Table 2. Average count (CNT) and shoot dry weight (SDW) per flat of weeds penetrating up through 9 landscape mats 30 days after sowing, experiment 2.

Mat type	Yellow Nutsedge		Pigweed		Bermudagrass		Johnsongrass	
	CNT	SDW (g)	CNT	SDW (g)	CNT	SDW (g)	CNT	SDW (g)
Dupont Typar 307	0.0 a[z]	0.0 a	0.0 a	0.0 a	2.5 a	2.9 ab	0.0 a	0.0 a
Dupont Typar 312	0.0 a	0.0 a	0.3 a	1.1 a	0.8 a	0.9 a	0.0 a	0.0 a
Weed Barrier Mat	0.3 ab	1.4 ab	0.0 a	0.0 a	0.0 a	0.0 a	0.3 a	0.3 a
Dewitt Pro 5	1.0 ab	3.6 ab	0.5 a	1.9 a	1.5 a	3.0 ab	2.3 a	5.8 ab
Geoscape Landscape Fabric	0.8 ab	4.6 b	0.0 a	0.0 a	9.3 a	4.4 b	0.3 a	4.3 ab
Amoco Rit-a-Weed	2.5 b	4.0 b	8.3 a	5.0 b	17.5 a	5.2 b	7.0 b	9.7 bc
Phillips Duon Fiber	3.3 b	3.6 ab	7.8 a	6.6 b	12.0 a	5.1 b	6.5 b	13.4 cd
Weedblock Fabric	1.8 ab	3.8 ab	20.3 b	12.1 c	72.6 b	10.3 c	8.0 b	10.4 bc
Control	8.3 c	23.1 c	48.8 c	13.2 c	112.8 c	12.8 c	12.8 c	19.7 d

[z]Mean separation within columns by Duncan's multiple range test, 5% level.

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Effects of Banding and IBA on Rooting and Budbreak in Cuttings of Apple Rootstock 'MM.106' and *Franklinia*[1]

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Abstract

Banding with Velcro™ of new shoot growth in moderately difficult-to-root apple rootstock MM.106 (*Malus domestica* Borkh.) for 7 days prior to taking cuttings, and treatment of cuttings with 500 to 2000 ppm indolebutyric acid (IBA) increased both percent rooting and root number. Banding, however, did not influence the rooting of easy-to-root *Franklinia alatamaha* Marsh. IBA at 0 to 1000 ppm induced a logarithmic increase in percent rooting of cuttings of MM.106 and root number of cuttings of *Franklinia*; but, higher levels of IBA reduced both. Banding prevented the rooting inhibition found at high concentrations of IBA in cuttings of MM.106, while simultaneously stimulating lateral budbreak and greater root number. Stem banding improved the establishment of cuttings treated with 1000 ppm and 2000 ppm IBA. Without banding, establishment of these cuttings was markedly decreased.

Index words: auxin, blanching, propagation

Species used in this study: Franklin tree (*Franklinia alatamaha* Marsh.); Common apple (*Malus domestica* Borkh.).

Significance to the Nursery Industry

The immediate release of lateral buds in rooted softwood cuttings should shorten production time and hence reduce ultimate production costs of woody plants when propagated vegetatively. Moreover, rooted cuttings with new shoot growth may overwinter better than those without growth after rooting (15). This study demonstrated that banding softwood shoots with Velcro™ not only promoted rooting in cuttings of moderately difficult-to-root apple rootstock 'MM.106' (*Malus domestica* Borkh.), but also stimulated lateral budbreak and partially prevented the inhibitory effect of indolebutyric acid (IBA) on budbreak in rooted cuttings. The nursery industry can accelerate both the propagation and subsequent growth of cuttings by using banding techniques and a lower concentration of IBA.

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Introduction

Since the 1940s, IBA treatment has become a common technique used to improve rooting of cuttings. A few recent studies, however, have shown that IBA inhibits budbreak or bud growth both *in vitro* and in rooted cuttings (1, 4, 7). DeVries and Dubois (7) found that basal IBA treatment > 312.5 ppm delayed axillary budbreak in 'Amanda' rose (*Rosa* 'Amanda' L.) softwood cuttings, while IBA of > 625 ppm significantly reduced bud break. However, IBA is commonly used at a range 2500–10000 ppm (9, 10). Most research only reports rooting response and neglects the effects of high auxin concentration on the subsequent budbreak and establishment of rooted cuttings.

Stockplant etiolation and stem blanching were found to promote rooting in cuttings of many difficult-to-root species (3, 5, 6, 13). Using an etiolation and banding technique with Velcro™ self-adhesive bands, Maynard and Bassuk (11, 12) significantly improved rooting in cuttings of many taxa. In this study, the effects of banding and IBA on rooting, lateral budbreak and early growth of softwood cuttings of *Franklinia* (*Franklinia alatamaha* Marsh.) and the apple rootstock 'MM.106' were determined.

Materials and Methods

Two-year-old stockplants of apple rootstock MM.106 were dug in early May, 1989 from fields of the New York State Agricultural Experiment Station, Geneva. Prior to planting, stockplants were stored in an unlit, 5 ± 1°C (40°F) cooler for 3 weeks. Plants of MM.106 were potted on June 1 in 5 l containers (approx. 1.4 gal), using a medium of 1 perlite:1 peat:1 soil:1 vermiculite (by vol). A photoperiod of 16 hours was achieved by using 100-watt incandescent light bulbs suspended 1.5 m (5 ft) above the plants and spaced 1.5m (5 ft) apart. Plants of 6-year-old *Franklinia* were grown in 40 l containers (approx. 11 gal) out-of-doors in Ithaca, NY. Fertilizer solution (200 mg/liter N, P, K with micronutrients) was applied weekly to both greenhouse- and outdoor-grown plants.

Second flush shoots of MM.106 were allowed to grow to 8–12 cm (3–5 in) before 2.5 × 2.5 cm (1 in) Velcro™ bands were applied to shoot bases on July 28 according to the method of Maynard and Bassuk (11, 12). IBA, however, was not included on bands. Shoots of *Franklinia* were banded on July 24. Many of these shoots were longer than 20 cm (8 in), and therefore bands were applied approximately 10 cm (4 in) below the shoot tip. Shoots of MM.106 were banded for 7 days and *Franklinia* for 10 days before cuttings were removed by excising the shoots proximal to the band. Nonbanded cuttings served as the controls. Cuttings of both species were pruned to a 5 to 7 cm (2 to 3 in) stem with two leaves.

Before placement in a perlite rooting medium, bands were removed and cuttings were treated with a 10 sec basal dip of 0, 500, 1000 or 2000 ppm IBA in 50% ethanol. After the auxin solution dried, cuttings were stuck and placed under intermittent mist which operated 5 sec every 4 min from 6:00 am to 10:00 pm daily. To minimize water stress, irradiance on rooting benches was reduced by 50% with one layer of Saran shade cloth. A completely randomized design was used throughout the whole study. The experiment with MM.106 had 5 replications of 5–6 cuttings each, while *Franklinia* was studied using 23–25 cuttings for every treatment without replication. Cuttings of MM.106 and *Franklinia* were harvested and evaluated for rooting percentage and root number, after 20 and 28 days, respectively. All cuttings with roots longer than 1 mm were counted as rooted cuttings. Rooted cuttings of MM.106 were transplanted to a medium of 1:vermiculite:1 perlite:1 peat (by vol) and grown under the same conditions as the stockplants. *Franklinia* cuttings were not transplanted. The percentage of any plants with released lateral buds and length of new shoot growth were recorded weekly during the first 8 weeks after transplanting.

The Chi-Square test was used with data relating to lateral budbreak and percent establishment of MM.106 (eg. cuttings with new growth/total cuttings) because some treatments yielded no rooted cuttings. The other data was analyzed by regression with SAS (14). Percentage data was transformed to Arcsin $(\text{percentage})^{1/2}$ before analysis.

Results and Discussion

Rooting response of cuttings to banding and IBA treatment. IBA significantly increased percent rooting and root number in apple rootstock MM.106 at concentrations of 500 to 1000 ppm (Table 1). Cuttings of *Franklinia* rooted well without any treatment, although IBA at 500 to 1000 ppm increased root number (Table 2). IBA treatment with high concentrations, however, reduced percent rooting in cuttings of MM.106, and root number *Franklinia*. Blazich and Acedo (2) also reported that IBA at high concentration inhibited rooting of stem cuttings of *Osmanthus heterophyllus* cv. 'Ilicifolius' and 'Rotundifolius'. Banding of shoots of MM.106 for 7 days not only promoted rooting, but also negated the inhibitory effect of high IBA (Table 1). Banding for 10 days did not alter the already high level of rooting for cuttings of *Franklinia* (Table 2). Banding of shoots typically required 4 to 8 weeks (8, 11, 12). The present study, however, showed that banding with Velcro for just 7 days was effective in softwood cuttings of MM.106. Banding permitted the use of lower IBA concentrations in rooting difficult-to-root cuttings.

To understand how banding might modify the rooting of cuttings of MM.106 to IBA treatment, the whole data set

Table 1. Effects of banding and IBA on rooting of softwood cuttings of MM.106.

	Nonbanded		Banded	
IBA Concn (ppm)	Rooting (%)	Roots/rooted cutting	Rooting (%)	Roots/rooted cutting
0	4.5[z]		23.5	1.7
500	59.5	4.1	71.5	5.5
1000	87.5	9.2	93.0	9.4
2000	55.5	9.8	93.0	15.1
Significance[y]				
	IBA Concn. ≤ 1000 ppm		**IBA Concn. ≥ 1000 ppm**	
Banding	**PR>F = 0.0211**		**PR>F = 0.0184**	
IBA	**PR>F = 0.0001**		**PR>F = 0.0308**	
Banding*IBA	**PR>F = 0.2162**		**PR>F = 0.0638**	

[z]Mean of 5 replications of 5–6 cuttings.

[y]The data was separated into responses above and below 1000 ppm IBA. The rooting responses below 1000 ppm regressed on Log(IBA), while those with 1000 and 2000 ppm were analyzed by analysis of variance.

Table 2. Effects of banding and IBA on rooting of softwood cuttings of *Franklinia*.

IBA Concn (ppm)	Nonbanded Rooting (%)	Nonbanded Roots/rooted cutting	Banded Rooting (%)	Banded Roots/rooted cutting
0	96[z]	8.0	87	9.4
500	100	90.9	96	88.5
1000	100	127.2	96	124.0
2000	100	100.0	96	105.5

Significance (Roots/rooted cutting)		
Banding		PR>F=0.8103
IRA	linear	PR>F=0.0012
	quadratic	PR>F=0.0019
Banding*IBA	linear	PR>F=0.4909
	quadratic	PR>F=0.3982

[z]Means of 23–25 cuttings

Table 4. Effects of banding and IBA on the lateral budbreak of cuttings of *Franklinia* after a 28-day rooting period.

IBA Concn (ppm)	Nonbanded	Banded
0	88.0[z]	96.5
500	28.0	44.0
1000	2.5	11.0
2000	2.5	11.0

Significance		
Banding		PR>F=0.0653
IBA	Linear	PR>F=0.0006
	Quadratic	PR>F=0.0019

[z]Means of 23–25 cuttings.

was separated into responses observed above and below 1000 ppm. The rooting responses below 1000 ppm IBA were regressed on the logarithm of IBA concentration, while those with 1000 to 2000 ppm IBA treatment were analyzed by analysis of variance. Without banding, percent rooting of cuttings of MM.106 had a logarithmic response to increasing IBA concentration up to 1000 ppm and declined thereafter. Banding did not interact with IBA treatment at 0 to 1000 ppm but did in the range of 1000 to 2000 ppm (PR>F = 0.0638). For 2000 ppm IBA, banded cuttings rooted well and responded with an additional increase in root number (Table 1).

Effects of IBA and banding on lateral budbreak in cuttings. Stimulating budbreak is thought to be essential for the establishment and overwintering of rooted cuttings in some taxa (15). IBA delayed and reduced axillary budbreak in rooted cuttings of MM.106. This inhibition increased with IBA concentration. Eight weeks after transplanting, only 6% of the rooted cuttings of MM.106 from the nonbanded, 1000 ppm IBA treatment showed lateral budbreak. None of the non-banded, 2000 ppm IBA-treated cuttings broke bud in this period (Table 3). Many of the cuttings treated with 2000 ppm IBA failed to grow under greenhouse condition, even several months later. In contrast, banding for just 7 days significantly stimulated budbreak and partially prevented inhibition of budbreak by IBA, especially at higher IBA concentrations (Table 3). Lateral buds in cuttings of *Franklinia* often broke during rooting, although even 500 ppm IBA inhibited budbreak up to 60% (Table 4). Application of 1000 and 2000 ppm IBA almost completely inhibited budbreak in cuttings of *Franklinia*. Banding of shoots of *Franklinia* for 10 days increased budbreak at all IBA concentrations (PR>F = 0.0653), but did not overcome the inhibitory effect of IBA. Christensen *et al.* (4) also reported that 1000 and 2000 ppm auxin retarded budbreak in cuttings of apple rootstock.

Growth and establishment of rooted MM.106 cuttings. New shoots produced after transplanting were longer from banded than from nonbanded cuttings of MM.106 (Table 3). Although no correlations of root number and budbreak were found for cuttings of MM.106 and *Franklinia* (data not presented), new growth of rooted cuttings of MM.106 after 4 weeks was highly correlated with the average root number ($R^2 = 0.97$). After 8 weeks, shoot length was correlated with both root number of the time of budbreak (i.e. number of days after transplanting to reach 50% of the final budbreak). The presence of longer shoots on banded cuttings probably resulted from both early bud-break and the greater number of roots. Although IBA increased percent rooting and root number in MM.106, the overall establishment of

Table 3. Effects of banding and IBA on lateral budbreak and subsequent growth of rooted cuttings of MM.106.

IBA Concn. (ppm)	No. of rooted cuttings Nonbanded	No. of rooted cuttings Banded	After 4 weeks Nonbanded	After 4 weeks Banded	After 8 weeks Nonbanded	After 8 weeks Banded
			Plants with released buds (%)[z]			
0	0	7	0.0	85.7	0.0	100
500	19	21	31.6	85.7**	73.7	85.7n.s.
1000	17	24	0.0	66.7**	5.9	75.0**
2000	14	25	0.0	28.0*	0.0	60.0**
			New growth (cm, mean ± se)			
0			2.2 ± 0.7		8.0 ± 1.8	
500			2.6 ± 0.9	2.7 ± 0.6	7.1 ± 1.5	13.0 ± 1.6
1000			0.0	4.4 ± 0.6	11.0 ± 0	13.8 ± 1.8
2000			0.0	5.6 ± 1.9	0.0	13.3 ± 2.9

[z]NS, *, ** Nonsignificant, or significant from nonbanded treatments at p≤0.05 or p≤0.01, respectively (Chi-square test).

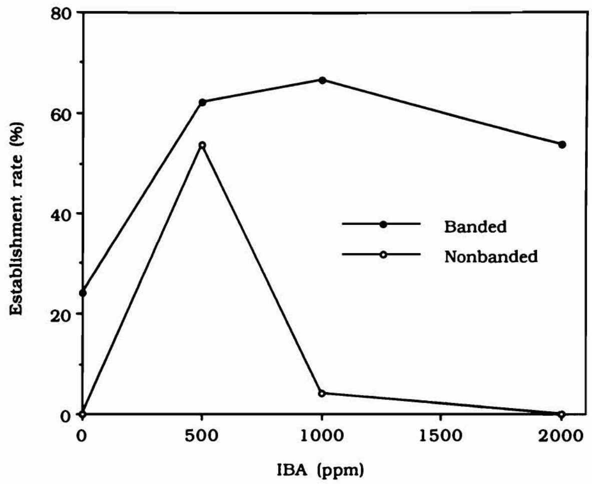

Fig. 1. Effects of IBA and banding on the establishment of cuttings of MM.106 after 8 weeks.

cuttings after 8 weeks following transplanting (number of cuttings with new growth/total number of cuttings used) decreased when IBA exceeded 500 ppm (Fig. 1). In non-banded cuttings, 500 ppm IBA resulted in the best establishment. Banding improved the establishment of cuttings, particularly at higher IBA concentrations (Fig. 1).

The over-winter survival of banded cuttings of MM.106 remains to be examined as does the long-term effect of IBA on budbreak in rooted cuttings.

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