

EVALUATION OF SOME NURSERY TECHNIQUES IN THE PRODUCTION OF “KNIP-BOOM” APPLE TREES DAŽĀDU ĀBEĻU „KNIP-KOKU” VEIDOŠANAS TEHNIKU IZVĒRTĒJUMS

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Kopsavilkums

Divās izmēģinājumu sērijās (2000-2001 un 2001-2002) šķirne 'Sawa' tika potēta uz M.9 EMLA. Klona potcelmi tika atdalīti no mātesauga un potēti dažādos laikos: (1) potcelmi atdalīti novembrī, uzglabāti +1°C, potēti martā, pieauguši 12-15°C temperatūrā 15-20 dienas un izstādīti kokaudzētavā; (2) potcelmi atdalīti decembrī, un turpmākais kā (1); (3) potcelmi atdalīti marta beigās – aprīļa sākumā, potēti un uzreiz izstādīti kokaudzētavā. Otrajā veģetācijas gadā acotņi tika galotņoti 70 cm augstumā, ataugušais centra dzinums apstrādāts ar Arbolin 36 SL un vainags veidots no sasteigtajiem dzinumiem („knip-koku” tehnika). Labākais stādu iznākums bija pielietojot (1) un (2) metodes. Otrā izmēģinājumā trīs stumbru veidošanas metodes tika izmantotas „knip-koku” veidošanā šķirnēm 'Shampion' uz M.9 T339 acotai 2002. gadā un 'Rubin' uz P 59 acotai 2003. gadā. Pilnīga sānzaru izgriešana, atstājot tikai jaunizveidoto centrālo dzinumu, prasīja mazāk darbaspēka ieguldījuma nekā sānzaru galotņošana un vēlāka izgriešana. Stādu kvalitāte neatšķiras.

Abstract

In two experimental series (2000-2001 and 2001-2002) 'Sawa' was bench grafted on M.9 EMLA. Rootstocks were separated from mother plants at different dates and grafts treated in a different way: (1) rootstocks taken from stoolbeds in November, stored at +1°C, grafted in March, callused at 12-15°C for 15-20 days and then planted in the nursery; (2) rootstocks separated in December, then treated as (1); (3) rootstocks separated at the end of March or beginning of April, grafted and planted directly in the nursery. In the second year scion shoots were headed back at 70 cm, the renewed leader treated with Arbolin 36 SL and the crown formed by sylleptic shoots (“knip-boom” method). The higher output of nursery trees was obtained from the treatments (1) and (2), when rootstocks were separated in autumn or winter and grafts callused. In another experiment, three methods of cleaning stems were compared in production of „knip-boom” trees developed from budding, using 'Shampion' on M.9 T339 in 2002 and 'Rubin' on P 59 in 2003. The complete cleaning of stems and leaving a single renewed leader at once required less labour than successive cleaning with or without pinching of additional sprouts, left temporarily on the stem. Quality of trees produced by either method was similar.

Key words: apple, two-year-old trees, knip-boom trees, bench grafting, callusing, stem cleaning

Introduction

The use of two-year-old trees for establishing intensive apple orchards results in early bearing (Merezhko, 1985; Bootsma and Baart 1990; Włodarczyk 1994, Sadowski *et al.*, 2000, Bielicki *et al.*, 2002, 2004). Two-year-old trees may be produced in a different ways (Sadowski and Górski, 2003). Nowadays, two-year olds with a renewed leader and feathers (sylleptic laterals), commonly named in Dutch as “knip-boom”, are preferred (Bootsma, 1995; Bielicki *et al.*, 2004). Such trees not only provide early and high production, but also their growth in the orchard may be more easily controlled (Balkhoven-Baart *et al.*, 2000).

The production of “knip-boom” trees involves application of various treatments in the nursery. Bench grafting of scion cultivar on a rootstock in the wintertime provides an opportunity of shortening the nursery cycle to two years (Sadowski and Górski, 2003). In this study different timing of taking rootstocks assigned for grafting and of different treatment of grafts was evaluated. In the other experiments different methods of stem cleaning, in the process of training of a new leader (after heading back a scion shoot), were compared.

Materials and Methods

Two different nursery trials were carried out in Warsaw-Wilanów, Central Poland, each in two series. Soil of the site was silty loam alluvial, rich in humus.

Trial 1. Sawa apple cultivar was grafted on M.9 EMLA rootstocks 9-11 mm in diameter, at 20 cm above root collar. Rootstocks used were separated from the mother plants at different dates and grafts treated in a different way: (1) rootstocks separated from mother plants at the beginning of November, stored in cold storage at +1°C, grafted in March, subjected to callusing (heat pre-treatment) at 12-15°C for 15-20 days, followed by storage at 1°C for 5-7 days and then planted; (2) rootstocks separated in the second half of December, then treated as (1); (3) rootstocks separated at the end of March or beginning of April, grafted and immediately planted in the nursery. In the 2nd year of nursery (2001 or 2002) scion shoots were headed back at 70 cm, the renewed leader treated with Arbolin 36 SL (branching promoter, BA + GA₃) and crown formed of sylleptic shoots (“knip-boom” method).

Both experimental series were set in a randomised block design, with 6 replications and 30 plants per plot. Before digging out the trees (in autumn 2001 and 2002) stem diameter at 35 cm, tree height and length of lateral shoots were recorded. In the series I tree height was also measured after the 1st year (in autumn 2000). The total output of trees and output of branched trees was also calculated.

Trial 2. Both experimental series of this trial were carried out on trees produced in the three-year nursery cycle, where scion shoot was developed in the 2nd year of nursery – from budding performed in the 1st year. In the 3rd year, this scion shoot was headed back at 70 cm and the renewed leader was treated with Arbolin 36SL, when it reached the length of 25-35 cm above the cut, at the end of May. All suckers bursting from the rootstock were removed as they appeared.

Needless scion sprouts, appearing on the stem after cutting were eliminated in a different way: (1) all sprouts (except for one, which was assigned for a renewed leader) were removed at once when they had 3-5 leaves; (2) sprouts appearing at the basal, 40-cm part of the stem and 2-3 upper sprouts, competing with the leader, were removed at once, whereas the remaining ones (4-7) were left temporarily for a period of ca 3 weeks and finally removed 2-3 days before the Arbolin treatment; (3) the same as (2) + pinching of the tips of temporary sprouts.

The first series of this trial was carried out on 'Šampion' on M.9 T339 rootstock, with experimental treatments performed in 2002, the second series on 'Rubin' on P 59, with treatments in 2003. Both series were set in a randomised block design, with 5 replications and 21-24 trees per plot. Stem diameter and length of lateral shoots were measured before digging, as in the trial 1. Additionally, the length of the renewed leader was measured before treating it with Arbolin. Time spent on cleaning of stems by different methods was also recorded.

Results of measurements of both trials were elaborated by analysis of variance, separately for each experimental series. Significance of differences between treatment means was estimated using the Newman-Keuls test, at $\alpha=0.05$. Data related to the output of trees and to the time spent on the cleaning of stems in the trial 2 were not subjected to statistical analysis.

Results

Trial 1. As expected, rootstocks taken from the stoolbeds in April had mature (brown) roots, while rootstocks taken in November or even in December had a high proportion of white, delicate roots, which could be easily damaged while handling. In series I the output of trees was high, irrespective of the date of taking rootstocks and the treatment of grafts (Table 1). In series II a considerably lower output of trees was obtained when rootstocks were taken in April, immediately grafted and planted without callusing grafts. A low percentage of branched trees was also noted in this treatment.

Table 1. Output of trees, 'Sawa' on M.9 EMLA, % in relation to the grafts planted

Date of taking rootstocks	Date of grafting	Treatment of grafts	Series I (2000-2001)		Series II (2001-2002)	
			total	branched	total	branched
November	March	callusing	93.0	88.9	86.4	79.5
December	March	callusing	97.2	92.8	85.7	72.6
April	April	planting at once	97.2	94.4	78.6	52.6

In series I, after the 1st year, significantly lower trees were obtained, when grafting was made on rootstocks taken in April and non-callused (treatment 3) than with grafting in March on rootstocks taken in November or December and callused before planting (treatment 1 or 2) – Table 2. After the 2nd year these differences were effaced and no significant differences due to treatment were noted in

this series in the final height or in the stem diameter of two-year-olds. In series II there were no differences in the final tree height. However, trees obtained from grafts made on rootstocks taken in April and non-incubated were definitely thinner. Trees coming from grafts made on rootstocks taken in December were slightly thinner than made on rootstocks taken in November.

Table 2. Indices of tree size, 'Sawa' on M.9 EMLA

Date of taking rootstocks	Date of grafting	Treatment of grafts	Series I (2000-2001)			Series II (2001-2002)	
			one-year-olds	two-year-olds		two-year-olds	
			height, cm	height, cm	diameter, mm	height, cm	diameter, mm
November	March	callusing	117 b ¹	166 a	14.8 a	166 a	14.2 c
December	March	callusing	115 b	166 a	14.4 a	166 a	13.0 b
April	April	planting at once	105 a	163 a	14.3 a	163 a	11.8 a

¹ Mean values marked with the same letters (within the columns) are not significantly at different (at $\alpha=0.05$).

No significant differences in the number or length of lateral (syllaptic) shoots were found in the series I of this trial (Table 3). In series II the lowest number of lateral shoots and the smallest total length of laterals was obtained with grafting on rootstocks taken in April and non-callused grafts, while the highest indices of branching were noted with grafting in March on rootstocks taken in November and grafts callused.

Table 3. Indices of lateral shoots, 'Sawa' on M.9 EMLA

Date of taking rootstocks	Date of grafting	Treatment of grafts	Shoot number per tree			Total shoot length, cm	Mean shoot length, cm
			<20 cm	≥20 cm	total		
Series I (2000-2001)							
November	March	callusing	1.5 a	4.2 a	5.7 a	253 a	46.2 a
December	March	callusing	1.3 a	3.9 a	5.2 a	230 a	46.9 a
April	April	planting at once	1.4 a	4.0 a	5.4 a	234 a	44.9 a
Series II (2001-2002)							
November	March	callusing	1.2 a	4.3 b	5.5 b	248 b	47.1 a
December	March	callusing	1.2 a	3.5 a	4.7 ab	203 ab	45.2 a
April	April	planting at once	0.9 a	3.2 a	4.1 a	175 a	45.3 a

Trial 2. Immediate removal of all additional sprouts from stems (treatment 1) was the least laborious in both series of trials (Table 4).

Table 4. Time spent on cleaning of stems from additional sprouts, per 100 trees

Treatment of temporary sprouts on the stem	Date and time of cleaning			
	first cleaning	correction	final cleaning	total
Series I – 'Sampion' on M.9 T 339 – 2002				
	08.05	20.05	24.05	
Complete cleaning of all additional sprouts at once	19' 30"	1' 25"	2' 55"	23' 50"
Successive cleaning of additional sprouts	14' 30"	7' 15"	20' 15"	38' 40"
Successive cleaning with pinching of sprouts left	24' 40"	7' 15"	17' 25"	49' 20"
Series II – 'Rubin' on P 59 – 2003				
	10.05	21.05	28.05	
Complete cleaning of all additional sprouts at once	12' 30"	5' 30"	4' 10"	22' 10"
Successive cleaning of additional sprouts	13' 50"	6' 55"	5' 35"	26' 20"
Successive cleaning with pinching of sprouts left	24' 20"	8' 20"	5' 30"	38' 10"

The most laborious was successive cleaning of stems with additional pinching of tips of the temporarily left sprouts (treatment 3). Only in series II the new leader, developed after heading back of

scion shoot (maiden tree) in the 3rd year of nursery, was shorter when the complete cleaning of stem was applied at once (Table 5). However, this has not affected the final quality of two-year-old “knip-boom” trees (Table 5 and 6). A slightly smaller number of lateral shoots, resulting from the treatment 2, was noted in the series II (Table 6).

Table 5. Length of the renewed leader¹ and indices of the final tree size

Treatment of temporary sprouts on the stem	Length of new leader ¹ , cm	Tree height, cm	Stem diameter, cm
Series I – 'Šampion' on M.9 T 339 – 2002			
Complete cleaning of all additional sprouts at once	26.0 a	168 a	14.6 a
Successive cleaning of additional sprouts	26.6 a	166 a	14.7 a
Successive cleaning with pinching of sprouts left	27.2 a	167 a	14.9 a
Series II – 'Rubin' on P 59 – 2003			
Complete cleaning of all additional sprouts at once	23.7 a	171 a	16.2 a
Successive cleaning of additional sprouts	28.3 b	175 a	15.9 a
Successive cleaning with pinching of sprouts left	28.2 b	173 a	15.8 a

¹ before treatment with Arbolin 36SL

Table 6. Indices of lateral shoots

Treatment of temporary sprouts on the stem	Shoot number per tree			Total shoot length, cm	Mean shoot length, cm
	<20 cm	≥20 cm	total		
Series I – 'Šampion' on M.9 T 339 – 2002					
Complete cleaning of all additional sprouts at once	6.5 a	5.9 a	12.4 a	309 a	25.4 a
Successive cleaning of additional sprouts	5.0 a	6.3 a	11.3 a	312 a	26.9 a
Successive cleaning with pinching of sprouts left	5.7 a	6.0 a	11.7 a	332 a	27.7 a
Series II – 'Rubin' on P 59 – 2003					
Complete cleaning of all additional sprouts at once	5.1 a	3.4 a	8.5 b	161 a	18.8 a
Successive cleaning of additional sprouts	4.7 a	2.8 a	7.5 a	135 a	17.8 a
Successive cleaning with pinching of sprouts left	5.1 a	3.4 a	8.5 b	164 a	18.6 a

Discussion

Under the weather conditions of Central Poland, vegetative rootstocks may be taken from the stoolbeds either in late autumn or in spring, as in the wintertime the ground is usually frozen. Only during occasional periods of thawing it is possible to take rootstocks from stoolbeds in mid-winter, as happened in the trial 1 in December 1999 and 2000. The roots of rootstocks taken in autumn are immature, white and delicate, and may be easily damaged while handling, in contrast to the roots of rootstocks taken in spring. Hence, it was assumed that taking rootstocks in spring might result in a better survival and growth of trees. On the other hand, in the process of production of trees from bench grafting, a heat pre-treatment of grafts for a period of 2-3 weeks is usually recommended, in order to stimulate formation of the *callus* and in consequence a better take of grafts; this treatment is commonly named “callusing”. For callusing, grafting must be performed at the beginning of March and for this purpose rootstocks should be taken in autumn and cold stored. Callusing is impossible when rootstocks are taken from stoolbeds in spring, as then it is too late for the heat pre-treatment, grafts must be planted immediately. The results of the experiments carried out within our trial 1 did not confirm the original hypothesis. Although rootstocks taken in spring had mature roots, grafts made on them resulted in the same or lower output and in a similar or lower final tree quality. Apparently callusing of grafts was a decisive factor for success of bench grafting, as indicated in the study of Włodarczyk and Grzywaczewski (1994).

It is worth noting that, in general, satisfactory results were obtained with bench grafting. This is in line with the results of Sadowski and Górski (2003), who have shown that “knip-boom” two-year-old apple trees produced in a 2-year nursery cycle may not be inferior to “knip-boom” trees produced from budding – in a 3-year cycle.

The techniques of cleaning stems in the process of formation of a new leader for a "knip-boom" tree has not been referred in the special literature. According to the common opinion of nurserymen, immediate complete cleaning of stems of the needless sprouts is not desirable, as some leaves are needed to feed the stem with assimilates until the new leader develops an adequate number of leaves. The results of the trial 2 have shown that this is not necessary. Although in series II of this trial the renewed leader was slightly weaker when the complete cleaning of stem was applied at once, this had not any significant effect on the final tree quality. Apparently, considering a slightly weaker initial growth of the renewed leader, application of a branching promoter (Arbolin) should be delayed by few days when the method of immediate complete cleaning of stems is applied. On the other hand, a lower labour expense is an important advantage of this method.

Conclusions

Vegetative apple rootstocks assigned for bench grafting should be taken from stoolbeds in autumn, because then they can be grafted in March and subjected to callusing before planting. Planting of non-callused grafts may result in inferior results.

In the process of formation of the new leader of "knip-boom" trees, temporary leaving additional sprouts on the stem is not needed. Immediate complete cleaning of stems is less laborious and results in the same tree quality.

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