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Stem Banding Enhances Rooting and Subsequent Growth of M.9 and MM.106 Apple Rootstock Cuttings

Wen-Quan Sun[1] and Nina L. Bassuk[2]
Department of Floriculture and Ornamental Horticulture, Cornell University, Ithaca, NY 14853-5908

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Abstract. **Softwood shoots of apple (*Malus domestica* Borkh.) rootstocks M.9 and MM.106 were banded with Velcro for up to 20 days before cuttings were propagated. Percent rooting and the number of roots per cutting were significantly improved by banding for 10 to 20 days, with and without IBA application. As the duration of stem banding increased from 0 to 20 days, percent rooting and the number of roots of both M.9 and MM.106 cuttings increased linearly or curvilinearly. Stem banding also stimulated budbreak of cuttings. In M.9, banding resulted in a higher survival rate and increased new shoot growth of transplanted cuttings after 4 months. Percent budbreak and new shoot growth were highly correlated with the number of roots per cutting in both cultivars. The effects of stem banding on budbreak and subsequent growth of the cuttings were largely due to the enhanced rooting of cuttings. Chemical names used: 1*H*-indole-3-butyric acid (IBA).**

Many clonal apple rootstock cultivars are difficult to root from cuttings and are primarily propagated through stool layering, an inefficient propagation method (Gorecki, 1979; Vasek and Howard, 1984). Maintenance of stoolbeds is time-consuming and expensive; moreover, stool-layered dwarfing and semidwarfing rootstocks often fail to maintain vigorous annual shoot growth despite severe winter pruning, resulting in a large proportion of small shoots having no commercial value (Vasek and Howard, 1984). In vitro propagation was once considered to have great potential for apple rootstock multiplication (James and Thurbon, 1979); however, numerous studies have demonstrated that root initiation is difficult in such apple shoots (Alvarez et al., 1989; Werner and Boe, 1980).

Using techniques such as etiolation, shading, blanching, and, more recently, growing stock plants in a polythene tunnel has led to significant progress in rooting apple rootstock softwood and hardwood cuttings in the past 15 years at the East Malling Research Station (Campen et al., 1990; Harrison-Murray; 1981; Harrison-Murray and Howard, 1983; Howard et al., 1985). Other researchers have obtained similar results for apple cuttings with etiolation and blanching (Delargy and Wright, 1978, 1979) or with reduced stock plant irradiance (Christensen et al., 1980).

In our previous work, Velcro banding of softwood shoots of MM.106 was found not only to promote rooting, but also to stimulate lateral budbreak in rooted cuttings (Sun and Bassuk, 1991). The objectives of the present study were to investigate the rooting responses of M.9 and MM.106 cuttings to the duration of stem banding and the effects of banding on budbreak and subsequent growth of transplanted cuttings.

In the 1989 experiments, 2-year-old plants of M.9 and MM.106 were dug in early May from fields of the New York State Agricultural Experiment Station, Geneva, and stored at 5 ± 1C for 3 weeks. In 1990, additional stock plants (≈1 cm caliper) were purchased (Oregon Rootstock, Woodburn, Ore.) and both sets of stock plants were stored at 5 ± 1C in darkness from Dec. to Mar. 1990 before being potted into 5-liter plastic containers filled with a 1 perlite : 1 peat : 1 sandy loam soil medium (by volume). In the spring, the greenhouse was at 20/16 ± 2C (day/night). A 16-h photoperiod was used with 100-W incandescent light bulbs suspected 1.5 m apart and 2.0 m above the plants. A fertilizer solution of 20N–20P–20K at 200 mg·liter⁻¹ for each nutrient was applied weekly.

Velcro bands (2.5 × 2.5 cm) were applied to shoot bases according to the method of Maynard and Bassuk (1987). No IBA was used on bands. Following budbreak, young shoots were banded after 15, 20, 25, or 30 days, and cuttings of all treatments were excised 35 days after budbreak. The nonbanded shoots served as controls. Therefore, cuttings were obtained with banding periods from 0 to 20 days. This treatment design yielded cuttings of the same age that then were rooted under the same conditions.

Softwood cuttings were taken by excising banded shoots immediately below Velcro bands, or the equivalent position for nonbanded shoots, and immersed into a fungicide solution of 3a, 4, 7, 7a-tetrahydro-2-[(trichloromethyl)thio]-1*H*-isoindole-1,3(2*H*)-dione (captan) 50% WP at ≈500 mg·liter⁻¹. All cuttings were trimmed to be 5 to 7 cm long with two leaves, and the bases of cuttings were dipped for 10 sec into 2000 mg IBA/liter in 50% aqueous ethanol, unless indicated otherwise. The auxin solution was allowed to dry for 5 to 10 min before cuttings

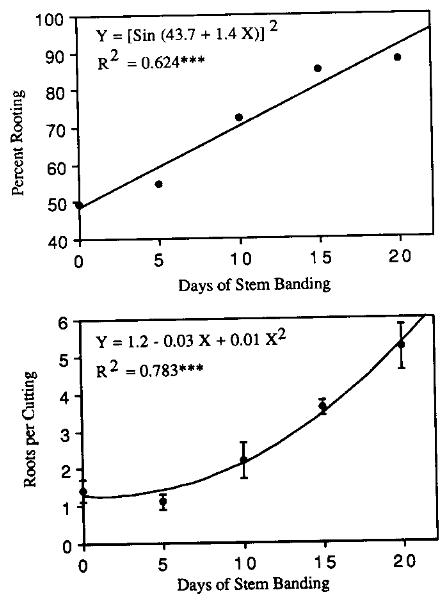

Fig. 1. Rooting responses of M.9 apple rootstock cuttings as a function of the duration of stem banding (May 1990). The equation of percent rooting is mathematically transformed from arcsin statistics. Bases of cuttings were dipped for 10 sec in IBA at 2000 mg·liter⁻¹ in 50% ethanol.
***Significant at P = 0.001.

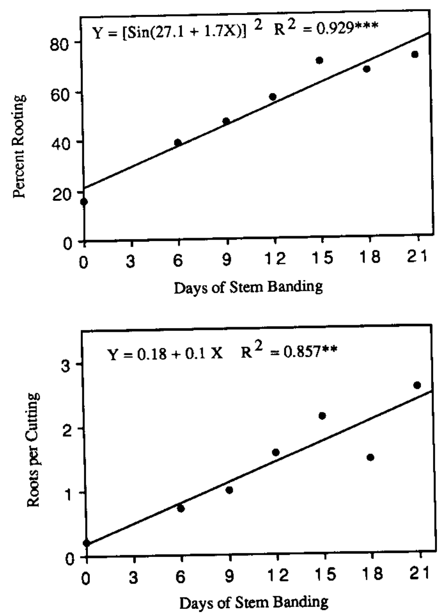

Fig. 2. Rooting responses of MM.106 apple rootstock cuttings as a function of the duration of stem banding (May 1990). The equation of percent rooting is mathematically transformed into arcsin statistics. Bases of all cuttings were dipped for 10 sec in IBA at 500 mg·liter⁻¹ in 50% ethanol.
,*Significant at P = 0.01 and 0.001, respectively.

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[1]Graduate Research Assistant.
[2]Associate Professor.

Table 1. Rooting and basal rotting of cuttings of M.9 and MM.106 apple rootstocks after 10 days of stem banding before taking cuttings.[z]

	Apple rootstocks					
	M.9			MM.106		
Duration of banding (days)	Rooting (%)	Roots/ cutting	Basal rotting (%)	Rooting (%)	Roots/ cutting	Basal rotting (%)
0	7	0.2	70	20	0.6	33
10	39	1.1	22	73	4.4	5
Significance	**	*	**	***	***	*

[z]Trials were carried out from May to Aug. 1989.
*,**,***Significant at P = 0.05, 0.01, and 0.001, respectively.

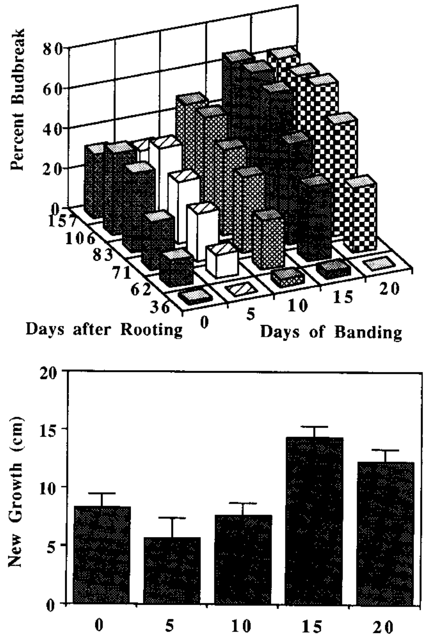

Fig. 3. Effects of stem banding on lateral budbreak (**top**) and subsequent growth (**bottom**) of M.9 apple rootstock cuttings. Cuttings were harvested 36 days after rooting. Data of budbreak on day 157 present final survival rates of cuttings. Bars indicate standard errors for new growth.

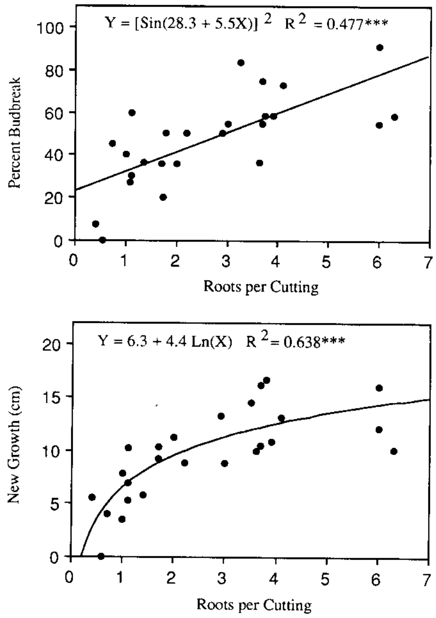

Fig. 4. Relationships between lateral budbreak, growth, and the number of roots per cuttings of M.9 apple rootstock. The equation of budbreak is mathematically transformed from arcsin statistics.
***Significant at P = 0.001.

Table 2. Effect of stem banding on rooting and budbreak of MM.106 apple rootstock cuttings.[z]

Duration of banding (days)	Rooting (%)	Roots/ cutting	Budbreak (%)
Without IBA			
0	11	1.0	3
10	26	2.2	13
20	43	2.0	20
With 2000 mg IBA/liter			
0	67	5.6	0
10	78	9.4	0
20	80	10.7	0
Significance			
IBA	***	***	***
Banding	***	**	*
IBA × banding	NS	NS	*

[z]Trial was carried out in Mar. 1990.
NS,*,**,***Nonsignificant or significant at P = 0.05, 0.01, and 0.001, respectively.

were inserted into a 100% perlite rooting medium. Intermittent mist operated for 5 sec·4 min^{-1} from 6:00 AM to 10:00 PM daily. During summer, irradiance on rooting benches was reduced 50% by using a single layer of Saran shadecloth to reduce water stress.

Cuttings were harvested after 20 to 30 days in the rooting bench, and percent rooting and the number of roots per cutting were recorded. All cuttings with roots >1 mm were considered as rooted. Whether rooted or not, cuttings were transplanted to 0.5-liter plastic pots with a medium of 1 perlite : 1 peat : 1 sandy loam soil (by volume), left on the rooting bench for 3 weeks, where misting was gradually reduced from 5 sec·4 min^{-1} to 5 sec·24 min^{-1}, and then transferred to the same conditions as the stock plants. Percent budbreak of new plants and length of new shoot growth were recorded at 10- to 20-day intervals. A completely randomized design was used throughout the study. In 1989 experiments, treatments had six replications with five to seven cuttings each. In the 1990 study, treatments had five replications of eight to 15 cuttings, except for one trial of the MM.106 in May, in which 15 to 19 cuttings were used without replication.

The other two experiments were carried out from June to Dec. 1990 to further clarify the relationships between the number of roots and subsequent budbreak of rooted cuttings. Rooted cuttings of MM.106 were grouped according to the number of roots per cutting and then grown under the conditions described above. In Expt. I, cuttings were divided into three groups (zero, one to three, and four to six roots per cutting). Four replications with 30 cuttings each were used. In Expt. II, 25 cuttings were used for each of four groups (zero, two, four, and 11 roots per cutting). Percent budbreak of cuttings were obtained after 2 months.

Data were tested by analysis of variance or regression with SAS (SAS Institute, 1985). Percentage data were arcsin-transformed before analysis (Snedecor and Cochran, 1980), and then converted back for presentation.

Stem banding with Velcro for 10 days before taking cuttings remarkably increased percent rooting and the number of roots per cutting of both rootstocks and also decreased basal rotting of cuttings (i.e., necrosis and pathogen-caused rot of stems in medium) (Table 1). Basal rotting of cuttings is considered a serious problem in apple rootstock propagation (Gorecki, 1979; Harrison-Murray and Howard, 1983).

The promotion of rooting by stem banding was significant both with and without application of IBA before rooting (Table 2). However, stem banding and IBA were observed to interact to improve rooting at a higher IBA concentration in another trial (Table 3). In nonbanded cuttings of MM.106, increasing IBA from 2000 to 4000 mg·liter^{-1} affected neither percent rooting nor the number of roots per cutting, while in cuttings banded for 15 days, raising the IBA concentration resulted in an additional 35% increase in percent rooting (Table 3). Using the difficult-to-root 'Bramley' apple, Delargy and Wright (1979) observed that IBA application could only improve rooting of cuttings previously taped with black polythene. Etiolation and taping were also reported to increase the responsiveness of cuttings to auxin treatment in M.9 propagation (Harrison-Murray, 1981). In our previous work, banding for 7 days prevented the inhibitory effect of high levels of IBA in MM.106 cuttings and at the same time resulted in a large increase in the number of roots per cutting (Sun and Bassuk, 1991).

Responses of M.9 and MM.106 cuttings to the duration of stem banding was further quantified. As the duration of banding increased from 0 to 20 days, percent rooting and the number of roots per cutting of M.9 increased linearly and quadratically, respectively (Fig. 1); in MM.106, both increased linearly (Fig. 2). However, such results were not reproduced in a trial of MM.106 conducted in June 1990, where 87% of control cuttings rooted, making it impossible to detect any difference due to stem banding (data not presented).

Stem banding greatly influenced budbreak of cuttings. In MM.106, banded cuttings showed greater percent budbreak when harvested after rooting, although IBA at 2000 mg·liter^{-1} inhibited budbreak (Table 2). In M.9, cuttings banded for 15 and 20 days broke buds earlier and had higher survival

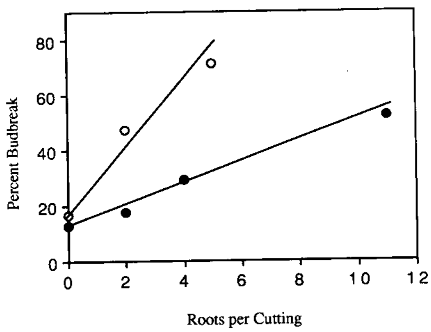

Fig. 5. Relationship between the number of roots and budbreak of MM.106 apple rootstock cuttings. The data were recorded 2 months after transplanting. The equation of percent rooting is mathematically transformed from arcsin statistics.
,*Significant at P = 0.01 and 0.001, respectively.

Table 3. Banding and IBA effects on rooting of softwood cuttings of MM.106 apple rootstock.[z]

IBA concn (mg·liter^{-1})	Rooting (%)	Roots/ cutting
Bands for 0 days		
0	4	1.0
2000	26	2.9
4000	30	3.1
Banding for 15 days		
0	19	4.0
2000	38	3.3
4000	75	5.8
Significance		
Banding	***	**
IBA	***	*
Banding × IBA	*	NS

[z]Trial was carried out in July 1990.
NS,*,**,***Nonsignificant or significant at P = 0.05, 0.01, and 0.001, respectively.

rates (after 4 months) than those banded for 0 or 5 days. The new growth of those cuttings that survived was also affected by banding treatment. Fifteen and 20-day banding treatments had significantly longer new shoots than other treatments (Fig. 3). Similar effects of stem banding have been recently reported in rooted cuttings of MM.106 and *Franklinia* (Sun and Bassuk, 1991). We attribute the effects of Velcro stem banding on budbreak and subsequent growth of apple rootstock cuttings to its effect on root initiation of cuttings. Percent budbreak and new shoot growth of rooted cuttings was positively correlated with the number of roots per cutting (Fig. 4). In the two experiments to further examine the relationship between the number of roots per cuttings and percent budbreak, the two factors also were linearly related (Fig. 5).

As a pretreatment of cuttings, light exclusion conventionally consists of growing stock plants in darkness during their initial growth and then banding the bases of the new shoots for an additional 4 to 8 weeks after the cover material is removed (Delargy and Wright, 1978, 1979; Gardner, 1936; Maynard and Bassuk, 1987). The light-excluding technique used in this study (black Velcro bands) was simpler than those used by other researchers. In addition, results are consistent with many other investigations on the effect of banding on rooting (Delargy and Wright, 1978, 1979; Gardner, 1936; Harrison-Murray, 1981; Harrison-Murray and Howard, 1983; Howard et al., 1985). Therefore, rooting, subsequent budbreak, and growth of cuttings can be promoted by a short period of banding on light-grown shoots before taking cuttings.

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