J. AMER. SOC. HORT. SCI. 112(2):273–276. 1987.

Stockplant Etiolation and Blanching of Woody Plants Prior to Cutting Propagation

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Additional index words. *Acer griseum, A. platanoides, A. saccharum, Betula papyrifera, Carpinus betulus, Castanea mollissima, Corylus americana* cv. Rush, *Pinus mugo, P. strobus, P. sylvestris, P. thunbergii, Quercus coccinea, Q. palustris Q. robur, Q. rubra, Syringa vulgaris, Taxus* x *media, Tilia cordata*, banding, rooting

Abstract. **A modification of the traditional technique of etiolation and blanching, using Velcro adhesive fabric strips as the blanching material, was used with success in improving cutting propagation of a wide range of difficult-to-root woody species. Stockplants were etiolated under black cloth at budbreak, followed by banding for a period of 4 weeks, to produce a cutting with an etiolated base. Rooting of softwood cuttings from 18 of 21 species tested was improved significantly by these stockplant pretreatments. The use of Velcro as the banding material facilitated blanching, permitted the application of rooting hormone as a part of the blanching procedure, wounded underlying stem tissues, and resulted occasionally in the formation of adventitious roots on intact shoots.**

Etiolation (the exclusion of light) as a part of the propagation process promotes adventitious root initiation in stem tissues and has been used successfully as a pretreatment in cutting propagation (4, 15). The techniques of ground layering, stooling, and air layering also make use of this phenomenon.

Banding is a pretreatment, adjunct to etiolation, that involves excluding light from a zone of the stockplant stem that is to become the cutting base. Banding either may be applied to etiolated shoots, which are subsequently allowed to develop normally in the light, or applied to developing light-grown shoots, which are still in the softwood stage, in which case the band is said to "blanch" the underlying tissues (7).

Etiolation as a stockplant pretreatment was used with success on woody plants as early as the 1920s (12, 13, 18). The additional pretreatment of banding originated with Gardner in 1936 (4), who wrapped stems of apple close to the growing tip with black insulation tape, resulting in a 70% increase in rooting. The procedure has remained essentially unchanged since that time and has been the subject of a number of reviews (3, 7, 10, 15). In common use, etiolation is effected by fastening black cloth or polyethylene over a structure enclosing the stockplant. When stems have elongated to ≈5 cm, the shading is removed. Banding materials have included black tape (4), paper (3), aluminum foil (1, 5, 6), or even black paste (14).

Herman and Hess (8) conducted an extensive study of etiolation and banding to effect blanching, using Red Kidney bean and *Hibiscus rosa-sinensis*. The combination of the two pretreatments markedly increased both rooting percentage and root numbers in both species.

The technique of etiolation and banding has been refined by Howard and co-workers at the East Malling Research Station, Kent, U.K., using apple, linden, and other difficult-to-root woody species. Their work examined the optimum timing and duration of etiolation and banding, as well as the influence of heat and humidity in the promotion of rooting by etiolation (9). Etiolation increased the rooting response of M 9 apple shoots from 14% to 84% on the average. Furthermore, up to a 20% transmission of light was allowed without a significant decrease in rooting.

Received for publication 21 Apr. 1986. This work was supported in part by grants from The Horticultural Research Institute, The Eastern Region International Plant Propagators Society, and a National Science Foundation predoctoral fellowship to B.K.M. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

The objective of this work was to investigate the usefulness of etiolation and banding techniques in a wide range of difficult-to-root woody plants. In the course of our work, a banding technique was developing using opaque strips of a reusable adhesive banding material, commonly known by the trade name Velcro.

Materials and Methods

Dormant stockplants, previously chilled at 5°C for 8 weeks, were potted in a 1 soil : 1 peat : 1 perlite medium (by volume) and fertilized and watered once weekly from above with 200N–200P–200K (ppm). Incandescent lamps (40 W) spaced 1 m apart and 1 m above the plant canopy were used to maintain an 18-hr photoperiod. Air temperatures in the greenhouse were controlled to 20°C day/15° night.

Etiolation was achieved by covering stockplants with black cloth (≈99% light exclusion). Coverings were applied just before budbreak, as determined by noticeable changes in the swelling or softness of the buds, and were left in place for a period of 2 weeks, or until the majority of new shoots were at least 5 cm long. Covers were removed in stages by first admitting light on the north side and then, over the course of 1 week, rolling up the other three sides, to avoid stressing or scorching the etiolated shoots. When the covers were first lifted, shoots were banded, either with 2-cm-wide black plastic electical tape wound two to three times about the base of the new shoot, or with 2-cm-wide Velcro bands 2.5 cm in length, which were peeled apart and pressed onto the basal section of the stem. At the time of banding, 1*H*-indole-3-butanoic acid (IBA) in talc (0.8%, w/w) was applied by pressing either a section of electrical tape or an opened strip of Velcro onto a layer of the hormone in a petri dish. Excess talc was tapped from the band before application to the shoot. Banding was applied at the base of the current flush of growth when shoots reached 5 cm or more in length. "Blanched" shoots were obtained by banding light-grown shoots and "etiolated and banded" shoots by banding etiolated shoots. Shoots were banded for 4 weeks, over which time the distal portions of the new shoots became green.

After the bands were removed, cuttings were taken by severing the shoot immediately below the banded or equivalent light-grown stem segment. Deciduous cuttings were trimmed distally, leaving a cutting 10 to 15 cm in length with two or three leaves. Coniferous cuttings were left intact and varied in length from 5 to 15 cm. Cuttings were dipped in 1 cm of a preparation of 0.4% (w/w) IBA plus 25% (w/w) 3a,4,7,7a-tetrahydro-2-[(trichloromethyl)thio]-1*H*-isoindole-1,3(2*H*)-dione (captan) in talc, tapped against the edge of the container to remove excess talc, and allowed to stand for 10 min before insertion into the rooting medium. The rooting medium was 2 perlite : 1 peat : 1 white sand (by volume). The cuttings were inserted in dibbled holes to avoid loss of talc from the cuttings. The propagation area was illuminated by 40-W incandescent lamps for a daily 18-hr photoperiod. The rooting medium was bottom-heated to 25°C and the cuttings misted for 6 sec every 12 to 24 min from 6:00 AM until 8:30 PM. Shading was used from May until September, with whitewash on the propagation house glass and 25% Saran hung above the propagation bench.

Rooting data were analyzed by analysis of variance using SAS (16) when sufficient numbers of shoots were available, with three replications of 10 cuttings each for each treatment. Rooting response was transformed to arcsin (percent rooting)$^{1/2}$ before analysis, and transformed back to percent rooting before being presented. Means were separated by a Waller–Duncan LSMEANS option (16). When the number of shoots was limiting, cuttings were rooted in groups according to treatment, and the probability of significant differences calculated by the χ^2 test for goodness of fit (19). Data analyzed by the χ^2 test were judged significantly different when the probability of a greater χ^2 value was <0.05.

Results and Discussion

In the first series of trials, stockplants of 13 woody species were subjected to one of the following treatments: 1) etiolation of developing shoots, 2) no light exclusion (i.e., shoot extension in full sunlight), 3) blanching of light-grown shoots, or 4) etiolation followed by banding to maintain an etiolated zone of stem tissue. In each instance banding was with Velcro that had been coated with a layer of IBA (0.8%) in talc.

In 17 of 22 individual taxa some type of light exclusion during shoot development was of benefit in promoting rooting (Table 1). In 14 taxa, the optimum response was to the combination of etiolation followed by banding, which, in half of these, was significantly ($P < 0.05$) better than either etiolation or banding alone. Banding without etiolation (blanching) was superior in five taxa, while etiolation alone gave the greatest response in two taxa. Thus, it is apparent that the optimum combination of stockplant pretreatments may differ among species, between cultivars, and within a species when stockplants are of different ages.

Of particular interest were those trials conducted within a species. Shoots of *Carpinus betulus* exhibited a response primarily to banding alone in a 1- and 30-year-old trees, but more to etiolation in 10-year-old trees. In this species and in *Betula papyrifera* it was noted frequently that root primordia formed under the hormone-laden Velcro band while the shoot was still attached to the stockplant. These shoots produced substantial root masses in the propagation bench within days of being stuck. The development of root primordia has also been reported to occur in *Phaseolus vulgaris* (8, 11) under opaque but not under clear bands (11). Gardner (4) and Howard (9) observed similar rooting on apple shoots that were banded after having been etiolated.

The response of lilac shoots to etiolation and banding varied among cultivars. The combination of etiolation and banding was optimal for four of six cultivars. Averaging over the cultivar responses for each treatment revealed that the rooting of banded shoots (54% without etiolation, 65% with) was significantly greater than that of nonbanded shoots (16% if light-grown, 32% if etiolated, $LSD_{0.05} = 20\%$).

An apparent requirement for etiolation as a pretreatment was exhibited by shoots of *Castanea mollissima* and *Quercus coccinea*. Shoots of *Corylus americana* cv. Rush, on the other hand, responded only to banding in the present study, suggesting that each new species or cultivar to be propagated using these pretreatments should be tested with each of the four stockplant pretreatments considered here. In a number of studies comparing the relative efficacy of etiolation and banding in the propagation of apple (2, 4, 7, 9), it was shown that etiolation is about twice as effective as banding, while combining the two pretreatments always exceeded the response obtained by either alone.

The next series of experiments investigated the necessity of including hormone in the banding treatments. Also, the dependence of the rooting response on the structure of the Velcro band was investigated because it was noted that the hormone-coated nubs of the Velcro bands wounded any stem tissues they came into contact with. This experiment tested the hypothesis that these wounds might be significant in hormone uptake. Variations in the basic banding technique were tested, including tape, denubbed Velcro (made by melting the nubs with a hot spatula), and intact Velcro, each with or without 0.8% IBA. Again a wide range of species was tested (Table 2).

Velcro was significantly better than electrical tape when applied to light-grown shoots of *Pinus strobus* and when hormone was included in treating light-grown shoots of *Carpinus betulus*. In other taxa, there was a slight but insignificant increase in rooting when Velcro was used as the banding material.

Shoots of *Corylus americana* cv. Rush responded significantly to the addition of hormone in each variation of the banding material. Velcro banded shoots of 10-year-old *Carpinus betulus* also benefitted significantly from adding IBA. In other trials, the use of hormone with Velcro was usually of a slight, though nonsignificant, benefit. This trend was not readily apparent when tape or denubbed Velcro were used, which may reflect either a lack of hormone response in the tissues thus treated, or application of excess hormone (IBA was applied both at banding and at the time of sticking the cutting).

The etiolation and banding of *Taxus* x *media* shoots, with or without hormone, significantly increased rooting over that of light-grown, unbanded controls. In shoots of this species, the rooting of light-grown material was restricted to the base of the cutting, while etiolated material rooted further up the stem. Similiar observations have been made by other researchers (12, 17).

The number of roots per rooted cutting of shoots taken from a 10-year-old hedge of *Carpinus betulus* was increased by Velcro banding, either with or without IBA (Table 3). Similarly, rooting from shoots of *Pinus mugo* improved, with an increase in roots per rooted cutting when Velcro plus hormone was applied. However, for the most part, root number did not vary with the treatment received. These results conflict with studies conducted by Howard and co-workers (9), in which significant variations were observed in the average number of roots per rooted M 9 apple shoot. Root numbers in the present work varied from an average of two per rooted cutting for *Acer griseum*, to 11 for *Betula papyrifera*.

The results of our work expand considerably the number of species for which etiolation and banding pretreatments have been reported to improve rooting responses. The use of this technique is greatly facilitated by banding with Velcro strips, which substitute effectively for the traditional band of black plastic elec-

Table 1. Percent rooting response of 13 woody ornamental species to stock plant lighting and banding pretreatments.

Species	Stockplant treatment: Light-grown, No band	Light-grown, Velcro + IBA	Etiolated, No band	Etiolated, Velcro + IBA	Rooting time (weeks)
Acer griseum Pax. (1-year seedlings)	7 a[z]	12 ab	14 ab	34 b	4
A. griseum (30-year trees)	0	0 bc	0	5	4
A. saccharum Marsh. (1-year seedlings)	47	64	65	86*	2
Betula papyrifera Marsh. (1-year seedlings)	51 a	65 ab	71 b	100 c	2
Carpinus betulus L. (1-year seedlings)	0 a	63 b	5 a	94 c	2
Carpinus betulus (10-year hedge)	19 a	65 b	96 c	92 c	2
Carpinus betulus (30-year hedge)	14 a	52 bc	37 ab	72 c	2
Castanea mollissima Bl. (4-year seedlings)	0	0	44*	100*	2
Corylus americana Marsh. cv. Rush (20-year hedge)	4 a	83 b	0 a	87 b	4
Pinus mugo Turra. (3-year seedlings)	41	64*	---[y]	---	12
Quercus coccinea Muenchh. (1-year seedlings)	0	0	0	46*	4
Q. palustris Muenchh. (1-year seedlings)	31 a	24 a	50 a	44 a	4
Q. robur L. (1-year seedlings)	36 a	70 b	53 b	58 b	4
Q. robur (30-year hedge)	0 a	9 a	27 b	36 b	4
Q. rubra L. (2-year seedlings)	37 a	50 a	29 a	35 a	4
Syringa vulgaris L.					
Belle de Nancy	28 a	65 a	21 a	38 a	5
Charles Joly	0 a	51 b	26 b	63 b	5
Charles X	20 a	70 c	45 b	79 c	5
Michel Buchner	21 a	79 c	43 b	83 c	5
Mme. Lemoine	10 a	10 a	21 a	83 b	5
Pres. Grevy (4-year clones)	10 a	48 a	35 a	42 a	5
Tilia cordata Mill. (30-year hedge)	11 a	4 a	0 a	8 a	4

[z]Mean separation within rows by Waller–Duncan, $P = 5\%$, based on three replications of 10 cuttings.
[y]Treatment not applied.
*Significantly different from the no-band, light-grown control, probability of a greater χ^2 value < 0.05, based on 10 to 18 cuttings per treatment without replication.

Table 2. Percent rooting response of nine woody ornamental species to stockplant lighting and variations in banding pretreatments.

Species	Stockplant lighting	Banding: None	Tape −IBA	Tape +IBA	Denubbed Velcro −IBA	Denubbed Velcro +IBA	Intact velcro −IBA	Intact velcro +IBA	Rooting time (weeks)
Acer platanoides L. (3-year seedlings)	LG[z]	18 a[y]	41 ab	56 b	62 b	54 b	44 ab	60 b	5
	E	16 a	50 b	43 ab	44 ab	30 ab	20 a	43 ab	
A. saccharum (1-year seedlings)	LG	47 ab	64 b	60 b	70 b	30 a	67 b	64 b	2
Carpinus betulus (10-year hedge)	LG	19 a	44 abc	39 ab	46 bc	42 abc	15 a	65 c	2
C. betulus (30-year hedge)	LG	14 a	41 ab	35 ab	38 ab	57 b	44 b	52 b	2
Corylus americana cv. Rush (20-year hedge)	LG	4 a	22 ab	63 c	46 b	75 c	23 ab	83 c	4
Pinus strobus L. (3-year seedlings)	LG	29 a	38 a	---[x]	---	---	58 b	79 b	12
	E	58 b	50 ab	---	---	---	83 b	83 b	
P. sylvestris L. (3-year seedlings)	LG	50 a	92 b	---	---	---	75 ab	73 ab	12
	E	70 ab	88 ab	---	---	---	90 b	89 b	
P. thunbergii Parl. (3-year seedlings)	LG	58 a	92 b	---	---	---	83 b	92 b	12
Quercus robur (30-year hedge)	LG	0 a	15 ab	6 a	21 b	13 ab	5 a	9 a	4
Taxus x media Rehd. (30-year hedge)	LG	33 a	---	---	---	---	60 ab	20 a	8
	E	58 ab	---	---	---	---	100 c	88 bc	

[z]Stockplant lighting treatments: LG refers to light-grown, E to etiolated.
[y]Significant differences ($P = 0.05$) between treatments within a species are indicated with lowercase letters. All comparisons are based upon the χ^2 test using 1-df contrasts. Means are based on 25 cuttings per treatment, without replication.
[x]Treatment not applied.

trical tape. Furthermore, the application of root-promoting compounds to the stem is facilitated when using Velcro bands. These compounds can result in stem wounding, swelling, and root formation. Hare (5) also reported stem swelling, occasional root formation on intact stems, and improved rooting of *Platanus occidentalis* L. (5) and *Quercus nigra* L. (6), resulting

Table 3. Roots per rooted cutting of light-grown cuttings in response to stockplant banding pretreatments.

	Banding							
		Tape		Denubbed Velcro		Intact Velcro		
Species	No band	−IBA	+IBA	−IBA	+IBA	−IBA	+IBA	$LSD_{0.05}$
Carpinus betulus (10-year hedge)	4.0	8.0	9.5	5.7	5.9	10.7	10.7	4.5
Pinus mugo (3-year seedlings)	4.0	---	---	---	---	---	8.0	2.4

from the application of rooting hormone under a band of aluminum foil. Although the present research has not addressed the cause of the observed stem swelling, it seems plausible that it reflects changes in the anatomy of the stem, such that adventitious root initiation is favored. It is an attractive hypothesis that the hormone-laden hooks of a Velcro band might introduce root-promoting auxin into the succulent tissues of a stem, stimulating callusing and root initiation while excluding light from the intended rooting zone, with the shoot still attached to the parent plant.

In 18 of 21 taxa tested, either etiolation, banding, or a combination of these pretreatments resulted in significant increases in the rooting response of cuttings. The majority of the taxa tested are known to be particularly difficult to root. Furthermore, Velcro banding was frequently an improvement over taping, perhaps because Velcro does not constrict the stem or unwind, as electrical tape may do, but yields to increases in stem diameter, maintaining the exclusion of light. Velcro is also an improvement over tape as a banding material in that it is easy to apply, is reusable, and permits the application of root-promoting compounds as a part of the banding procedure.

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