

INDUCTION OF FEATHERING OF APPLE PLANTING MATERIAL SASTEIGTO DZINUMU VEIDOŠANĀS SEKMĒŠANA ĀBEĻU STĀDIEM

Kviklys D.

Lithuanian Institute of Horticulture, LT-54333 Babtai, Kauno distr., Lithuania.

Kopsavilkums

Lietuvas Dārzkopības institūtā 2001 -2003 gados tika veikti izmēģinājumi, kuros pārbaudīja sasteigto dzinumumu veidošanos viengadīgiem ābeļu stādiem. Tika pētītas triju grupu šķirnes: 'Jonagold' un 'Aldas', kuras viegli veido sasteigtos dzinumus; 'Aukšis', 'Rubin' un 'Alwa', kuras parasti pirmajā gadā neveido sasteigtos dzinumus; 'Shampion' un 'Ligol', kuras vidēji spēcīgi veido sasteigtos dzinumus. Sānu dzinumumu veidošanu stimulēja pielietojot augšanas regulatoru Arbolin 36SL (BA+GA₃) un galvenā dzinuma galotņošanu, vai lietoja abas metodes kombinēti. Visu apstrādes veidu lietošana šķirnēm, kuras viegli veido sāndzinumus, būtiski palielināja stādu kvalitāti. 'Shampion' un 'Ligol' stādu kvalitāte uzlabojās lietojot tikai augšanas regulatorus vai abas metodes kombinēti. Šķirnēm, kuras ģenētiski vāji veido sāndzinumus, jāpielieto abu metožu kombinācija.

Abstract

In 2001-2003 nursery trials were conducted at the Lithuanian Institute of Horticulture. The aim of the trial was to test apple cultivars and different treatments in order to increase the lateral branching of one year old trees at North European climatic conditions. Three types of cultivars were included: 'Jonagold' and 'Aldas' that one year old trees easily form feathers; 'Aukšis', 'Rubin' and 'Alwa' that do not form feathers during the first year; 'Sampion' and 'Ligol' that belong to intermediate type. Feathering was stimulated by growth regulator Arbolin 36SL (BA+GA₃), pinching of terminal leaves or combination of both factors. Maiden trees were assessed for height, percentage of trees with laterals, number of laterals and spurs, shoot length. All treatments for cultivars with easy feathering habit stimulated production of high quality maidens. Application of growth regulator or its combination with pinching of terminal leaves were the best treatments for 'Sampion' and 'Ligol', while only pinching did not give sufficient quality every year. In order to produce one-year-old feathered trees of cultivars that do not form feathers naturally, application of growth regulators together with pinching of terminal leaves should be applied.

Key words: *Malus x domestica*, nursery, lateral branches, quality, growth regulators.

Introduction

Quality of planting material is key factor for an early crop in the orchard and quick economic returns. For intensive orchards feathered trees are preferred (Bootsma and Baart, 1990; Poniedzialek *et al.*, 1994). The most popular type of apple planting material in West and Central European nurseries is a two-year-old tree with a one-year-old crown (knip type tree) (Bielicki *et al.*, 2002; Bielicki and Czynczyk, 1999). In North Europe due to differences in vegetation period, sum of temperatures and cultivars choice, the quality of the knip type tree is still under discussions, so that is why traditionally trained two-year-old tree is still prevailing there.

Because of economical reasons, nurserymen prefer to grow one-year-old trees. But not all apple cultivars grown as one-year-olds are suitable for the establishment of intensive orchards, since they do not produce lateral branches (Bootsma and Baart, 1990; Kviklys, 2004). Chemical agents or other techniques could induce feathering of one year old maidens. 6-benzyladenine (BA) and gibberellic acid (GA) are the most common plant growth regulators that promote formation of lateral branches (Buban, 2002; Hrotko *et al.*, 2000; Jacyna 2001; Wertheim and Estabrooks, 1994). They are successfully applied for different fruit crops (Jacyna and Puchala, 2004; Magyar and Hrotko, 2005 and Neri *et al.*, 2004). Trials on concentration of regulators, terms and the number of repetitions of application were conducted in different countries (Magyar and Hrotko, 2002; Jacyna, 1996; Theron *et al.*, 2000; Wertheim and Estabrooks, 1994). In North European climate conditions, do not every season apple maidens reach recommended height needed for application of plant growth regulators,

therefore other treatments as pinching of terminal leaves should be tested. Until now there are no publications presenting trials performed in climatic conditions similar to Lithuania.

The aim of the trial is to test reaction of various apple cultivars to treatments that induce feathering and to compare the efficiency of different treatments.

Materials and Methods

Nursery trials were conducted at Lithuanian Institute of Horticulture in 2001-2003. Maidens of apple cultivars 'Aldas', 'Alwa', 'Auksis', 'Jonagold', 'Ligol', 'Rubin', and 'Sampion' on rootstock M9 were tested. Rootstocks were planted at 0.9x0.3 m distance and budded at the beginning of August 2001 and 2002. Treatments inducing formation of lateral branches were applied during the following year at the end of June – beginning of July (2002 and 2003). Plant growth regulator Arbolin 36SL (BA+GA₃) at concentration 25 ml l⁻¹ was sprayed once when the maidens reached 55-65 cm height. Arbolin was applied at the top part of these maidens. Pinching of terminal leaves leaving apical growing point intact was started at the same time and was repeated 4 times at weekly intervals. The third treatment was a combination of Arbolin and pinching of terminal leaves. Control trees were left intact. All feathers appearing lower than 70 cm above the ground were removed immediately after their emergence.

At the end of the vegetation, percentage of feathered trees was calculated, where maidens with at least three feathers higher than 70 cm above the ground were considered as feathered. Tree height and trunk diameter (at 30 cm) was measured. The number and length of feathers longer than 10 cm, number and length of spurs below 10 cm, and total lateral shoot length was calculated.

Vegetation conditions during the two years of the experiment were comparable. Temperature was higher than the year's average in April and May, which promoted bud break and fast growth of maidens. The temperature of July exceeded the years' average by 3 degrees and induced better feathering. Higher temperatures stayed in August 2002, but were lower in August 2003. Precipitations were more abundant in July and August 2003, which benefited to slightly better feathering. Since there were no interactions between years and tendencies of feathering were the same, the results are presented as an average of two years.

The trial was set up in 4 replications with 30 trees per replicate. Differences between treatments and cultivars were estimated by two-way analysis of variance.

Results and Discussion

Combined treatment the pinching of terminal leaves and the application of Arbolin - was the most effective in breaking the dormancy of summer buds of one-year-old apple nursery trees, though there were no significant differences compared to treatment with Arbolin for cvs. 'Sampion', 'Ligol', 'Jonagold', and 'Aldas' (Table 1). Later two cultivars had 100% of feathered trees when only pinching was done.

Table 1. Effect of different treatments on the percentage of feathered trees, %

Cultivar	Treatment			
	pinching	Arbolin	pinching+Arbolin	control
'Auksis'	0	82	100	0
'Sampion'	78	100	100	23
'Jonagold'	100	100	100	80
'Aldas'	100	100	100	78
'Ligol'	34	87	97	22
'Alwa'	3	63	97	0
'Rubin'	0	0	70	0

Cultivar LSD_{0.01} – 16.2; treatment LSD_{0.01} – 12.6; cultivar x treatment LSD_{0.01} – 24.5

Naturally branched 80% of maidens of cvs. 'Jonagold' and 'Aldas', and only 22-23% of cvs. 'Sampion' and 'Ligol'. Control and pinched trees of cv. 'Auksis' and 'Rubin' did not form laterals at

all. Only 3% of cv. ‘Alwa’ maidens feathered when pinching of terminal leaves was performed, but it could be induced by occasional damage of apical growing point.

Cv. ‘Rubin’ did not respond to branching inducing treatments and even in combined treatment had a significantly lower percentage of feathered trees than other cultivars.

Table 2. Effect of different treatments on number of shoots longer than 10 cm

Cultivar	Treatment			
	pinching	Arbolin	pinching+Arbolin	control
‘Auksis’	0	6.0	7.1	0
‘Sampion’	3.4	8.6	9.2	0.4
‘Jonagold’	8.4	10.2	9.7	4.5
‘Aldas’	7.2	9.5	10.8	4.2
‘Ligol’	1.3	3.1	5.0	1.0
‘Alwa’	0.2	3.0	6.2	0
‘Rubin’	0	0	3.4	0

Cultivar $LSD_{0.01} = 1.85$; treatment $LSD_{0.01} = 1.31$; cultivar x treatment $LSD_{0.01} = 2.52$

Treatments that determined higher percentage of feathered maidens increased the number of laterals longer than 10 cm too. On average, the most numerous laterals (7.2) were formed when pinching and Arbolin were combined (Table 2). At this treatment cv. ‘Alwa’, ‘Ligol’, and ‘Rubin’ had the most significant increase of feathers compared to other treatments. ‘Jonagold’, ‘Aldas’, and ‘Sampion’ had more feathers than other cultivars after the application of Arbolin and combined treatment. ‘Sampion’ had significantly less feathers than ‘Jonagold’ and ‘Aldas’ in control and pinching treatment. There were no significant differences between Arbolin and the combined treatment for cvs. ‘Sampion’, ‘Jonagold’, ‘Aldas’ and ‘Auksis’. Cv. ‘Rubin’ had significantly less sylleptic shoots than other cultivars included in the trial.

Effect of treatments on spurs formation was less pronounced and no significant differences occurred when cultivars or treatments were compared. On average, somewhat more spurs developed when Arbolin or pinching+Arbolin were applied (Table 3). Though mainly these differences were caused by cultivars that did not form feathers in control and pinching treatments. Reaction of cv. ‘Sampion’, ‘Jonagold’, ‘Aldas’, and ‘Ligol’ to different treatments was not adequate.

Table 3. Effect of different treatments on the number of spurs

Cultivar	Treatment			
	pinching	Arbolin	pinching+Arbolin	control
‘Auksis’	0	1.4	1.7	0
‘Sampion’	1.7	0.4	2.5	1.0
‘Jonagold’	0.4	1.6	1.4	1.3
‘Aldas’	0.5	1.5	2.0	1.0
‘Ligol’	0.6	1.6	1.1	0.9
‘Alwa’	0.1	0.1	1.3	0
‘Rubin’	0	0	0.3	0
Mean	0.5	1.0	1.4	0.6

Cultivar not significant (NS); treatment NS; cultivar x treatment NS

Total shoot length varied upon cultivar and correlated with a number of feathers longer than 10 cm. ‘Jonagold’ and ‘Aldas’ had the biggest shoot growth in all treatments (Table 4). Pinching increased total shoot length for ‘Sampion’, ‘Jonagold’, and ‘Aldas’ compared to control, but it was not effective for other tested cultivars. Application of Arbolin was superior to pinching treatment for all cultivars. The combination of pinching and Arbolin significantly increased total shoot length for cvs.

‘Sampion’, ‘Aldas’, ‘Ligol’, and ‘Alwa’. Total shoot growth of cv. ‘Jonagold’ was better after application of Arbolin.

Table 4. Effect of different treatments on total shoot length, cm

Cultivar	Treatment			
	pinching	Arbolin	pinching+Arbolin	control
‘Auksis’	0	125.2	133.2	0
‘Sampion’	78.7	176.3	243.5	14.5
‘Jonagold’	205.7	314.0	299.0	93.7
‘Aldas’	197.2	270.0	320.5	87.2
‘Ligol’	27.3	55.5	112.3	21.3
‘Alwa’	5.3	95.3	210.3	0
‘Rubin’	0	0	76.3	0
Mean	73.5	149.2	198.2	31.0

Cultivar LSD_{0.01} 15.62; treatment LSD_{0.01} 12.75; cultivar x treatment LSD_{0.01} 31.24

Pinching of terminal leaves and Arbolin did not increase the mean shoot length of cv. ‘Ligol’ compared with control (Table 5). For other cultivars all branching inducing treatments gave longer sylleptic shoots than the control trees. For ‘Jonagold’ and ‘Aldas’ Arbolin and combined treatments were superior to pinching. For cv. ‘Sampion’ pinching and combined treatment resulted in longer laterals. Arbolin and combined treatment bore very similar results for other cultivars and no significant differences were recorded between them. Significantly longer laterals grew on maidens of cvs. ‘Sampion’, ‘Jonagold’, ‘Aldas’ and ‘Alwa’ compared with other cultivars.

Table 5. Effect of different treatments on mean shoot (longer than 10 cm) length, cm

Cultivar	Treatment			
	pinching	Arbolin	pinching+Arbolin	control
‘Auksis’	-	19.0	21.3	-
‘Sampion’	24.2	20.6	26.7	12.3
‘Jonagold’	24.2	30.8	30.8	18.1
‘Aldas’	23.2	28.2	29.5	17.2
‘Ligol’	15.4	17.4	21.8	13.6
‘Alwa’	-	32.6	34.2	-
‘Rubin’	-	-	23.2	-
Mean	21.8	24.8	26.8	15.3

Cultivar LSD_{0.05} – 6.56; treatment LSD_{0.05} – 3.82; cultivar x treatment - n.s.

Between tested cultivars great differences exist in response to applied treatments. For apple cultivars with easy branching habits every treatment was sufficient to increase the percentage of feathered trees. Cultivars that normally do not produce lateral branches during the first year in the nursery had different response to treatments. Arbolin alone was not an effective treatment to cv. ‘Rubin’. Similar results are reported by Sadowski and Gorski (2003) for cv. ‘Gloster’, that develops few and short feathers in spite of treatment with Arbolin. For such cultivars more application of plant growth regulators might be needed to increase the percentage of feathered trees as is reported in different trials (Hrotko *et.al.*, 1997; Jacyna, 2001; Magyar and Hrotko, 2005; Wertheim and Estabrooks, 1994). Pinching of terminal leaves did not increase sufficiently the percentage of feathered trees of cvs. ‘Rubin’, ‘Auksis’, ‘Alwa’ and ‘Ligol’. For these cultivars combination of Arbolin and pinching of terminal leaves was the best treatment. Only 20% of cv. ‘Sampion’ and ‘Ligol’ feathered naturally though there is information on good branching habits of these cultivars.

The combination of Arbolin and pinching significantly increased the number of laterals for all tested cultivars that are very important for the establishment of intensive orchards (Bielicki and

Czynczyk, 1999; Bootsma and Baart, 1990; Sadowski *et al.*, 2003). Cvs. 'Alwa', 'Ligol' and 'Rubin' had the highest response for this treatment. Cvs. 'Jonagold' and 'Aldas' had almost the same number of laterals treated by Arbolin alone or when pinching was applied. A surprisingly high efficiency of Arbolin was recorded for cv. 'Auksis', which do not form feathers during the first year in the nursery. Six shoots obtained after one treatment with Arbolin could be comparable with repeated sprays by other plant growth regulators in some trials performed with difficult to feather cultivars (Wertheim and Estabrooks, 1994). For cv. 'Sampion' Arbolin was also more effective compared with pinching.

Treatments inducing branching had no effect on the development of spurs. Short laterals usually form flower buds on the top and are important for first yields in the orchard (Bielicki and Czynczyk, 1998). Application of Arbolin only once per season and other treatments seems to be insufficient for spur formation. Regular application of plant growth hormones could increase the number of laterals with flower buds, what is reported for apples (Buban, 2000) and cherries (Magyar and Hrotko, 2005), though contradictory results are obtained too (Wertheim and Estabrooks, 1994). Application of higher concentrations of BA, which was not tested in our trial, also benefits to short laterals formation (Magyar and Hrotko, 2002; Wertheim and Estabrooks, 1994).

Total shoot length correlated with the number of laterals. Total shoot length more than 3 m of cvs. 'Jonagold' and 'Aldas' that had the highest number of laterals is less than reported in other trials (Wertheim and Estabrooks, 1994). These differences could be caused by the length of the vegetation season. On the other hand in our trial only laterals that emerged higher than 70 cm above the ground were measured.

The average length of sylleptic shoots was increased in most cases when plant growth regulator Arbolin 36SL was applied. Pinching alone did not have such positive effect on average shoot length. The length of laterals depended on the genotype. Cultivars with better branching habits formed longer shoots. The exception was cv. 'Alwa' which formed few but long laterals.

Conclusions

Up to 100% of feathered one-year-old apple trees of cvs. 'Jonagold' and 'Aldas' could be obtained in the nursery when plant growth regulator Arbolin 36SL or pinching of terminal leaves is applied.

Pinching of terminal leaves four times in weekly intervals is not an effective treatment to obtain feathered trees of cvs. 'Auksis', 'Rubin', 'Alwa' and 'Ligol'.

Application of Arbolin 36SL or a combination of Arbolin 36SL and pinching of terminal leaves sufficiently induce feathering of apple maidens of cvs. 'Sampion' and 'Ligol'.

The combined application of the growth regulator together with pinching of terminal leaves is needed for cvs 'Auksis', 'Rubin' and 'Alwa' in order to produce one-year-old planting material of high quality.

On average for all apple cultivars combination of Arbolin 36SL and pinching of terminal leaves increased the number of sylleptic shoots and total shoot length.

References

1. Bielicki P., Czynczyk A. and Nowakowski S. (2002) Influence of plant material quality on growth and yield of two apple cultivars. *Horticulture and Vegetable Growing*, 21 (4), 33-38.
2. Bielicki P. and Czynczyk A. (1999) Drzewka jabloni do nowoczesnych sadow XXI wieku. *Zeszyty naukowe AR Krakow*, 66, 59-65.
3. Bielicki P. and Czynczyk A. (1998) Mozliwosci modelowania jakosci drzewek dwuletnich. *Materialy XXXVII ogolnopolskiej naukowej konferencji sadowniczej*. Skierniewice, 174-177.
4. Bootsma J. and Baart J. (1990) Choice of half-produced trees is not right. *Fruiteelt*, 80, 22-23.
5. Buban T. (2000) The use of benzyladenine in orchard fruit growing: a mini review. *Plant Growth Regulation*, 32, 381-390.
6. Hrotko K., Magyar L. and Ronay Z. (2000) Improved feathering on apple nursery trees by BA application. *Acta Horticulturae*, 514, 113-122.
7. Hrotko K., Magyar L. and Buban T. (1997) Improved feathering by benzyladenine application on one-year-old 'Idared' apple trees in the nursery. *Acta Horticulturae*, 451, 673-678.

8. Jacyna T. and Puchala A. (2004) Application of environment friendly branch promoting substances to advance sweet cherry tree canopy development in the orchard. *Journal of Fruit and Ornamental Plant Research*, 12, 177-182.
9. Jacyna T. (2001) Studies on natural and induced branching in temperate fruit and ornamental trees. *Rozprawy naukowe akademii rolniczej w Lublinie*, 246, 45-66.
10. Jacyna T. (1996) Induction of lateral branching in nursery pear and apple trees with plant growth regulators. *Fruit Varieties Journal*, 50 (3), 151-156.
11. Kviklys D. (2004) Apple rootstock effect on the quality of planting material. *Acta Horticulturae*, 658 (2), 641-646.
12. Magyar L. and Hrotko K. (2005) Effect of BA (6-benzyladenine) and GA₄₊₇ on feathering of sweet cherry cultivars in the nursery. *Acta Horticulturae*, 667, 417-422.
13. Magyar L. and Hrotko K. (2002) Effect of 6-benzyladenine (BA) and gibberellic acid (GA₄₊₇) application on feathering of plum cultivars in nursery. *Acta Horticulturae*, 577, 345-349.
14. Neri D., Mazzoni M., Zucconi F. and Dradi G. (2004) Feathering control in sweet cherry (*Prunus avium* l.) nursery, by deblading and cytokinin. *Acta Horticulturae*, 636, 119-127.
15. Poniedziałek W., Nosal K. and Porebski S. (1994) Wpływ rozgaleziania się drzewek jabłoni w szkółce na ich wzrost i owocowanie w sadzie. *Zeszyty naukowe AR Krakow*, 21, 59-67.
16. Sadowski A. and Gorski M. (2003) Quality of apple planting stock depending on its method of production. *Plant Science*, 40, 394-398.
17. Sadowski A., Rybacka I. and Jablonski K. (2003) Initial growth, yield and fruit quality of "Gloster" apple trees, depending on the type of one-year-old nursery trees used for planting. *Horticulture and Vegetable Growing*, 22 (4), 60-67.
18. Theron K.I., Steyn W.J. and Jacobs G. (2000) Induction of proleptic shoot formation on pome fruit nursery trees. *Acta Horticulturae*, 514, 239-244.
19. Wertheim S. J and Estabrooks E .N. (1994) Effect of repeated sprays of 6-benzyladenine on the formation of sylleptic shoots in apple in the fruittree nursery. *Scientia Horticulturae*, 60, 31-39.