ETIOLATION TO IMPROVE SOFTWOOD CUTTING PROPAGATION: ASPECTS OF HORMONE APPLICATION AND TIMING OF TAKING CUTTINGS

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Abstract. The research presented here focuses on the factors affecting hormone application and timing of taking etiolated cuttings, with the goal of developing etiolation and banding into practical methods for use by the plant propagator. Etiolation was found to be more beneficial than banding when applied to 4 cultivars of *Fagus sylvatica* and 2 of 4 cultivars of *Acer saccharum*. In experiments with 2 cultivars of *Syringa reticulata*, banding, with or without etiolation, was most beneficial in stimulating rooting. The treatment of *S. reticulata* cuttings with 4000 ppm IBA was of little additional benefit. Conversely, cuttings from etiolated shoots of *Stewartia pseudocamellia* rooted best, the effect still evident after 2 months greening. Hormone applied at sticking was of a significant benefit to the rooting of *Stewartia* cuttings.

INTRODUCTION

Etiolation is a process which involves growing shoots in the dark. This technology has had a place in the efforts of plant propagators to improve the rooting of softwood cuttings since F. E. Gardner reported in 1937 on his success in rooting etiolated apple cultivar cuttings (4). In the past 50 years perhaps the greatest contribution toward developing etiolation and its related technique of banding into methods of practicality to the nurseryman has been made by Howard and co-workers at the East Malling Research

Station, Kent, England. We, at Cornell University, have followed over the last five years a similar tack toward developing etiolation and banding as practical methods for the softwood or semi-hardwood cutting propagation of difficult-to-root woody plant species. In this time we have greatly expanded the list of ornamental tree species which may be successfully rooted using etiolation. Furthermore we have worked with the techniques of etiolation and banding so that they are now simple and productive components of the vegetative propagation program at Cornell. As an improvement to Gardner's method of using black tape or paper we have developed the use of Velcro adhesive strips as a banding material. What we now have is a more effective banding method requiring less effort and allowing for the application of a root-promoting hormone [usually indole-3-butyric acid (IBA) in a talc base] to intact stems. Using hormone-laden Velcro we are able to promote callusing and even root initiation in a way similar to, but much easier and faster than, air layering. Previous results have been reported to this Society (1, 2, 6) and in the American Nurseryman (7).

The usefulness of etiolation and banding in improving the success of cutting propagation has been proven in the propagation of a number of species including maples, birches, hornbeams, chestnut, pines, hazelnut, and six cultivars of common lilac (*Syringa vulgaris*). Questionable initial results have been obtained at Cornell *only* with *Acer platanoides, Quercus rubrum,* and *Q. palustris* (6). We have a number of reasons for continuing a very active research program on the use of etiolation to improve rooting. First, there continues to be a large number of woody plant species which cannot be rooted at all, or only at very specific times of year (i.e. 'windows of rooting'). Also, problems still exist with graft incompatibility (e.g. *Psuedotsuga menziesii, Quercus palustris* 'Sovereign', and *Acer rubrum* cultivars), or poor "take" (e.g. budded *Acer saccharum*) (3). The relatively high labor costs and lengthy production times associated with grafting/budding could also be avoided were cutting propagation possible. Non-vegetative propagation (i.e. seed) is subject, of course, to genetic variability and to dormancy problems, resulting in poor or inconsistent cropping (5). Finally, though micropropagation may eventually replace all other means of cloning plants it is probably safe to assume, because of the cost, technological prerequisites, and problems with somaclonal variation, that there will always be a place for the cutting propagation of woody plants.

There is good evidence that etiolation serves to extend the "window of rootability" (1), that period of weeks, or perhaps only days, when a species may be rooted successfully, which is flanked by extended periods of poor rooting. Futhermore, we commonly observe that previously etiolated cuttings root readily, often in as little as two weeks. This allows for the rooting of cuttings earlier in the growing season, resulting in improved overwintering and the production of finished plants in as little as one-half the time needed to produce a finished plant from budded stock. This shortened production time combined with the ability to take cuttings over a greatly lengthened "window of rooting" means that a tremendous potential exists for increasing production of desirable plant materials.

At present our research efforts are geared toward improving the technology of etiolation and banding, and toward understanding what processes are at work in generating the improved rooting responses of treated cuttings. We are investigating the timing of treatment and of the taking of cuttings to discern the precise effect of etiolation on this "window of rooting". By studying the optimum number and strength of hormone applications we will determine the conditions producing the fastest rooting response in the propagation bench. Each season we continue to expand the number of species propagated using etiolation, and welcome suggestions of other species we might try. And we are studying the aftercare of cuttings, such that etiolation technology may be adapted completely to the nursery production situation (2). Finally, we are looking closely at the changes occurring in etiolated or banded stems, anatomical and physiological, which might explain the root-promoting response to etiolation. Recent research results relating to the aforementioned objectives are presented in this report.

MATERIALS AND METHODS

The etiolation and banding technique has been presented in detail elsewhere (7). Briefly, field-grown or containerized dormant stock plants are covered at bud break with an opaque material, usually black cloth or plastic (about 95% light exclusion); taking care to allow space for the new growth to extend. Initial growth is allowed to proceed in the dark (etiolation) until new shoots are between 5 and 7 cm long, after which time the shade is gradually removed over the period of one week so as not to scorch the very tender shoots. On the first day of shade removal, Velcro strips approximately 2.5 cm wide by 2.5 cm long are placed at the base of each new shoot (the future cutting base). A rooting hormone (8000 ppm IBA in talc) is added to the Velcro before banding the shoot. Both pieces of Velcro are dipped in the talc preparation; the excess powder is tapped off, and the Velcro band applied firmly to "sandwich" the shoot. Velcro bands are left on the shoots for about 4 weeks, after which the cuttings are removed from the stock plant below (proximal to) the banded area. The bands are removed and the cutting bases are again treated with hormone (4000 ppm IBA in 50% aqueous ethanol) before sticking them in the rooting medium. The rooting medium consists of peat and perlite (1:1, v/v) with bottom heat (25°C), overhead mist, saran shading (50%), and a 16 hr photoperiod supplied by 60 watt incandescent bulbs hung 1 meter above the bench. Cuttings are left in the bench for 2 to 5 weeks. After rooting, the cuttings are potted up, weaned from under the mist, fertilized, and kept under long days (16 hours) to encourage growth.

Blanching is accomplished by banding shoots as described above, except that stock plants are not initially covered, so new growth develops in the light. The hormone-coated Velcro is applied when the soft, green shoots are 5 to 7 cm long.

The *Fagus sylvatica* clones with which we experimented were established plants approximately 15 years of age and located in the Cornell Test Gardens. The four *Acer saccharum* and two *Syringa reticulata* cultivars, plus stock plants of *Stewartia pseudocamellia* were kindly donated by George Schichtel of Orchard Park, New York. These plants were 3 to 5 years of age.

RESULTS AND DISCUSSION

***Fagus sylvatica* cultivars:** The four European beech clones were treated in the field in the spring and summer of 1986. Banding alone was not beneficial in improving the rooting response of any of the four beech clones tested (Table 1). However, when etiolated shoots were banded to maintain etiolation, significant increases were obtained with the species clone (i.e. not a named cultivar), and the cultivars, 'Atropurpurea' and 'Laciniata'. The cultivar 'Fastigiata' did not respond significantly to either blanching or etiolation plus banding, perhaps because the buds of this plant broke nearly a week before an etiolation structure could be erected over the developing shoots.

Table 1. Rooting percent response of four *Fagus sylvatica* clones to blanching, and etiolation followed by banding.

Treatment	Cultivar			
Stockplant/ shoots	Species	'Atropurpurea'	'Laciniata'	'Fastigiata'
Light grown/ no band	13.9[z]a	2.5 a	18.0 a	27.5 a
Light grown/ blanched	20.0 a	0.0 a	12.5 a	26.1 a
Etiolated/ banded	64.3 b	25.0 b	84.6 b	44.0 a

[z] Means within cultivar separated by Duncan's LSD, $p=0.05$.

***Acer saccharum* cultivars:** The responses to etiolation and banding were compared among *A. saccharum* cultivars Arrowhead, Green Mountain, Legacy, and Seneca Chief, which were containerized and forced in a greenhouse during the winter of 1987

(Table 2). The two cultivars, 'Arrowhead' and 'Seneca Chief' broke bud about 2 weeks before the other cultivars and showed significant responses to etiolation though not the additional treatment of banding. The other cultivars, Green Mountain and Legacy, broke bud later and, as a result, were grown and propagated in a substantially warmer greenhouse environment, which may have affected their responses to etiolation and banding. Shoots of 'Green Mountain' showed a slight trend toward improved rooting of etiolated shoots. The rooting response of 'Legacy' shoots actually appeared to be inhibited by banding. All *A. saccharum* cuttings were allowed to root for 35 days.

***Syringa reticulata* cultivars:** Plants of *S. reticulata* were containerized and forced in a greenhouse during the winter of 1987. With the two cultivars, Ivory Silk and Summer Snow, we investigated the necessity for an application of rooting hormone at the time of sticking the cutting. Rooting responses were assessed at

Table 2. Rooting percent response of four *Acer saccharum* cultivars to blanching, etiolation, and etiolation followed by banding.

Treatment	Cultivar			
Stockplant/ shoots	'Arrowhead'	'Green Mountain'	'Legacy'	'Seneca Chief'
Light grown/ no band	0.0[z]a	22.8 a	42.0 a	28.1 a
Light grown/ blanched	—[y]	14.4 a	20.1 a	—
Etiolated/ no band	38.6 b	27.8 a	38.3 a	72.1 b
Etiolated/ banded	38.6 b	27.4 a	18.5 a	72.3 b

[z] Means within cultivar separated by Duncan's LSD, p=0.05.
[y] (—) this treatment not applied.

Table 3. Rooting percent response of *Syringa reticulata* 'Ivory Silk' to blanching, etiolation, and etiolation followed by banding; with or without a 4000 ppm IBA (50% EtOH) quick-dip at the time of sticking.

Treatment	Rooting time in bench (weeks)			
	2		4	
Stockplant/ shoots	No hormone	IBA quick dip	No hormone	IBA quick dip
Light grown/ no band	0.0[z]a	5.3 ab	22.3 a	40.0 ab
Light grown/ blanched	3.3 ab	43.8 c	81.7 d	86.7 d
Etiolated/ no band	0.0 a	10.0 b	57.4 bc	75.4 cd
Etiolated/ banded	6.7 ab	78.0 d	75.0 cd	88.0 d

[z] Means within rooting time separated by Duncan's LSD, p=0.05.

both 2 and 4 weeks to discern if the speed of rooting was affected by the etiolation or banding treatments.

Blanched cuttings of the cultivar, Ivory Snow, which had rooted for 2 weeks yielded significantly greater rooting percentages than the light-grown, unbanded control only when treated with IBA at sticking (Table 3). A clear synergism occurred between etiolation and banding.

After 4 weeks in the rooting bench, cuttings treated by blanching, or etiolation plus banding, rooted significantly better than the control, whether or not hormone had been applied at sticking. More than two times as many roots per rooted cutting were present in cuttings which had been blanched or etiolated and banded (data not shown). In no case did adding hormone at sticking significantly improve the rooting response. From this data it would appear that blanching alone, with no additional hormone treatment, can insure successful rooting of *S. reticulata* 'Ivory Silk'.

Cuttings of the cultivar, Summer Snow, allowed to root for 2 weeks also showed significant responses to blanching without significant increases in response to either etiolation or the application of IBA at sticking (Table 4). The same trends were evident for cuttings allowed to root for 4 weeks, the best rooting obtained from etiolated and banded shoots. Again, etiolated and banded cuttings produced twice as many roots per rooted cutting on the average (data not shown).

As opposed to the *A. saccharum* cultivars, shoots of *S. reticulata* responded best to banding, not etiolation. Thus, in this case, it might be advisable to retain only the blanching treatment, eliminating the need for prior etiolation. Furthermore, when working with *S. reticulata* it would be possible to omit the application of IBA at sticking. A necessary follow-up experiment to this would be one examining the use of hormone on the band, when it is applied to the

Table 4. Rooting percent response of *Syringa reticulata* 'Summer Snow' to blanching, etiolation, and etiolation followed by banding; with or without a 4000 ppm IBA (50% EtOH) quick-dip at the time of sticking.

Treatment	Rooting time in bench (weeks)			
	2		4	
Stockplant/ shoots	No hormone	IBA quick dip	No hormone	IBA quick dip
Light grown/ no band	4.0[z]a	4.4 a	36.0 a	70.0 bc
Light grown/ blanched	12.0 ab	34.0 bc	72.0 c	79.2 c
Etiolated/ no band	4.0 a	6.0 a	40.0 a	40.8 ab
Etiolated/ banded	22.0 abc	48.3 c	86.0 c	93.3 c

[z] Means within rooting time separated by Duncan's LSD, p=0.05.

developing shoot, to determine if the banding effect derives from the exclusion of light, the presence of IBA in close proximity to the developing stem, or both treatments.

Stewartia pseudocamellia: Ten stock plants of *S. pseudocamellia* were containerized and forced in a greenhouse during the winter of 1987, again to examine the need for hormone application at sticking. Cuttings of *Stewartia* rooted rapidly, usually within 2 weeks. Furthermore, we were able to obtain a tremendous number of cuttings from just a few stock plants (1000 cuttings from ten 72 cm plants). Therefore, in addition to the usual cutting "take" at 4 weeks we took cuttings at 8 weeks, to see if a "window of rooting" indeed existed for *Stewartia,* and if this might be affected by etiolation.

In contrast with the effect of hormone application on the rooting of *S. reticulata* shoots, cuttings of *Stewartia* showed significant increases in percentage rooting whenever hormone was applied at sticking (Table 5). After 4 weeks greening any light exclusion treatment had significantly improved rooting. Etiolation and blanching were equally effective in promoting the rooting of cuttings treated with IBA before sticking. Etiolation plus banding yielded 100% rooting within 2 weeks, a significant improvement over blanching alone. Etiolation plus banding also tripled the number of roots produced per rooted cutting on the average (approximately 18), while etiolation of any sort doubled the average length of the longest roots produced (data not shown).

The rooting of all *Stewartia* cuttings decreased after 8 weeks greening. The best rooting was sustained in cuttings which had been initially etiolated and then treated with IBA at sticking. Furthermore, cuttings from shoots which had been etiolated, banded, and treated with IBA still rooted at close to 100%. Again, the banding of etiolated shoots resulted in a trebling of root number (data not shown).

Table 5. Rooting percent response of *Stewartia pseudocamellia* to blanching, etiolation, and etiolation followed by banding; with or without a 4000 ppm IBA (50% EtOH) quick-dip at the time of sticking.

Treatment	Stockplant greening time after banding applied (weeks)			
	4		8	
Stockplant/ shoots	No hormone	IBA quick dip	No hormone	IBA quick dip
Light grown/ no band	4.0[z]a	68.0 d	0.0 a	23.8 bc
Light grown/ blanched	22.0 b	88.0 ef	18.2 bc	35.0 c
Etiolated/ no band	50.0 c	97.5 fg	14.7 b	85.7 d
Etiolated/ banded	76.0 de	100.0 g	8.6 ab	94.4 d

[z] Means within greening period separated by Duncan's LSD, p=0.05.

Clearly, having initially etiolated shoots resulted in nearly 100% rooting in cuttings of *S. pseudocamellia*, even as the rooting response of control cuttings decreased during the additional 4 week period of greening. Etiolation alone extended the "window of rooting". When hormone is applied to shoots which have been previously etiolated it would appear that the additional treatment of banding may be omitted.

CONCLUSIONS

From this work it appears that the successful rooting of *Fagus sylvatica, Acer saccharum,* and *Stewartia pseudocamellia* may be accomplished using shoots which have been etiolated in the first week of their development. It is intriguing that shoots initially grown in the dark to a length of only 5 cm and greened for 2 months will still root so much more easily than light-grown shoots. Etiolated shoots of *Stewartia* greened for 4 or 8 weeks were morphologically indistinguishable from initially light-grown shoots. This reminds us of the intriguing possibility that anatomic and physiologic changes are occurring.

Stewartia cuttings also benefitted from additional hormone at sticking while *S. reticulata* cuttings did not. Of the species tested in this study, only *S. reticulata* responded more to banding than to etiolation. This pattern has been noted in previous studies with *Carpinus betulus, Corylus americana* 'Rush', and *Syringa vulgaris* cultivars (6).

Repeatedly, we have observed increases in the rooting of shoots treated by etiolating or banding. This has allowed us to make rapid progress in our studies of cutting propagation. The work is exciting and much remains to be done. In the years to come we hope to answer, in our study of the changes occurring in those tissues that are destined to form roots, many of the important questions regarding light effects on the adventitious rooting of cuttings.

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