

SUPPRESSION OF SPININESS IN M.26 AND P.22 APPLE ROOTSTOCKS DZELKŠŅAINĪBAS NOVĒRŠANA M.26 UN P.22 POTCELMIEM

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Kopsavilkums

Izmēģinājums tika veikts trīs eksperimentos, iekļaujot potcelmu aprausumu rindas un potcelmu stādījumus kokaudzētavā pirms acošanas M.26 un P.22 potcelmiem. Lai novērstu dzelkšņu attīstību tika lietoti dinitroanilīni (butralīns, butralīns + BFA un pendimetalīns). Sākotnējos pētījumos vēls butralīna vasaras miglojums 4000 mg l⁻¹ koncentrācijā samazināja dzelkšņainību mātesaugiem dzelkšņainajiem *Malus robusta* 5 x M 9 hibrīdiem, bet izsauca pātrinātu lapu nobīšanu bez mizas bojājumiem. M.26 mātesaugiem divreizējs miglojums 1500 mg l⁻¹ koncentrācijā neietekmēja dzelkšņainību. Potcelmu M.26 un P.22 stādījumā kokaudzētavā divreizējs miglojums ar jebkuru no minētajiem dinitroanilīniem 1000, 2000 vai 3000 mg l⁻¹ koncentrācijā (butralīnam un BFA), un 1500, 2500 vai 3500 mg l⁻¹ (pendimetalīnam) būtiski samazināja dzelkšņainību salīdzinājumā ar neapstrādātiem augiem. Divreizēja apstrāde ar rokām izrādījās efektīvāka par ķīmisko apstrādi.

Abstract

These studies were conducted in three separate experiments including rootstock production (mound layering) and rootstock liners (tree production prior to budding) using M.26 and/or P.22 plant materials. To counteract spininess in examined plants dinitroaniline compounds: butralin, butralin + fatty alcohols (BFA), and pendimethalin were applied. In a preliminary study late summer sprays of butralin at 4000 mg l⁻¹ reduced spininess in stool beds of excessive spiny hybrids of *Malus robusta* 5 x M 9 but caused premature plant defoliation with no bark injury. In stool beds with M.26 plants two applications of 1500 mg l⁻¹ did not affect spininess. In M.26 and P.22 rootstock liners two sprays of either butralin, BFA or pendimethalin at 1000, 2000 or 3000 mg l⁻¹ (for butralin and BFA), or 1500, 2500 or 3500 mg l⁻¹ (for pendimethalin) significantly reduced spininess as compared with intact plants but no differences in this respect among the chemicals and rates were found. Two manual operations were somewhat more efficient in spine removal than chemical treatments but no practical differences between them in the field were observed. There were no adverse residual effects of chemical treatments on nursery tree performance (Jacyna *et al.*, 2002).

Key words: butralin, dinitroaniline, *Malus robusta* 5, mound layering, pendimethalin, rootstock liner

Introduction

Spininess is a characteristic of many *Malus* species, especially in the juvenile phase of plant growth (Cummins and Aldwinckle, 1983). However, in the stool bed a mother plant may produce both spiny (juvenile) and smooth (senile) shoots. Spines are particularly pronounced with *Malus robusta* 5 and its progeny, and some of the Malling series rootstocks as M.2, M.9 or M.26 (Cummins, 1992). Rootstocks from Polish series P are mostly free of spines except P.22 (Czynczyk, 1998). This undesirable feature makes both rootstock (layering) and nursery tree production (rootstock liners) costly and laborious. In both cases spines are removed by hand.

Various chemical compounds have been examined to inhibit spininess either in citrus rootstocks (Rouse, 1994) or ornamental trees (Quinlan and Pakenham, 1984), and suckers in tobacco plants (Mylonas and Panagos, 1978). Yet little research has been done in deciduous fruit rootstocks and nursery trees so far (Quinlan, 1978; Jacyna *et al.*, 2000). Most commonly used chemicals to counteract suckering (spininess) were either dinitroaniline compounds such as butralin or butralin combined with fatty alcohols, or auxin derivative NAA-naphthaleneacetic acid (Quinlan, 1978; Keever and Foster, 1990; Jacyna *et al.*, 2000). The basis for either spine removal or desuckering is by using of no translocable chemicals. Studies on absorption and translocation of dinitroaniline compounds in many species indicated that little was translocated from the site of uptake to other

parts of the plant treated (Ashton *et al.*, 1976). NAA may also act either as growth promotor or inhibitor depending on the organ treated and the concentration applied (Thimann *in* Westwood, 1978). NAA has shown to be very efficient in spine growth inhibition in apple rootstocks Geneva 30 (Jacyna *et al.*, 2000).

The objective of this research was to examine different dinitroaniline compounds to counteract spininess both in stool beds and in tree nursery liners. This report was divided into three parts comprising a preliminary study in apple rootstock stool beds (USA, 1995), apple rootstock stool beds (Poland, 1999), apple rootstock liners in nursery rows (Poland, 2000).

Materials and Methods

The chemicals used in reported experiments were as follows: Tamex® - containing 360 g l⁻¹ of butralin (N-sec-butyl-4-tetra-butyl-2,6-dinitroaniline) marked in this text as butralin; Tamex AG® - containing 75 g l⁻¹ of butralin + 450 g l⁻¹ of fatty alcohols (C₈ + C₁₀) marked here as BFA; Stomp 330 EC® - containing 75 g l⁻¹ of pendimethalin {N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitroaniline} marked in the text as pendimethalin. During these studies the following experiments were carried out:

Experiment 1 (pilot trial-stool beds) Mother plants of progeny of apple rootstocks *Malus robusta* 5 x Malling 9 (Cornell University Apple Rootstock Breeding Program) in stool beds established in 1990 were used. About 60-80 plants from each of the following excessive spiny hybrids: 74R5M9-760 (type 1), 74R5M9-707 (type 2), and 75R5M9BR-521 (type 3) were used. The plants were sprayed with butralin either at 1000, 2000, or 4000 mg l⁻¹ to run off. The sprays were directed to the "future" budding zone located up to 30 cm from the soil line. The control plants remained intact (no spine removal). All measurements were made within the zone of chemical application and its equivalent in control plants. This trial was not replicated.

Experiment 2 (apple rootstocks-stool beds) Mother plants of Malling 26 grown in stool beds established in 1994 were used. The plants were sprayed twice within the budding zone with butralin either at 500, 1000 or 1500 mg l⁻¹. First sprays started when the spines were approximately 2-3 cm long, and the second spray was applied 19 days later. After rootstock harvest the following measurements were performed: rootstock diameter at 5 cm above the soil line, cumulative length of roots assessed according to the scale (1 - ≤20, 2⁰ - > 20 - ≤ 90, 3⁰ - > 90 - ≤ 200, 4⁰ - > 200 - ≤ 350, 5⁰ - > 350 cm), and total length of parent shoot. The experiment was set up as complete randomized block design with 10 replications of 3 plants each. The data was subjected to analysis of variance, and the means were separated with LSD test at P<0.05. Mutual relations between either rootstock diameter or length of parent shoot, and either cumulative length of spines or their total number were evaluated by Pearson's product moment correlation at P<0.05.

Experiment 3 (liners of apple rootstocks M.26 and P.22) It was carried out using rootstocks M.26 and P.22 planted in nursery rows (0.8 x 0.3 m) in separate field sections. At the time of planting the liners were free of spines. The plants were treated twice in biweekly interval with one of the following chemicals: butralin either at 1000, 2000 or 3000, BFA at 1000, 2000 or 3000, and pendimethalin at 1500, 2500 or 3500 mg l⁻¹. The sprays were confined to the budding zone, and started when c.40% of plants showed spine length of 2-3 cm. The spines of control plants were removed by hand twice depending on spine regrowth. In order to examine the effect of tested compounds on spine suppression a group of 36 stocks of P.22 were left intact. Rootstock (liner) diameter was taken from each plant before and after the season. Upon completion of the growing season the following measurements were made within the zone of chemical application and its equivalent in control plants: number of spines and their length distribution, estimation of the treatment phytotoxicity by annual increment of rootstock cross-sectional area and weight of fresh mass of shoots grown out above the treated area, and visual observations of bud take. The data from M.26 and P.22 rootstocks were analyzed separately. Both experimental subsets were set up as complete randomized block design with 18 replications of 10 plants each. The significance of the results was tested by analysis of variance and means comparisons were made by Tukey's HSD at P<0.05 (Statgraphics Software).

Results and Discussion

The results obtained from our preliminary trial (experiment 1) showed that application of butralin, especially at 4000 mg l⁻¹ may decrease the number of spines (Table 1; Figure 1, 2, 3).

Table 1. Effect of butralin on spine suppression in different progeny of *Malus robusta* 5 x Malling 9 apple rootstocks in stool bed, exp. 1 – pilot trial, 1995

Treatment, mg l ⁻¹	Number of spines per plant		
	Hybrid		
	74R5M9-760	74R5M9-707	75R5M9BR-521
1000	5.0	5.8	4.4
2000	4.3	5.4	6.2
4000	2.9	3.3	3.9
0 ^y	6.2	6.5	6.7

^y untreated control (no spine removal)

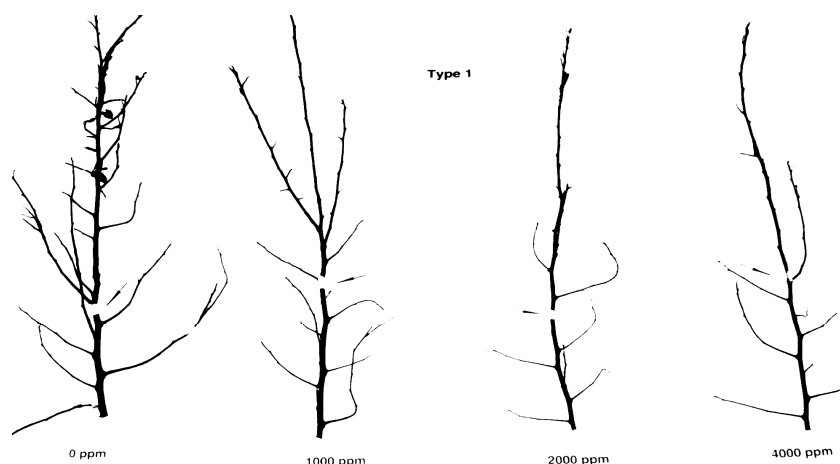


Figure 1. Effect of butralin application, in mg l⁻¹ = ppm, on suppression of lateral growth in hybrid 74R5M9-760. Blank spaces on parent shoot indicate the upper limit of the compound application

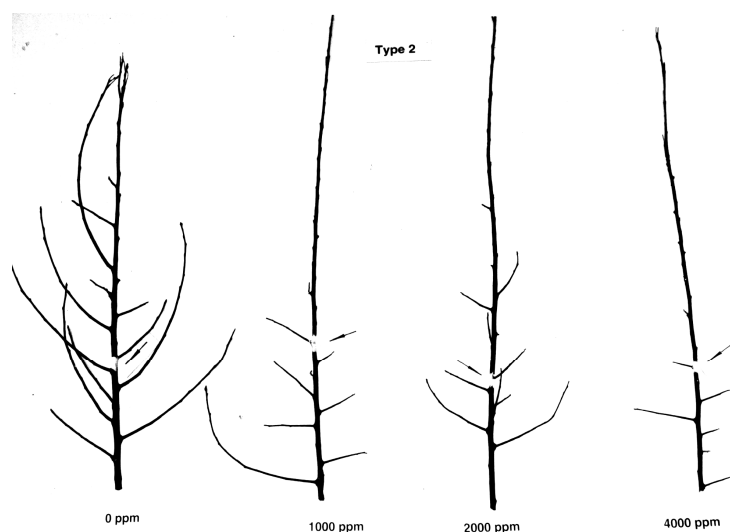


Figure 2. Effect of butralin application, in mg l⁻¹ = ppm, on suppression of lateral growth in hybrid 74R5M9-707. Blank spaces on parent shoot indicate the upper limit of the compound application

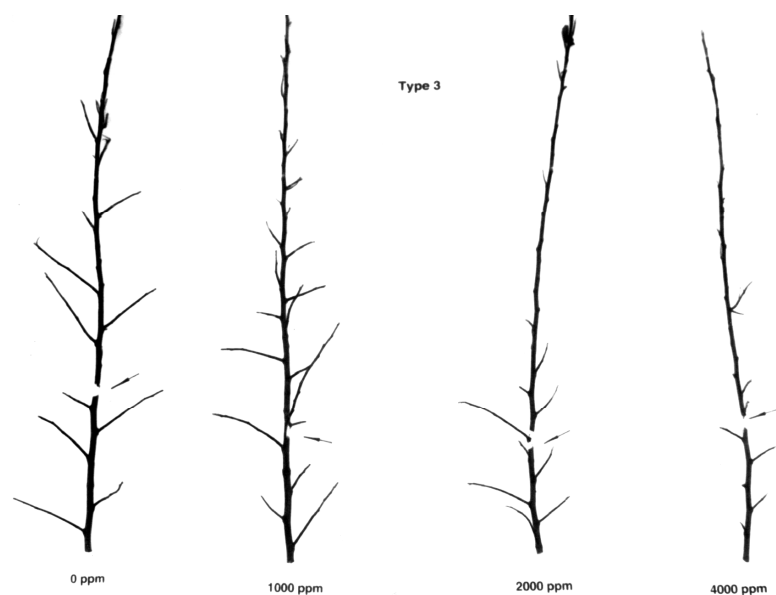


Figure 3. Effect of butralin application, $\text{mg l}^{-1} = \text{ppm}$, on suppression of lateral growth in hybrid 75R5M9BR-521. Blank spaces on parent shoot indicate the upper limit of the compound application

Malus robusta 5 and its progeny are known from excessive spininess (Cummins and Aldwinckle, 1983). Despite applying the chemical in late summer, the reduction in spine number was still satisfactory but the rate 4000 mg l^{-1} caused premature defoliation although no bark injury occurred. Visual observations showed that leaf injuries were confined to the zone of spraying with no translocation of these symptoms elsewhere.

Application of butralin in much lower concentrations than those used in experiment 1, did not bring about any suppression in spine growth of M.26 mother plants in stool beds (Table 2).

Table 2. Effect of butralin on spine suppression in M.26 apple rootstocks in stool bed (exp. 2, 1999)

Treatment, mg l^{-1}	Number of spines per plant			Total ^z
	$\leq 5 \text{ cm}$	$> 5 - < 10 \text{ cm}^z$	$\geq 10 \text{ cm}^z$	
500 x 2	7.0 b	1.0	0.5	8.5
1000 x 2	5.6 ab	1.0	0.5	7.1
1500 x 2	5.5 ab	1.0	0.6	7.1
0 ^y	4.9 a	1.4	0.8	7.1

Means followed by the same letter do not significantly differ at $P < 0.05$

^y untreated control (no spine removal); ^z means are not significantly different

There were no significant differences in spine number between the control and chemically treated plants. Consequently to the results shown in Table 2, no differences in quality characteristics among the treatments were found (Table 3).

Table 3. Effect of butralin on some quality characteristics of M.26 apple rootstocks in stool bed (exp. 2, 1999)

Treatment, mg l^{-1}	Rootstock diameter, mm^y	Length of rootstock parent shoot, cm^y	Cumulative length of roots, in scale ^{y,z}
500 x 2	8.1	88.0	2.9
1000 x 2	9.3	87.0	2.8
1500 x 2	8.8	87.3	3.1
0 ^x	9.3	92.4	2.9

^x untreated control (no spine removal); ^y means are not significantly different at $P < 0.05$; ^z see Materials and Methods for scale explanation.

It would indicate that butralin applied in given rates (Table 2) did not influence the growth of treated plants as expressed by rootstock diameter, length of rootstock parent shoot and development of root system (Table 4). Comparison of adverse effects caused by single application of 4000 mg l⁻¹ butralin (experiment 1) with no such effects with two sprays at 3000 mg l⁻¹ butralin (experiment 3) demonstrates different responses of treated plants depending on plant type or chemical rate. Quinlan (1978) reported no detrimental effects in maiden apple trees treated with 3000 mg l⁻¹ butralin but Knight (1979) found that the same rate of butralin caused serious defoliation of Quince rootstocks. The coefficients of correlation between basic rootstock quality parameters are given in Table 4. Spine growth expressed by cumulative length of spines and their number was positively correlated with the diameter and the length of rootstock parent shoot.

Table 4. Correlation coefficients for some quality characteristics of M.26 apple rootstocks in stool bed (exp. 2, 1999)

Correlation ^y	Coefficient of correlation, r	P-value
a x b	0.44	0.0000
a x c	0.20	0.0030
d x b	0.51	0.0000
d x c	0.35	0.0000

^y a – rootstock diameter, b – cumulative length of spines, c – total number of spines, d – length of rootstock parent shoot

The results obtained from application of other dinitroaniline compounds, i.e BFA and pendimethalin indicated that both might be safely used in the desuckering of apple rootstocks (experiment 3). Both compounds performed in similar way as butralin in reducing spininess when compared with manual procedures (Table 5).

Table 5. Effect of dinitroaniline compounds on spine suppression in M.26 and P.22 apple rootstock liners (exp. 3, 2000)

Treatment, mg l ⁻¹	Number of spines per plant						Total spine length/plant, cm ^x
	>0.5 - ≤1.0 cm		>2.0 - ≤2.5 cm		>3.0 cm		
	M.26	P.22	M.26	P.22	M.26	P.22	
butralin:							
1000 x 2	4.3 b	0.1	0.7	0.1	0.8 ab	0.5 ab	6.1 a
2000 x 2	3.0 b	0.2	0.8	0.4	1.1 b	0.5 ab	6.2 a
3000 x 2	5.4 b	0.2	0.4	0.3	0.7 ab	0.4 ab	6.4 a
BFA:							
1000 x 2	4.4 b	0.1	0.3	0.4	1.0 b	0.7 b	6.5 a
2000 x 2	3.7 b	0.1	0.6	0.4	0.6 ab	0.1 ab	3.9 a
3000 x 2	3.5 b	0.1	0.3	0.4	0.5 ab	0.3 ab	5.7 a
pendimethalin:							
1500 x 2	4.2 b	0.0	0.5	0.3	1.4 b	0.2 ab	6.2 a
2500 x 2	4.9 b	0.1	0.5	0.3	0.8 ab	0.4 ab	4.8 a
3500 x 2	4.2 b	0.1	0.5	0.2	0.5 ab	0.7 b	5.9 a
hand removal ^y intact ^z	0.0 a	0.0	0.0	0.0	0.0 a	0.0 a	53.6 b
P - value	0.0000	NS	NS	NS	0.0031	0.0230	0.0000

Means followed by the same letter do not significantly differ at P<0.05, ^y spines were removed twice or more depending on their regrowth; ^z no spine removal; ^x additional experiment (36 replicates of single rootstock each); NS – not significant.

There were some significant differences in spine reduction between chemical treatments and manual deshooking depending on spine length. Double manual removal was more effective than chemical

treatment. Short and long spines were more difficult to suppress than medium sized spines. This was particularly evident in Malling 26, and to the lesser extent in P.22 rootstocks (Table 5). However, from a nurseryman point of view, in most cases double chemical deshooting was as effective as double manual spine removal, being considerably less time consuming thus less expensive. Comparison of spine reduction effectiveness among the chemical treatments with exclusion of manual removal, showed no significant differences in relation to chemicals and rates applied (data not shown). Spine growth was significantly reduced by chemical treatments in comparison with intact plants (Table 5). Table 6 shows two characteristics of rootstock growth of which suppression may be considered as phytotoxicity indicators. Comparison of rootstock annual increment of cross-sectional area and the weight of fresh mass of shoots taken from untreated part of rootstock itself demonstrated no significant differences between chemically treated and untreated control plants (Table 6). The results of the follow-up research using previously treated rootstocks have shown no adverse residual effects on bud take and subsequent growth of budded trees as expressed by the number of feathers, diameter and height of trees in scab-immune apple cultivars 'Jonafree', 'Rajka' and 'Topaz' (Jacyna *et al.*, 2002).

Table 6. Performance of rootstock liners treated with dinitroaniline compounds for spine removal assessed at the end of season (exp. 3, 2000).

Treatment, mg a.i.l ⁻¹	Annual increment of rootstock cross-sectional area, (mm ²) ^z	Weight of fresh mass of shoots, g ^z
butralin:		
1000 x 2	31.5	106.7
2000 x 2	37.2	125.0
3000 x 2	26.3	106.7
BFA:		
1000 x 2	38.1	108.3
2000 x 2	39.7	116.7
3000 x 2	44.3	95.0
pendimethalin:		
1500 x 2	35.0	115.8
2500 x 2	30.0	129.0
3500 x 2	34.7	106.7
hand removal ^y	25.6	111.0

All values are not significantly different at P<0.05, ^y double (triple) spine removal subject to spine regrowth, ^z mass of shoots taken from above the application zone.

Reduction in time and labor costs for spine removal is the main advantage of chemical deshooting of rootstocks. Results from this research, supported by the others (Rouse, 1994 and Jacyna *et al.*, 2000), indicate that chemical treatment may be competitive nursery technology with manual spine removal. It seems that in Poland the most suitable compound, which meets the criteria for chemical deshooting, would be pendimethalin (Stomp 330[®]), having official registration for fruit and vegetable production. However, more research is needed, especially in layering technology, to obtain precise protocols for various species.

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