Journal of Horticultural Research 2015, vol. 23(2): 95-104
DOI: 10.2478/johr-2015-0019

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INFLUENCE OF CHEMICALS OF ARBOLIN GROUP ON BRANCHING OF MAIDEN TREES OF THREE APPLE CULTIVARS

Pavel ZHALNERCHYK, Andrzej A. PRZYBYŁA*, Franciszka JAUMIEŃ
Warsaw University of Life Sciences – SGGW, Warszawa, Poland

Received: September 2015; Accepted: November 2015

ABSTRACT

Studies realized in 2008 and 2009 proved that Neo Arbolin Extra (10 g GA_{4+7} and 50 g BA in 1 l of solution) and Neo Arbolin (18 g GA_{4+7} and 18 g BA in 1 l of solution) applied separately or with Algamino Plant (18% extract from seaweeds and 10% of potassium salt of amino acids) stimulated the development of axillary buds on apple maiden trees of 'Ligol', 'Golden Delicious' and 'Mutsu' cultivars grafted on M.9 rootstock, thus enhancing the number of feathers longer than 10 cm. Preparations were applied twice, from the middle of June to July 9. Results differed between years, which may be related to different weather courses during the growing seasons. Neo Arbolin Extra at a concentration 30 $ml \cdot l^{-1}$ with adjuvant addition (Adpros 5 $ml \cdot l^{-1}$) gave the best results in branching of maiden trees of three examined cultivars. Trees treated with those preparations twice produced more than 10 feathers (> 10 cm) in the year highly favoring maiden tree growth and more than 6 feathers in the less favorable year. Algamino Plant did not influence apple tree branching.

Key words: apple, nursery trees, scion, feathers, GA+BA

INTRODUCTION

The ability of apple trees to branch in a nursery is an inborn characteristics, conditioned by genes. They control branching ranging from the formation of the apex of the axillary bud and in particular the process of its vascularization and connection with the parent vascular tissue. Among apple cultivars there are moderately branching such as 'Ligol' and poorly branching such as 'Rubin' and 'Mutsu'. Environmental conditions have a notable effect on apple tree branching in a nursery (e.g. soil quality, water and nutrition availability). Long lasting drought as well as abundant rainfalls inhibit plant growth processes (Poniedziałek, Porębski 1992).

In seed plants, the lateral apical meristems are formed in the axils of the leaf primordia usually on a side of the stem. During subsequent growth, part of the stem between the top and the place located above the higher leaf bud develops. In this way, the lateral apical meristem becomes an axillary meristem.

In perennial plants, on the shoots formed in a particular vegetative season, the lateral apical meristems usually produce axillary buds, which either develop in the next year or remain dormant. In some cases, the lateral apical meristems still grow forming leaf primordia, which unfold either in the same year or in the next spring (Hejnowicz 2002).

Vascular connection of a lateral bud with the parent tissue of the main shoot is the most important process in branching (Larson & Pizzolato 1977). According to Wareing and Phillips (1978), the stimulating effect of the bud on vascular tissue development concerns hormones, type and concentration, particularly auxin and gibberellin but also cytokinin. A good branching of maiden apple trees was stimulated by Promalin 3,6 SL (a mixture of 1.8% 6-benzyladenine (BA) and 1.8% gibberellin A_4 and A_7), commonly applied at the concentration of 25 $ml \cdot l^{-1}$ as a single spraying of the upper part of the tree (Edgerton 1983). Experiments carried out in three successive years (1980-1982) showed good effectiveness of this preparation on eight cultivars

*Corresponding author:
e-mail: andrzejabp@o2.pl

of apple trees in a nursery. That effect was very clear on poorly branching cultivars 'Gloster', 'Boskoop' and 'Mutsu'. However, results concerning these cultivars varied in particular years. Although trees grew always in the same locality and always were grafted on M.9 rootstock, the number of feathers of the 'Gloster' and 'Mutsu' in 1982 was significantly higher than in 1981 (Goffinet et al. 1983).

Experiments with Arbolin realized in different regions of Poland (Gąstoł et al. 1999; 2012; Gudarowska, Szewczuk 2003; Kopytkowski, Markuszewski 2009; Kapłan 2010) gave favorable results. Studies with other chemicals for branching, especially with Paturyl, were carried by Basak et al. (1993).

The aim of our investigations was to study the effect of new preparations: Neo Arbolin 50 SL Extra and Neo Arbolin on branching of apple maiden trees in the nursery. The preparations contained GA_{4+7} instead of GA_3; their novelty in comparison to Arbolin Extra 075 and Arbolin 036 SL was studied.

MATERIALS AND METHODS

In 2008 and 2009 an experiment was carried out in the nursery of Warsaw University of Life Sciences (SGGW) on apple trees cvs 'Ligol', 'Golden Delicious' and 'Mutsu' that were grafted on an M.9 rootstock aimed at examining their branching in the result of application of preparations from the Arbolin group (Varichem sp. z o.o., Poland): Neo Arbolin Extra (10 g GA_{4+7} and 50 g BA in 1 l of solution), Neo Arbolin (18 g GA_{4+7} and 18 g BA in 1 l of solution) and Algamino Plant containing 18% of extract from sargassum seaweeds and 10% of potassium salts of amino acids. Trees of each cultivar were evaluated in separate experiments, which included 12 combinations of preparations in 4 replications and 5 trees in each.

Trees were sprayed at four fixed dates (Tables 1, 2, 3). On the first and third date, only Algamino Plant was used at concentration of 5 $ml \cdot l^{-1}$ and on the second and fourth Neo Arbolin Extra at concentration of 15 $ml \cdot l^{-1}$ or 30 $ml \cdot l^{-1}$ and Neo Arbolin at concentration of 17 $ml \cdot l^{-1}$ or 54 $ml \cdot l^{-1}$ (Tables 1, 2, 3). At the first spraying the height of trees amounted to 78-86 cm, depending on the cultivar. In 2009, the same experimental treatments were repeated. Maiden trees were grown on different fields of the same nursery than in the previous year. In both years the adjuvant Adpros at concentration of 5 $ml \cdot l^{-1}$ was added to the preparations. Spraying precisely covering a 20 cm of maiden tree shoots below the apex was always done from 8:30 to 12:00 h using a knapsack sprayer.

In the autumn of 2008 and 2009, prior to digging out, the height of trees as well as the length of feathers longer than 10 cm was measured. The height of trees, the sum of the length and number of feathers and the mean length of these shoots were analyzed statistically for each year separately using a one-factor analysis of variance. The significance of differences between means was evaluated with the Newman-Keuls test at the significance level of $\alpha = 0.05$.

Weather course was different in the subsequent years of the study. May and June, an important period in the growth of young trees, were more advantageous in 2008. The mean 24-hour temperature was most often higher than at similar period in 2009 and the distribution of precipitations was more regular. Long lasting cloudiness in 2009 probably decreased the intensity of photosynthesis and the excess of water in the soil made more difficult the air flow to the roots and thus their intake of mineral components. July 2008 was cooler than 2009 and fluctuations of 24-hour temperatures were lower. Similarly to May and June, July of 2008 was less humid (the sum of precipitations was 100 mm) than in 2009 (126 mm).

In both years of investigations the spraying with Arbolin preparations was performed on warm and sunny days. On the day before spraying in 2008, the nursery was watered, which caused an increase in air relative humidity around trees.

RESULTS

'Ligol'

Maiden trees of 'Ligol' grew more strongly in the vegetation season of 2008 than in 2009. They were higher by 14% and mean lengths of feathers were longer by 77%. In 2009, there were almost three times more feathers (Table 1). There were no statistically significant differences in tree height between non treated and treated trees, although the

highest were those sprayed with Neo Arbolin 27 ml·l^{-1} (147 cm) and the lowest sprayed with Neo Arbolin 54 ml·l^{-1} (125 cm). In 2009, the height of trees did not differ significantly between the combinations, and amounted from 107 to 124 cm.

In 2008, the mean length of the feathers (15.9-18.7 cm) did not significantly differ between the combinations in which the Arbolin preparations were used, but it was significantly smaller as compared with the length of such shoots of the control trees. In 2009, the differences in the length of feathers (14.9-18.6 cm) were not significant between all the combinations (Table 1).

In both years of the experiment, Neo Arbolin Extra and Neo Arbolin stimulated the growth of feathers from the axillary buds on trees sprayed with those preparations. No clear differences were observed between similar combinations with Neo Arbolin Extra and Neo Arbolin. Big differences in the results were observed between the years of the investigations.

In 2008, the highest number of feathers (11.0 and 11.9) were formed on the trees sprayed with Neo Arbolin Extra 30 ml·l^{-1} and Neo Arbolin 54 ml·l^{-1} respectively. A single spraying led to worse results in 2008. In 2009, there were no differences between preparations treatments. The best result (7.2 feathers) was obtained when maiden trees were sprayed twice with Neo Arbolin Extra 30 ml·l^{-1}. In 2008, as a result of a higher number of shoots, the sum of their lengths in all combinations was higher than in 2009. Control trees always produced only few feathers and thus the sum of their lengths was significantly smaller as compared with the sum of shoot lengths on trees sprayed with the Arbolin preparations. In both years of the investigations, no significant effect of Algamino Plant on the investigated traits was observed (Table 1).

In the same year 2009, the damage of trees could be observed at a height of about 75 cm from the ground on trees twice sprayed with Neo Arbolin at concentration of 54 ml·l^{-1}. At a distance of 10-15 cm towards the maiden tree apex, the feathers reached only about 10 cm in length. They did not develop leaves and had a dry apex. In combinations, in which the same preparation was used at a similar concentration but only at the earlier date, such damages were not observed. No similar damages were found in 2008.

'Golden Delicious'

In both years, maiden trees of 'Golden Delicious' grew with similar intensity reaching a height of about 150 cm and feathers length about 25 cm. Trees treated with Arbolin preparations were always smaller than control trees but significantly only in 2008 at concentrations higher than 15 ml·l^{-1} (Table 2).

'Golden Delicious' has been rated among easily branching cultivars of apple, although in the years of the study the control trees had, on the average, only 2.9 and 2.2 feathers (> 10 cm) respectively. However, that cultivar stronger reacted to Arbolin preparations than two other cultivars. In 2008, trees treated with those preparations produced 10.7-15.5 feathers > 10 cm and in 2009 7.9-11.1 of such shoots (Table 2). In each year, there was a 100% branching and 100% trees produced more than five feathers in the combinations with double or single spraying with Neo Arbolin Extra at a concentration of 30 or 15 ml·l^{-1}. Trees produced the highest number of feathers > 10 cm when sprayed with Neo Arbolin Extra 30 ml·l^{-1}. The length of feathers did not differ in a significant way from the control in both years of study (Table 2).

In 2008 and 2009, the sum of the lengths of feathers on treated trees was a few times greater as compared to the same number of control trees. This resulted from a much higher number of shoots on the treated trees of similar length to the shoots on the control trees (Table 2).

In the season of 2009, some damages were observed on trees of 'Golden Delicious', similarly to those on 'Ligol' trees at the highest Neo Arbolin concentration.

'Mutsu'

In 2008, maiden trees of 'Mutsu' reached heights of 161-170 cm and were higher than in 2009 (136-148 cm). There were no significant differences in tree height and length of feathers between Arbolin treated and untreated trees (Table 3).

Table 1. The influence of Neo Arbolin Extra, Neo Arbolin and Algamino Plant on the branching of 'Ligol' maiden trees (2008 and 2009)

No. Treat.	Treatment and date of sprays				2008				2009			
	T_1 17.06.08	T_2 23.06.08 01.07.09	T_3 26.06.08	T_4 05.07.08 09.07.09	Tree	Σ length of feathers >10 cm	Number of feathers >10 cm	Mean feather length (cm)	Tree height	Σ length of feathers >10 cm	Number of feathers >10 cm	Mean feather length (cm)
1	-	Control	-	-	138 abc	21 a	0.8 a	26.2 b	121 a	10 a	0.3 a	14.8 a
2	Alg. Pl.	Neo Arb. Ext.15**	Alg. Pl.	Neo Arb. Ext.15	137 abc	88 b	5.3 b	16.6 a	112 a	81 b	5.0 bc	16.3 a
3	-	Neo Arb. Ext.15	-	Neo Arb. Ext.15	142 bc	137 bc	8.0 bcd	16.7 a	116 a	109 b	5.9 c	18.1 a
4	Alg. Pl.	Neo Arb.27	Alg. Pl.	Neo Arb.27	141 abc	113 bc	7.1 bc	16.5 a	119 a	97 b	5.6 bc	17.1 a
5	-	Neo Arb.27	-	Neo Arb.27	147 c	120 bc	7.1 bc	16.2 a	117 a	102 b	6.0 c	16.7 a
6	Alg. Pl.	Neo Arb. Ext.30	Alg. Pl.	Neo Arb. Ext.30	133 abc	134 bc	8.2 bcd	16.6 a	107 a	124 b	7.2 c	17.1 a
7	-	Neo Arb. Ext.30	-	Neo Arb. Ext.30	135 abc	176 bc	11.0 cd	16.1 a	117 a	108 b	6.5 c	16.2 a
8	Alg. Pl.	Neo Arb. Ext.30	Alg. Pl.	-	135 abc	122 bc	6.4 b	18.7 a	114 a	71 b	4.4 bc	16.0 a
9	Alg. Pl.	Neo Arb.54	Alg. Pl.	Neo Arb.54*	125 a	130 bc	8.2 bcd	16.1 a	118 a	108 b	6.0 c	17.8 a
10	-	Neo Arb.54	-	Neo Arb.54*	125 a	187 c	11.9 d	16.3 a	120 a	94 b	5.5 bc	17.0 a
11	Alg. Pl.	Neo Arb.54	Alg. Pl.	-	128 ab	133 bc	7.1 bc	17.3 a	124 a	53 b	2.9 b	18.0 a
12	-	Neo Arb. Ext.15	-	Neo Arb.27	134 abc	129 bc	8.1 bcd	15.9 a	118 a	101 b	5.4 bc	18.6 a

Means within columns followed by the same letter are not significantly different at $\alpha = 0.05$; Alg. Pl. = Algamino Plant, Neo Arb. = Neo Arbolin, Neo Arb. Ext. = Neo Arbolin Extra; *damages, **in ml l^{-1}.

Table 2. The influence of Neo Arbolin Extra, Neo Arbolin and Algamino Plant on the branching of 'Golden Delicious' maiden trees (2008 and 2009)

No. Treat.	Treatment and date of sprays				2008				2009			
	T_1 17.06.08	T_2 23.06.08 01.07.09	T_3 26.06.08	T_4 05.07.08 09.07.09	Tree height	Σ length of feathers >10 cm	Number of feathers >10 cm	Mean feather length (cm)	Tree height	Σ length of feathers >10 cm	Number of feathers >10 cm	Mean feather length (cm)
1	-	Control	-	-	153 b	75 a	2.9 a	25.8 ab	151 a	56 a	2.2 a	24.9 a
2	Alg. Pl.	Neo Arb. Ext.15**	Alg. Pl.	Neo Arb. Ext.15	140 ab	286 b	11.7 b	24.4 ab	142 a	223 b	9.1 b	24.2 a
3	-	Neo Arb. Ext.15	-	Neo Arb. Ext.15	137 ab	304 bc	12.1 b	25.3 ab	143 a	246 b	9.4 b	26.0 a
4	Alg. Pl.	Neo Arb.27	Alg. Pl.	Neo Arb.27	138 ab	331 bc	13.2 bc	25.0 ab	143 a	269 b	10.7 b	24.7 a
5	-	Neo Arb.27	-	Neo Arb.27	133 a	324 bc	13.6 bc	23.8 a	140 a	245 b	10.0 b	24.0 a
6	Alg. Pl.	Neo Arb. Ext.30	Alg. Pl.	Neo Arb. Ext.30	140 ab	429 c	15.5 c	27.6 ab	141 a	265 b	11.1 b	23.7 a
7	-	Neo Arb. Ext.30	-	Neo Arb. Ext.30	134 a	401 bc	15.5 c	25.9 ab	141 a	281 b	10.9 b	25.8 a
8	Alg. Pl.	Neo Arb. Ext.30	Alg. Pl.	-	142 ab	352 bc	12.7 bc	27.7 ab	147 a	204 b	9.2 b	22.3 a
9	Alg. Pl.	Neo Arb.54	Alg. Pl.	Neo Arb.54*	128 a	300 bc	11.5 b	26.1 ab	143 a	215 b	9.3 b	23.1 a
10	-	Neo Arb.54	-	Neo Arb.54*	129 a	318 bc	10.7 b	29.7 b	137 a	208 b	8.9 b	23.6 a
11	Alg. Pl.	Neo Arb.54	Alg. Pl.	-	135 a	344 bc	11.4 b	30.3 b	147 a	171 b	9.9 b	21.3 a
12	-	Neo Arb. Ext.15	-	Neo Arb.27	140 ab	347 bc	13.7 bc	25.3 ab	145 a	276 b	9.8 b	28.1 a

Note: See Table 1

Table 3. The influence of Neo Arbolin Extra, Neo Arbolin and Algamino Plant on the branching of 'Mutsu' maiden trees (2008 and 2009)

No. Treat.	Treatment and date of sprays				2008				2009			
	T_1 17.06.08	T_2 23.06.08 01.07.09	T_3 26.06.08	T_4 05.07.08 09.07.09	Tree height	Σ length of feathers >10 cm	Number of feathers >10 cm	Mean feather length (cm)	Tree height	Σ length of feathers >10 cm	Number of feathers >10 cm	Mean feather length (cm)
1	-	Control	-	-	170 a	16.3 a	0.6 a	27.2 a	143 a	2.8 a	0.1 a	28.0 b
2	Alg. Pl.	Neo Arb. Ext.15**	Alg. Pl.	Neo Arb. Ext.15	167 a	194 bc	7.3 bc	26.7 a	136 a	135 b	6.7 b	19.6 ab
3	-	Neo Arb. Ext.15	-	Neo Arb. Ext.15	161 a	185 bc	7.1 bc	26.3 a	141 a	142 b	7.0 b	19.3 ab
4	Alg. Pl.	Neo Arb.27	Alg. Pl.	Neo Arb.27	164 a	146 b	5.3 b	28.7 a	143 a	134 b	6.6 b	19.9 ab
5	-	Neo Arb.27	-	Neo Arb.27	165 a	151 b	6.5 bc	23.3 a	145 a	103 b	5.2 b	19.5 ab
6	Alg. Pl.	Neo Arb. Ext.30	Alg. Pl.	Neo Arb. Ext.30	169 a	214 bc	9.0 cde	24.0 a	137 a	125 b	6.6 b	18.6 ab
7	-	Neo Arb. Ext.30	-	Neo Arb. Ext.30	166 a	268 c	11.5 e	23.3 a	139 a	115 b	6.4 b	17.6 a
8	Alg. Pl.	Neo Arb. Ext.30	Alg. Pl.	-	168 a	172 b	7.0 bc	25.3 a	146 a	80 b	4.5 b	18.0 a
9	Alg. Pl.	Neo Arb.54	Alg. Pl.	Neo Arb.54	165 a	208 bc	8.9 cde	23.1 a	142 a	136 b	6.3 b	21.3 ab
10	-	Neo Arb.54	-	Neo Arb.54	162 a	240 bc	10.6 de	22.6 a	139 a	116 b	5.9 b	19.3 ab
11	Alg. Pl.	Neo Arb.54	Alg. Pl.	-	166 a	175 b	7.5 bc	23.2 a	147 a	94 b	4.4 b	21.4 ab
12	-	Neo Arb. Ext.15	-	Neo Arb.27	165 a	154 b	8.4 bcd	19.1 a	148 a	151 b	6.8 b	22.3 ab

Note: See Table 1

Table 4. Percentage of 'Ligol', 'Golden Delicious' and 'Mutsu' maiden trees with the number of feathers in 12 treatments (2008 and 2009)

No. Treat.	Year	'Ligol'				'Golden Delicious'				'Mutsu'			
		% of branched trees	% of trees with no. of feathers:			% of branched trees	% of trees with no. of feathers:			% of branched trees	% of trees with no. of feathers:		
			4	5	> 5		4	5	> 5		4	5	> 5
1	2008	0	-	-	-	25	40	40	20	0	-	-	-
	2009	0	-	-	-	25	40	40	20	0	-	-	-
2	2008	65	-	15	85	100	-	-	100	90	-	6	94
	2009	80	62	13	25	100	-	-	100	95	-	21	79
3	2008	85	-	-	100	90	-	10	90	95	10	16	74
	2009	80	31	19	50	100	-	-	100	95	10	16	74
4	2008	90	17	11	72	100	-	-	100	68	27	20	53
	2009	75	27	27	46	100	-	-	100	85	-	12	88
5	2008	90	11	22	67	100	-	-	100	100	10	30	60
	2009	75	13	7	80	75	6	-	94	75	7	33	60
6	2008	90	-	6	94	100	-	-	100	100	-	-	100
	2009	70	7	7	86	100	-	-	100	85	-	12	88
7	2008	100	-	5	95	100	-	-	100	90	-	-	100
	2009	65	23	-	77	100	-	-	100	90	11	11	78
8	2008	75	7	7	86	100	-	-	100	75	20	-	80
	2009	55	55	18	27	100	-	-	100	70	43	21	36
9	2008	90	6	-	94	100	-	-	100	100	-	-	100
	2009	70	21	22	57	95	-	-	100	90	22	22	56
10	2008	100	-	-	100	100	-	-	100	100	-	5	95
	2009	75	20	27	53	100	-	5	95	80	19	6	75
11	2008	95	10	16	74	100	-	-	100	90	22	11	67
	2009	30	67	33	-	100	10	20	70	60	17	25	58
12	2008	100	-	7	93	100	-	-	100	100	13	7	80
	2009	75	7	33	60	100	-	-	100	95	5	16	79

Note: 1 – control; 2, 3 – Neo Arb. Ext.15; 4, 5 – Neo Arb.27; 6, 7, 8 – Neo Arb. Ext.30; 9, 10, 11 – Neo Arb.54; 12 – Neo Arb. Ext.15 and Neo Arb.27 (ml l^{-1})

The applied treatments increased instantly branching of 'Mutsu' in both years of study. Whereas in 2008 differences between treatments were observed, in 2009 none were found, and the number of feathers varied from 4.4 to 7.0. In 2008, the number of feathers ranged from 5.3 for Neo Arbolin 27 $ml \cdot l^{-1}$ treated trees to 11.5 feathers for Neo Arbolin Extra 30 $ml \cdot l^{-1}$ applied twice.

As a result of a higher number and length of feathers, the sum of lengths of these shoots was clearly bigger in 2008 as compared to 2009.

Neo Arbolin Extra applied at the concentration 30 $ml \cdot l^{-1}$ did not cause tree damages and thus it proved to be a better preparation as compared with Neo Arbolin.

Algamino Plant applied in 2008 prior to the treatment with Arbolin preparations and in 2009 as an additive to those preparations did not bring a clear effect (Table 3).

DISCUSSION

The results of two-year experiment revealed that apple trees of three cultivars on M.9 rootstock in the same habitat conditions grew with various intensities. The reaction to the weather conditions of each of those cultivars also varied in particular years of the investigations. The exception was 'Golden Delicious' whose trees reached a similar height in the control combination in both years of the investigations. 'Mutsu' and 'Ligol' proved to be sensitive to the adverse weather conditions in 2009. In that year, these trees reached heights smaller by 19% and 15%, respectively, than in 2008. Long lasting cloudy weather and continuous rains in May, June and July probably decreased the intensity of photosynthesis, and the excess of water caused soil overflooding and its poorer airing and thus impaired the physiological processes taking place in the roots (Poniedziałek & Porębski 1992).

The differences between years also concerned branching of trees of the same cultivar. This process could be affected by atmospheric precipitations and the temperature profile. In 2008, higher air temperatures were observed in May and June than at the same time in 2009. June is a particularly crucial period for growing axillary buds in apple trees. English and Belgian investigations showed that the growth of feathers is hindered at temperatures 16-21 °C and inhibited at temperature below 16 °C. Temperature fluctuations also decrease the growth of the leader and the formation of feathers on nursery apple trees (Goffinet et al. 1983). Gąstoł et al. (2012) and Robinson et al. (2014) in their experiments also observed a major influence of climatic conditions on feather production of apple maiden trees in nursery. This agrees with the results of our experiments. Trees of 'Ligol' and 'Mutsu' spontaneously produced more feathers in 2008 than in 2009, but 'Golden Delicious' in both years produced a similar number of such shoots.

Trees of 'Ligol' and 'Mutsu' treated and non-treated with the Arbolin preparations grew more strongly in 2008 in the advantageous weather conditions than in the adverse conditions in 2009; therefore, an increase in tree height had resulted in a larger number of feathers.

Trees of 'Golden Delicious showed a clear resistance to weather conditions. In both years, they reached a similar height in the control combination. In combinations with the Arbolin preparation in 2009 they were even higher than in 2008, which was more advantageous for tree growth. A smaller number of feathers on the trees in 2009 was probably the cause of a stronger elongation growth of the main shoot.

In both years of the investigations, Neo Arbolin Extra and Neo Arbolin very clearly stimulated the branching of the maiden trees of the three investigated cultivars. However, certain differences were observed between years in the number of lateral shoots of over 20 cm in length. In 2008, in which the weather conditions were more advantageous, there were 1 to 5 more of such shoots than in 2009. Goffinet et al. (1983) mentioned a poorer branching of 'Gloster' and 'Mutsu' trees in Belgium in 1981 than in 1982. Similarly in central Poland, trees of 'Red Boskoop' treated with Arbolin 036 SL at a concentration of 250 $mg \cdot l^{-1}$ grew on the average 7.8 feathers in 1995 and only 3.7 in 1997, although they grew on a similar rootstock and in a nursery in the same place (Jaumień & Dziuban 1998).

Vascular joining of the lateral bud with the parent tissue of the main shoot is the most important process in branching. An important role in this process is played by gibberellins and cytokinins (Wareing & Phillips 1978; Larsen & Pizzolato 1997;

Hejnowicz 2002). Promalin 3.6 SL, a mixture of 6-benzyladenine (1.8%) and gibberellin A_4 and A_7 (1.8%), widely used at a concentration of 25 ml·l^{-1} both in America and Europe resulted in a good branching of maiden apple trees (Edgerton 1983, Goffinet et al. 1983). The mixture of GA_3 and BA prepared directly prior to spraying and applied in various regions of Poland with different weather and soil conditions proved to be promising (Jaumień et al. 1993). The results from 1995 (Jaumień & Dziuban 1998), as was already mentioned were similar to the results obtained for Promalin 3.6 SL used at a concentration of 25 ml·l^{-1} (8.1 and 8.4 feathers) applied in 1980 and 1981 in Belgium on trees of the same cultivar 'Red Boskoop' on M.9 (Goffinet et al. 1983). The differences in years probably resulted from the fact that the weather conditions in Belgium were similar, unlike in Poland, in both years of the investigations. Thus it could be assumed that gibberellin GA_3 in Arbolin 036 SL and GA_{4+7} in Promalin 3.6 SL had a similar effect on branching of maiden apple trees.

Arbolin Extra 75 SL (10 g GA_3 + 65 g BA), a preparation containing a smaller amount of gibberellin and several times increased cytokinin content, was applied at concentrations of 6 to 18 ml·l^{-1} in the nursery of SGGW and in a commercial nursery on 'Gala', 'Šampion', 'Gloster', 'Alwa' and 'Elise', 'Witos' and 'Sawa' were treated only in Wilanów and 'Ligol', 'Jonagold', 'Celeste' and 'Rubin' only in the commercial nursery for the dwarf and semi-dwarf rootstocks in various habitat conditions and in years with different weather conditions. This produced similar results to those obtained in the same nurseries with Arbolin 036 SL (18 g GA_3 + 18 g BA) at a concentration of 25 ml·l^{-1}, that is several times higher (Jaumień et al. 2004).

In 2008 and 2009, Neo Arbolin Extra (10 g GA_{4+7} And 50 g BA) and Neo Arbolin (18 g GA_{4+7} and 18 g BA), which differ in the amount of gibberellin, were investigated at the nursery of SGGW. The first differs from Arbolin Extra 075 SL and the second from Arbolin 036 SL, both of which contain GA_{4+7} and not GA_3. Two years of investigations revealed that both these preparations had a good effect on the branching of apple trees in a nursery but similar to that for Arbolin 036 SL or Arbolin Extra 075 SL, both with gibberellin GA_3 and not A_4 and A_7.

In 2008 and 2009, the trees of 'Ligol' on M.9 in a nursery that were twice sprayed with Neo Arbolin Extra at a concentration of 15 ml·l^{-1} produced 8.0 and 5.9 feathers, respectively, and 'Golden Delicious' produced 12.1 and 9.4 feathers. Trees of 'Mutsu' on M.9 sprayed in a similar way produced 7.0 feathers in each of the two years. A similar result of 11 feathers was obtained in 2008, a year favorable to branching, on 'Ligol' trees sprayed twice with the preparation at a concentration of 30 ml·l^{-1}, that is twice higher.

In 2008, feathers of > 20 cm were shorter on those trees that had more such shoots. When 'Mutsu' trees had 7 feathers, their length amounted to 26 cm and on trees that grew 11 shoots, they amounted to 23 cm. The 'Ligol' trees developed 8 and 11 feathers of a similar length (16 cm), and 'Golden Delicious' produced 12 feathers of 25 cm or 9.4 of 26 cm, respectively. Many factors affect the elongation growth of shoots including the genetic factor.

The compared cultivars, 'Golden Delicious', 'Ligol' and 'Mutsu' show a similar branching tendency. Trees of these cultivars in a nursery produced spontaneously less than one lateral shoot on the average.

The cited results obtained after the application of Arbolin Extra 075 clearly show that GA_3 in the mixture with BA gives a similar and not a worse effect on apple tree branching in a nursery than A_4 and A_7 in a similar mixture with BA in Neo Arbolin 50 SL Extra. A bigger amount of gibberellin (by 15 g) in Arbolin Extra 075 SL could be important in stimulating the growth of axillary buds in the maiden apple trees. In addition, some differences in the results could arise from the habitat conditions, weather conditions or the thickness of rootstock and maiden trees grafted on them (Jaumień & Dziuban 1998). Preparations Axcel and Promalin in concentrations 400-500 ppm after 4-5 sprays induced a growth of more than 11 feathers per maiden tree of several apple cultivars (Robinson et al. 2014).

All the listed preparations: Promalin 3.6 SL, Arbolin 036 SL, Arbolin Extra 075 SL, Neo Arbolin 50 SL Extra and Axcel caused good branching of apple trees in a nursery. Farmers can choose between these preparations, similarly influencing branching of maiden trees, according to the needs resulting from the desired form of trees in an orchard, and the market price can be decided on demand.

Neo Arbolin Extra and Neo Arbolin gave similar results in apple tree branching in a nursery but Neo Arbolin at a concentration of 54 $ml \cdot l^{-1}$ and twice applied in a season caused tree damage of all the investigated cultivars.

In both years of the study, a clear effect of Algamino Plant was observed neither on the elongation of the main shoot nor on the number of shoots on maiden trees of three apple cultivars.

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