 1985].

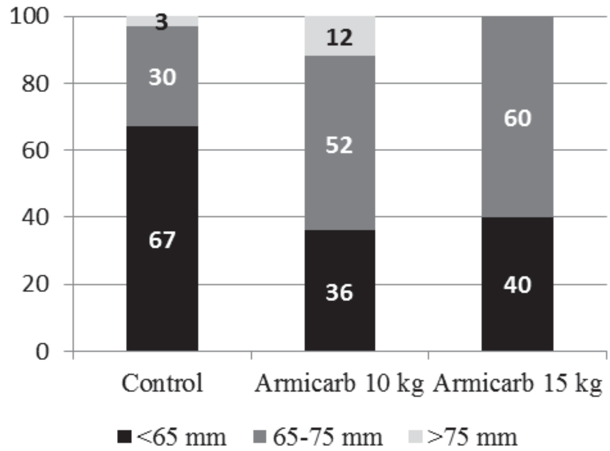

Fig. 1. The size distribution (%) in individual classes of fruit diameter for 'Braeburn Mariri Red' in 2013

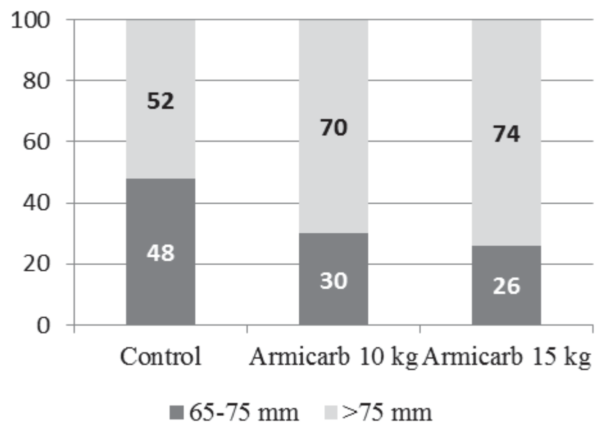

Fig. 2. The size distribution (%) in individual classes of fruit diameter for 'Braeburn Mariri Red' in 2014

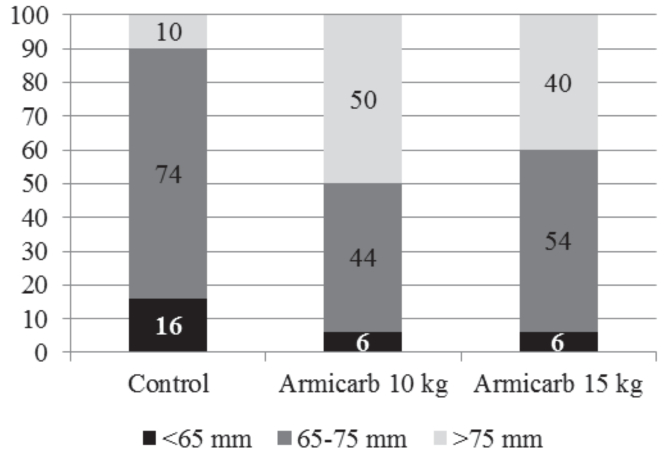

Fig. 3. The size distribution (%) in individual classes of fruit diameter for 'Šampion' in 2014

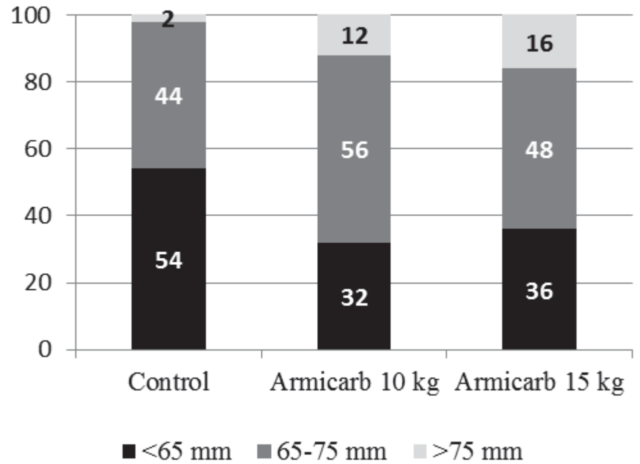

Fig. 4. The size distribution (%) in individual classes of fruit diameter for 'Šampion' in 2015

Fruit size distribution corresponds to a normal distribution curve. Every effective thinning treatment shifts the curve from the lower size categories to the higher ones [Link 2000]. In the first year of study on 'Braeburn Mariri Red' the use of the Armicarb® reflected in increasing of percentage of fruits with diameter between 65–75 mm and bigger (fig. 1). The percentage of fruits with diameter below 65 mm after using Armicarb® in the dose 10 kg·ha^{-1} was almost twice lower than in the control. In the second year of the study all apples were bigger, because even in the control there were no fruits with diameter below 65 mm (fig. 2). At both doses of Armicarb® the amount of fruits cv. 'Šampion' with diameter above 75 mm increased as compared to the control (figs 3, 4). In the case of 'Gala Must' in every year of study thinning by Armicarb® influenced on decreasing in percentage of small fruits with diameter below 6.5 mm (figs 5, 6). From the thinning trials of single year it may by concluded that the yield of large apples is about doublet, especially in the case of cv. 'Šampion' and 'Braeburn Mariri Red'. However the opportunity to increase the quantity of middle to large sized fruit is rather restricted. It was clearly shown, that it is depending on the cultivar and the year. In 2015 none of the thinning practices influenced on the increasing in size of apple cv. 'Gala Must'. There were no apples with diameter above 75 mm. It could be connected with unusually high temperatures and drought in August (tab. 7). Tukey [1970] stated, that thinning does not change a potentially small fruit into a large fruit, but rather insures that a potentially large fruit will size properly. Fruit thinning can quickly reach the point of diminishing returns. Rather than a high percentage of large fruits, the objectives of thinning should be elimination of the smallest fruits and improved fruit quality [Forshey and Elfving 1977]. In addition, a low yield of small and of oversized fruit is also expected.

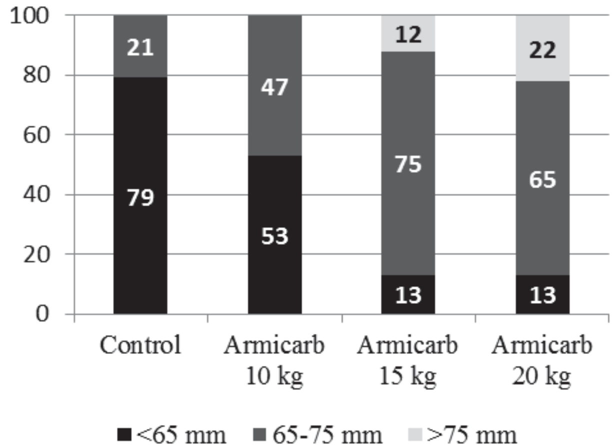

Fig. 5. The size distribution (%) in individual classes of fruit diameter for 'Gala Must' in 2014

The number and quality of seeds could have a decisive influence on the fruits, especially their size and form (symmetry), persistence, physical properties (firmness, juiciness etc.), moreover the rustiness of the skin and weight loss in the store [Barbier 1983, Mantinger 1997]. Not all seeds in the fruit are well developed. It was postulated that some of the seeds stop growing at different phases of the growing season, up to then, they may function as sources of growth substances as well, and participate in the stimulation of the growing fruits, and later, by their failure, they contribute to fruit drop. Racsko et al. [2009] founded that the number of empty (degenerated) seeds was low in all studied phases than the number of stout (normal) seeds. For some cultivars i.e. 'Golden Delicious', as many as 8 seeds per fruit are considered to be necessary to obtain high quality fruit, which means, the fruits are sensitive to the diminished number of seeds. Fewer than the critical number of seeds may cause russeting of the skin and appearance of ribs on fruits [Gautier 1983]. In the fruits of 'Red Delicious', a lower number of seeds per fruit (4–5) are expected. There was no influence of Armicarb® on the number of total and degenerated seeds in fruits of 'Braeburn Mariri Red' as compared to the control (tab. 3). Only application 15 kg·ha^{-1} of Armicarb® influenced on significant increase in the number of normal seeds relative to the control. Apples of 'Šampion' from trees treated with Armicarb® had much more seeds than control ones and these were normal shaped seeds (tab. 4). Significant increase in the number of normal seeds and in total number of seeds in the apples of 'Gala Must' after using Armicarb® at the dose 20 kg·ha^{-1} was stated (tab. 5). The individual varieties differed in the total number of seeds. The highest mean number of total seeds was noted for cultivar 'Šampion'. Apples of 'Braeburn Mariri Red' and 'Gala Must' were characterized by the lower mean number of total seeds (5.9 and 5.4 pieces·fruit^{-1}). Racsko et al. [2009] determining the differences in the seed production during the subsequent phases of the growing season stated at Gala's mutants had the greatest number of seeds (from 1138.3 to 1510.4 n°/tree). Seed production for Šampion was on the level 859.9 n°/tree and for Braeburn mutans from 123.5 to 161.2 n°/tree.

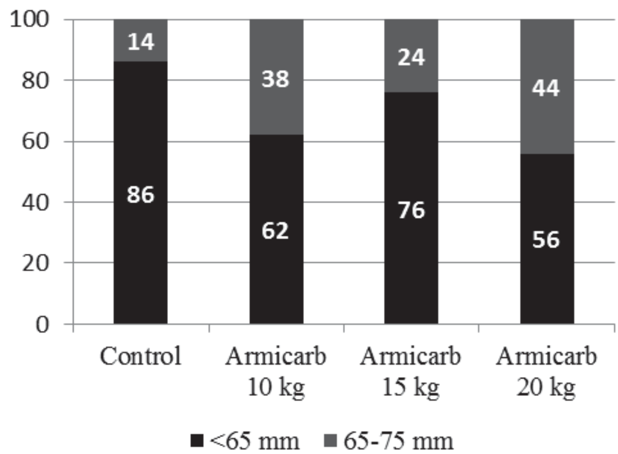

Fig. 6. The size distribution (%) in individual classes of fruit diameter for 'Gala Must' in 2015

A wide range of possible thinning effects on fruit firmness at harvest is to be expected, because fruit firmness is determined multifactorially by positive and negative effects caused for instance by fruit size, number and size of cells, volume of intercellular space, dry matter (pectin) and mineral content [Link 2000]. Johnson [1994] noted increase in fruit firmness at harvest, especially by thinning during the period from the five to fifteen days after full bloom with no increase when thinned at twenty-five days after full bloom for 'Cox's Orange Pippin'. On the other hand, firmness is often negatively associated with other thinning effects, such as mean fruit weight and calcium content of the fruit [Siddiqui and Bangerth 1995, Kacal and Koyuncu 2012]. The thinning of 'Braeburn Mariri Red' flowers with Armicarb® did not influence on significant differences in flesh firmness between studied treatments (tab. 3). Flesh firmness of the 'Šampion' apples after treating with Armicarb® at the dose 10 kg·ha^{-1} had significantly higher flesh firmness that the control ones (tab. 4). In the case of 'Gala Must' after spraying with Armicarb® at the doses 10 and 15 kg·ha^{-1} the significant decreasing in flesh firmness was stated (tab. 5).

An overall tendency is that fruit thinning decreases the percentage of green fruit and increases yellow background colour of yellow cultivars and the extent and intensity of skin blush in red cultivars. The number of leaves per fruit appear to enhance anthocyanin accumulation. This may be due to a result of more photosynthate being available per fruit and thus more sugar delivered for anthocyanin production. There was no significant influence of Armicarb® application on skin colour of 'Braeburn Mariri Red' (tab. 3). Apples of. cv. 'Šampion' from trees treated with Armicarb® were much better coloured relative to the control (tab. 4). Apples of 'Gala Must' from control trees treated with Armicarb® in the doses 15 and 20 kg·ha^{-1} were better coloured than the control ones (tab. 5).

When the growth rate of fruitlets is low, small cracks develop in the epidermis leading to fruit russeting [Skene 1982]. Hand-thinning usually increases the growth rate of fruitlets and thus reduces the amount of fruit with russeted skin. However chemical thinning is practiced during the most sensitive phases of fruit development, for example during flowering, so it is expected that thinning compounds might influence fruit russeting specifically [Stopar 2004]. For example the use of ATS to thinning flower caused sometimes, particularly at high concentration, more severe skin russeting [Irving et al. 1989, Noé 1996]. At apples cv. 'Braeburn Mariri Red' from trees treated with Armicarb®, skin was more russeted than in the control (tab. 3). In the case of Šampion' after using Armicarb® more severe skin russeting was observed, as compared to the control (tab. 4). Thinning practices with Armicarb® at the dose 15 kg·ha^{-1} influenced on significant increasing in skin russeting, as compared to the control (tab. 5).

The improvements in fruit size and colour by thinning are accompanied by higher contents of soluble solids and titratable acid. In the case of 'Braeburn Mariri Red' thinning practices had no significant influence on soluble solids content, but Armicarb® at the dose 15 kg·ha^{-1} caused that fruit had distinct higher acidity and lower sugar content than in control (tab. 3). Apples of cv. 'Šampion' from trees treated with Armicarb® characterized by higher soluble solids, dry matter content and lower acidity (tab. 4). There were no significant differences in chemical composition of apples cv. 'Gala Must' after using Armicarb®. Only treatment at the dose 10 kg·ha^{-1} caused significant decreasing in soluble solids content and at dose 15 kg·ha^{-1} decreasing in acidity, as compared to the control. However apples from trees treated with Armicarb® at dose 20 kg·ha^{-1} had much more dry matter content then the control ones (tab. 5).

Besides thinning practices the weather conditions had significant influence on fruit quality of studied cultivars. Fruit growth and development are influenced by different environmental factors. A general temperature effect in plants involves the ratio between photosynthesis and respiration. Higher than normal temperatures affect the photosynthetic process through the increase of enzyme activity. The growing season in 2014 characterized by the most favorable conditions for apple growth and development. The high air temperatures in April accelerated flowering of all cultivars in relative to the 2013 and 2015. Beside the temperature, the precipitation could affect the growth of fruit. In 2014 there were no month with the drought. In the May, when fruitlets growth intensively, the precipitation was much higher relative to multi – year mean (tab. 7).

Table 6. The comparison of yield and some chemical and physical characteristics of apples cv. 'Braeburn Mariri Red', 'Šampion' and 'Gala Must' between years of study

Studied features	'Braeburn Mariri Red'		'Šampion'		'Gala Must'	
	2013	2014	2014	2015	2014	2015
Total yield (N° of fruit·tree^{-1})	131.20 b*	88.33 a	113.9 a	130.67 b	183.15 a	260.25 b
Total yield (kg·tree^{-1})	19.66 a	20.41 a	19.77 b	18.28 a	28.36 a	29.64 a
Mean fruit mass (g)	151.57 a	232.11 b	176.90 b	143.27 a	157.89 b	127.44 a
Diameter of fruits (mm)	68.14 a	80.70 b	77.75 b	70.73 a	72.09 b	64.48 a
Length of fruits (mm)	62.01 a	75.67 b	68.79 b	62.31 a	67.58 b	60.13 a
Skin colour (scale 1–5)	4.69 a	4.97 b	4.43 b	3.05 a	3.11 a	3.10 a
Skin russeting (scale 1–9)	1.04 a	1.51 b	2.08 a	2.14 a	2.02 b	1.31 a
Number of normal seeds (N° of seeds·fruit^{-1})	3.8 a	5.0 b	6.6 a	8.2 b	3.9 a	6.2 b
Number of degenerated seeds (N° of seeds·fruit^{-1})	2.65 b	0.31 a	0.01 a	0,04 a	0.27 a	0.28 a
Total number of seeds (N° of seeds·fruit^{-1})	6.4 b	5.3 a	6.6 a	8.2 b	4.2 a	6.4 b
Flesh firmness (kG·cm^{-2})	10.42 b	9.21 a	6.04 a	7.17 b	7.95 b	6.83 a
Soluble solids content (%)	12.49 a	12.96 b	12.23 a	14.22 b	11.60 a	12.99 b
Dry matter content (%)	15.35 a	15.61 a	14.39 a	16.82 b	13.79 a	15.07 b

* – mean in the row in within the cultivar, followed by the same letter, do not differ $\alpha = 0.05$

Table 7. Mean monthly air temperatures and precipitation in the years 2013–2014 against the multi-year mean values (1951–2012) in Felin near Lublin

Month	Temperature (°C)			Multi-year| (1951–2012) mean (°C)	Precipitation totals (mm)			Multi-year (1951–2012) mean (mm)
	2013	2014	2015		2013	2014	2015	
April	7.9	9.7	7.8	7.4	55.1	50.3	29.2	39.0
May	14.8	13.4	12.5	13.0	109.2	242.8	115.1	60.7
June	17.8	15.6	16.7	16.3	114.5	62.7	18.8	65.9
July	18.6	20.2	19.3	18.0	88.1	87.4	47.5	82.0
August	18.6	17.8	21.9	17.2	16.0	93.2	7.4	70.7
September	11.5	14.1	14.7	12.6	42.2	30.7	88.4	53.7
October	9.8	9.1	6.7	7.6	6.9	23.6	60.2	40.1
Mean/sum for vegetation season	14.1	14.3	14.2	14.2	432	590.7	366.6	412.1

Apples of cv. 'Braeburn Mariri Red' characterized by much higher mean fruit mass, diameter and length of fruit, better colouring, had more normal seeds and soluble solids content in 2014 than in 2013 (tab. 6). Apples of cv. Šampion' in 2014 were significant bigger than in 2015. They have much higher mean fruit mass, diameter and length of fruit and were better coloured. However, these apples had significant less normal and total seeds and their flesh firmness, soluble solids and dry matter content were lower than in 2015. Apples of cv. 'Gala Must' in 2014 were significant bigger than in 2015 because of higher mean fruit mass, diameter and length of fruit. They had also significant higher flesh firmness. However, these apples were more severe russeted, had significant less normal and total seeds and their soluble solids and dry matter content were much lower than in 2015.

COCLUSIONS

1. Thinning of apple flowers with Armicarb® caused fruit set decrease, especially of cv. 'Gala Must' and 'Šampion'. However at all cultivars the fruit size distribution was much better than in control.
2. Each variety has responded by clear increase in the fruit size after thinning with Armicarb®. Mean fruit mass, the diameter and length of apples at all doses of Armicarb® were much bigger than in control.
3. Skin of apple was more severe russeted after application of Armicarb®. However skin russeting was also affected by the weather. In 2014, at cold temperatures and high precipitation during the period of intensively fruit growth, the skin of apples was more russeted relative to others seasons.

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PRZERZEDZANIE KWIATÓW JABŁONI W UPRAWIE EKOLOGICZNEJ ZA POMOCĄ WODOROWĘGLANU POTASU

Streszczenie. Przerzedzanie kwiatów lub owoców jest jedną z ważniejszych metod stosowanych w uprawie jabłoni dla poprawy jakości owoców. W uprawie ekologicznej zabrania się stosowania syntetycznych preparatów chemicznych oraz hormonów roślinnych w celu przerzedzania. W Polsce Armicarb® jest zarejestrowany jako fungicyd. Stosowany na kwiaty ma właściwości parzące – niszczy płatki, słupek i pręciki, tym samym zapobiegając ich zapyleniu. W latach 2013 i 2014 wodorowęglanu potasu użyto dwukrotnie w dawkach 10 i 15 $kg \cdot ha^{-1}$ na jabłonie odmiany 'Braeburn Mariri Red'/M.9 T337. Pierwsza aplikacja została wykonana na początku kwitnienia (BBCH 61), a druga w pełni kwitnienia (BBCH 65). Drzewa odmiany 'Šampion' były opryskiwane dwukrotnie w roku 2014 w stadium BBCH 61 i 65, natomiast w roku 2015 zastosowano jednokrotną aplikację preparatu. W latach 2014 i 2015 jabłonie odmiany 'Gala Must' traktowano wodorowęglanem potasu jednokrotnie, na początku kwitnienia, w dawkach: 10, 15 i 20 $kg \cdot ha^{-1}$. Przerzedzanie kwiatów za pomocą Armicarbu® obniżyło plon jabłoni, zwłaszcza odmian 'Gala Must' i 'Šampion'. Jednakże w przypadku każdej z odmian zanotowano wyraźną poprawę w rozmieszczeniu owoców w poszczególnych klasach wielkości w stosunku do kontroli. Każda z odmian zareagowała znacznym zwiększeniem rozmiaru owoców. Średnia masa pojedynczego owocu, średnica i długość jabłek po zastosowaniu Armicarbu® były znacznie większe niż w kontroli. Skórka owoców z drzew, gdzie zastosowano Armicarb®, była silniej ordzawiona. Zaobserwowano, że pogoda miała wpływ na stopień ordzawienia. W 2014 r.u, gdy w okresie intensywnego wzrostu zawiązków panowały niskie temperatury powietrza i było dużo opadów, skórka jabłek była bardziej ordzawiona niż skórka owoców uzyskanych w pozostałych sezonach.

Słowa kluczowe: regulowanie plonowania, jakość owoców, przerzedzanie kwiatów

Accepted for print: 11.02.2016

For citation: Szot, I., Basak, A., Lipa, T., Krawiec, P. (2016). Thinning of apple flowers with potassium bicarbonate (Armicarb®) in organic orchard. Acta Sci. Pol. Hortorum Cultus, 15(3), 29–43.