J. Amer. Soc. Hort. Sci. 105(1):91–95. 1980.

Growth Regulator Effects on Adventitious Root Formation in Leaf Bud Cuttings of Juvenile and Mature *Ficus pumila*[1]

F. T. Davies, Jr.[2] and J. N. Joiner
Department of Ornamental Horticulture, University of Florida, Gainesville, FL 32611

Additional index words. indolebutyric acid, 6-(benzylamino)-9-(2-tetrahydropyranyl)-9H-purine, gibberellic acid, creeping fig

Abstract. Adventitious root formation was stimulated with foliar application of indolebutyric acid (IBA) from 1000 to 1500 mg/liter for juvenile and 2000 to 3000 mg/liter for mature leaf bud cuttings of *Ficus pumila* L. IBA increased cambial activity, root initial formation, and primordia differentiation and elongation. IBA stimulated rooting when applied to juvenile cuttings at 3, 5, or 7 days after experiment initiation, but had no effect on mature cuttings when applied at day 15, the final treatment period. The interaction of IBA/gibberellic acid (GA_3) did not affect early root development stages, but reduced root elongation and quality once primorida had differentiated. IBA/6-(benzylamino)-9-(2-tetrahydropyranyl)-9H-purine (PBA) inhibited rooting at early initiation stages.

Recent researchers have generally agreed that adventitious root formation (ARF) involve sequences of histological steps with each step having different requirements for growth substances (5, 8, 9, 10, 11). Eriksen (5) and Mohammed and Eriksen (8) found that auxins and cytokinins had different affects on ARF depending on developmental stage. Sircar (11) reported 5 different histological stages in which GA_3 and IAA alternately promoted or inhibited ARF. Hypocotyl cuttings of herbaceous annuals have been used in previous sequencing

[1] Received for publication April 9, 1979. Florida Agricultural Experiment Station Journal Series No. 1731.
The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper must therefore be hereby marked *advertisement* solely to indicate this fact.

[2] Present address: Horticultural Science Department, Texas A&M University, College Station, TX 77843.

experiments, but herbaceous material may not give a true index of changes occurring in mature woody materials.

The woody ornamental creeping fig *(Ficus pumila)* exhibits strong dimorphism (2) and differences in rooting between the juvenile and mature forms. Objectives of this study were to determine the effect of IBA, PBA, and GA_3 applied at different rooting developmental stages to juvenile and mature leaf-bud cuttings (LBC) of *F. pumila.*

Materials and Methods

F. pumila cultivated on the University of Florida campus at Gainesville were used as stock plants. Leaf bud cuttings (LBC-lamina, petiole and 2.5 cm piece of stem with attached axillary bud) were rooted under an intermittent mist system in a medium of sterilized mason sand maintained at 24°C with a 2 hr night light interruption previously described (4). Juvenile LBC were harvested after 21 days and mature cuttings 42 days after experiments were initiated. All growth regulators were applied as aqueous sprays with 0.25 ml/liter of surfactant, emulsifiable A-C polyethylene and octyl phenoxy polyethoxy ethanol (Plyac).

In an experiment to establish optimum IBA concentration required for rooting, cuttings were taken in November and IBA applied at 500, 1000, 1500, 2000, 3000, and 10,000 mg/liter to juvenile and 2000, 2500, 3000, 4000, 5000, and 10,000 mg/liter to mature LBC at time of insertion. The design was a randomized complete block with 4 replications and 40 cuttings per treatment.

To characterize growth regulator effects at different root development stages a factorial experiment was initiated in May with 2 forms (juvenile, mature LBC) × 2 IBA pretreatments (control, treated) × 3 growth regulators (IBA, PBA, GA_3) × 3 application dates. An IBA spray of 1000 mg/liter was applied to half the juvenile cuttings and 3000 mg/liter to half the

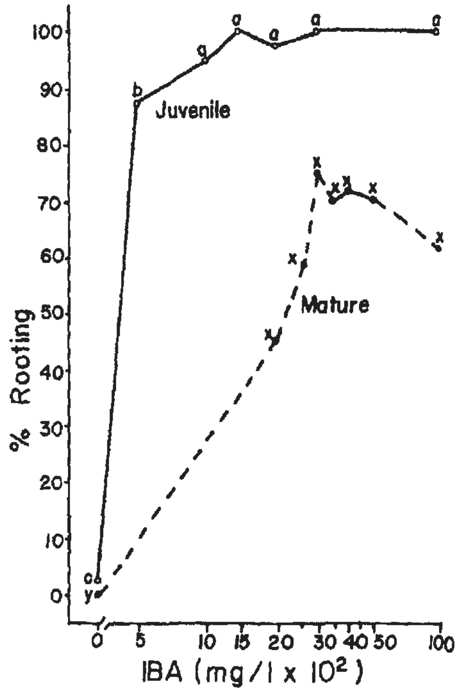


Fig. 1. Effect of IBA on rooting in juvenile and mature leaf bud cuttings of *Ficus pumila.* Points with same lower case letters are not significantly different.

mature material at the time of insertion. Growth regulators were then applied after 3, 5, or 7 days for juvenile and 3, 9 or 15 days for mature cuttings: IBA at 1000 mg/liter for juvenile and 3000 mg/liter for mature cuttings, 1000 mg/liter PBA and 3000 mg/liter GA_3 for both types. The design was a randomized complete block with 4 replications and 32 cuttings per treatment. To determine stage of ARF 10 cuttings of each treatment combination were selected at each of the 3 time intervals and fixed in formalin-acetic acid-ethanol (FAA) *in vacuo*, dehydrated in ethanol-tertiary butyl alcohol series and embedded in Paraplast-plus. Blocks containing stem pieces with one surface exposed were soaked in distilled water *in vacuo* for 5 days to soften tissues prior to sectioning. Serial cross and longitudinal sections were cut at 8 and 11 um and strained with safranin and fast green.

Cuttings were measured for percent rooting, root number, and root length (average of 3 longest roots) and rated on a quality scale of 1 to 4 with 1 = no rooting, 2 = small root system, 3 = intermediate root system and 4 = extensive root system.

Results

Optimum IBA concentration. IBA treatments stimulated ARF in both juvenile and mature LBC (Fig. 1, 2, 3, 4). At high IBA levels root length was reduced in both forms (Fig. 3) and root quality in juvenile cuttings was poor (Fig. 4). Best horticultural responses were obtained in juvenile material treated with 1000-1500 mg/liter and mature cuttings treated with 2000-3000 mg/liter IBA considering root number, length and quality (Fig. 2, 3, 4). The performance of IBA-treated juvenile LBC was better than IBA-treated mature cuttings.

Hormonal effects during rooting stages. Percent rooting in IBA pretreated cuttings was unaffected by additional IBA at any of the 3 time intervals after insertion, however, root length was reduced in all treatments (Table 1, 2). In juvenile LBC receiving no IBA pretreatment, later IBA application increased rooting in all dates (Table 1), but in mature cuttings only the first or second application period was stimulatory (Table 2).

GA_3 reduced root length and quality in IBA-pretreated cuttings (Table 1, 2 and Fig. 5, 6). In juvenile cuttings without IBA pretreatment, GA_3 reduced root length (Table 1), but had no effect on mature LBC without IBA pretreatment (Table 2).

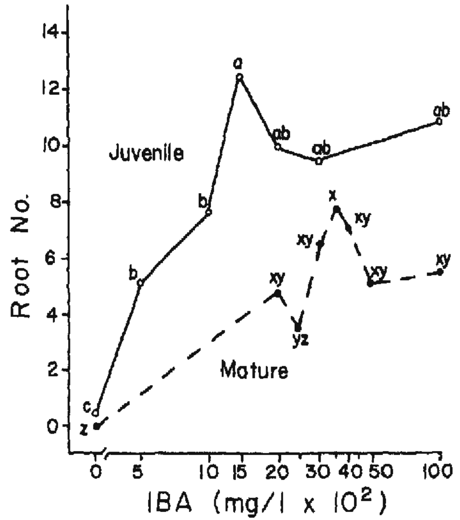


Fig. 2. Effect of IBA on root number in juvenile and mature leaf bud cuttings of *Ficus pumila*. Points with same lower case letters are not significantly different.

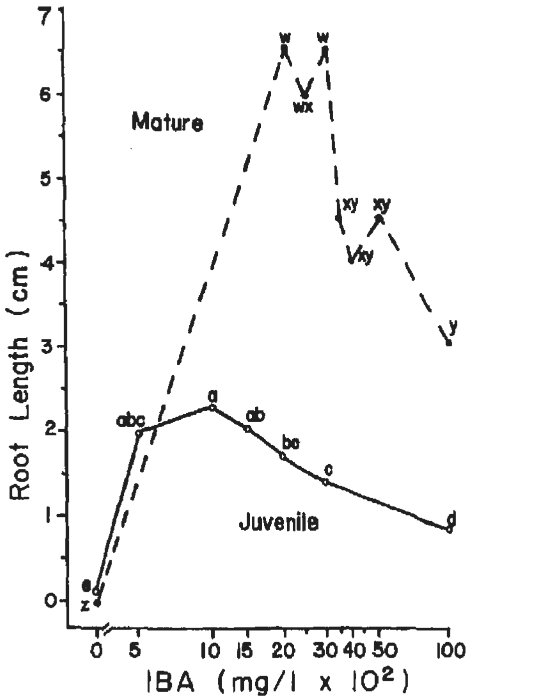


Fig. 3. Effect of IBA on root length in juvenile and mature leaf bud cuttings on *Ficus pumila*. Points with same lower case letters are not significantly different.

Table 1. Adventitious root formation in juvenile leaf bud cuttings of *Ficus pumila* treated with 3 growth regulators at 3, 5, or 7 days after experiment initiation. Half the cuttings were pretreated with 1000 mg/liter IBA.

IBA pre-treatment (mg/liter)	Growth regulator post treatment	Rooting (%)	No. roots	Root length (cm)	Root quality scale[z]
0	IBA				
	(1000 mg/liter)				
	day 3	100a[z]	9.5e	1.1bcde	2.6de
	day 5	100a	11.0bcde	1.1bcde	2.8cd
	day 7	100a	10.3cde	1.0bcde	2.5de
	GA_3				
	(3000 mg/liter)				
	day 3	31c	0.7h	0.8cde	1.3gh
	day 5	28c	0.8h	0.7de	1.3gh
	day 7	34c	1.0h	1.5bcd	1.5g
	PBA				
	(1000 mg/liter)				
	day 3	0d	0h	0h	1.0h
	day 5	25c	0.9h	1.2bcde	1.3gh
	day 7	25c	0.9h	1.4bcd	1.3gh
	Control	31c	0.8h	1.7b	1.3gh
1000	IBA				
	(1000 mg/liter)				
	day 3	100a	12.7b	1.5bc	3.0abc
	day 5	100a	15.2a	1.3bcd	3.2ab
	day 7	100a	12.4bc	1.0bcde	2.7cd
	GA_3				
	(3000 mg/liter)				
	day 3	100a	10.8bcd	1.3bc	2.7cde
	day 5	100a	9.0ef	1.5bc	2.8cd
	day 7	100a	10.2de	1.7b	2.8bcd

PBA effectively limited ARF in IBA-pretreated cuttings when applied during the first or second time intervals (Tables 1, 2). In juvenile LBC the greatest inhibition occurred during the first time interval which coincided with increased cambial activity associated with the dedifferentiation phase of ARF (Table 3). PBA caused less inhibition of ARF the second appli-

PBA (1000 mg/liter)				
day 3	38c	1.3h	0.5ef	1.4gh
day 5	66b	5.3g	1.3cde	2.0f
day 7	88a	7.2fg	1.2bcde	2.3ef
Control	100a	11.9bcd	2.5a	3.4a

[z]Root quality scale range from 1 to 4 with 1 = no root system, 2 = small root system, 3 = intermediate root system and 4 = extensive root system.
[y]Mean separation in columns by Duncan's multiple range test, 5% level.

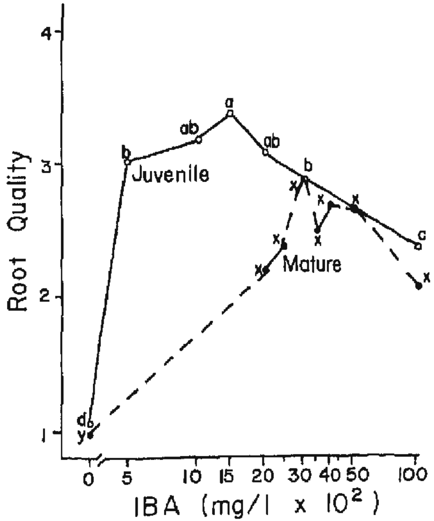


Fig. 4. Effect of IBA on root quality in juvenile and mature leaf bud cuttings of *Ficus pumila*. Points with same lower case numbers are not significantly different.

cation period when root initials and primordia were first observed. Half the LBC rooted by the third interval (Table 3); thus PBA application at this time did not affect % rooting but did reduce root number, length and quality. In mature cuttings PBA treatment at first application period completely inhibited ARF (Table 2) when no cambial activity was observed. PBA was less effective in inhibiting ARF during second application when cambial activity was first observed (Table 2, 4). Root length and quality were reduced with PBA application at any period, but had no effect on % rooting or number during the third treatment period.

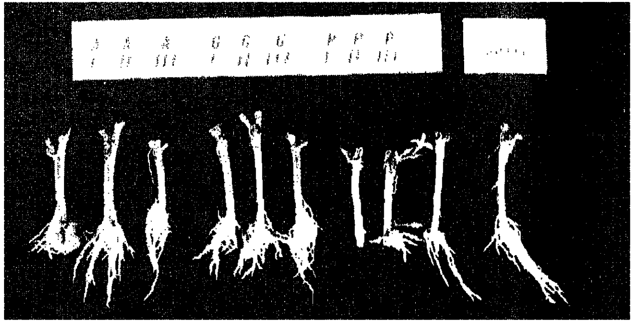
PBA reduced rooting in juvenile cuttings not pretreated with IBA when applied during the first treatment period when neither root initials nor primordia were observed (Table 1, 3). In mature cuttings PBA had no statistical effect on rooting; however, none of the treated cuttings formed roots, nor were root initials or primordia observed (Table 2, 4).

Discussion

Mature *F. pumila* cuttings did not root as efficiently as juvenile material. Thus, IBA-treated mature cuttings required higher exogenous auxin levels and longer time to obtain

Table 2. Adventitious root formation in mature leaf bud cuttings of *Ficus pumila* treated with 3 growth regulators at 3, 9, or 15 days after experiment initiation. Half the cuttings were pretreated with 3000 mg/liter IBA.

IBA pre-treatment (mg/liter)	Growth regulator post-treatment	Rooting (%)	No. roots	Root length (cm)	Root quality scale[z]
0	IBA				
	(3000 mg/liter)				
	day 3	84abc[z]	13.1abc	3.4ab	3.0ab
	day 9	94ab	8.6cde	3.0ab	2.7abc
	day 15	53cdefg	2.7fg	1.0cde	1.7efg
	GA_3				
	(3000 mg/liter)				
	day 3	44efg	2.0fg	0.7de	1.5fgh
	day 9	41fg	1.9fg	0.8cde	1.5fgh
	day 15	38fg	1.1fg	0.8cde	1.4gh
	PBA				
	(1000 mg/liter)				
	day 3	0h	0g	0e	1.0h
	day 9	0h	0g	0e	1.0h
	day 15	0h	0g	0e	1.0h
	Control	22gh	1.5fg	1.1cde	1.3gh
3000	IBA				
	(3000 mg/liter)				
	day 3	81abcd[z]	11.1bcd	2.1bcd	2.6bcd
	day 9	100a	16.1a	3.1ab	3.2ab
	day 15	91ab	13.7ab	2.1bcd	2.7abc
	GA_3				
	(3000 mg/liter)				
	day 3	66bcdef	8.4cde	1.6cd	2.0def
	day 9	50defg	6.0ef	1.7cd	1.8efg
	day 15	66bcdef	7.3de	2.2bc	2.1cde



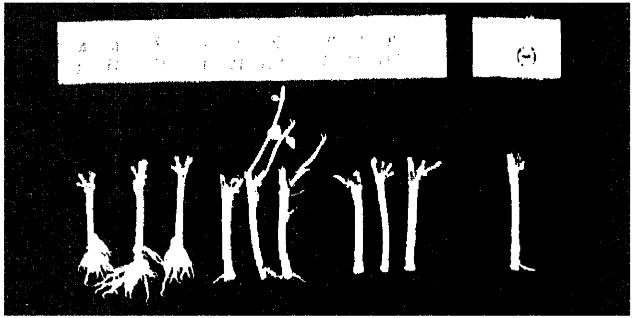


Fig. 5. Effect of IBA, GA_3 and PBA on adventitious root formation when applied at 3 time intervals to juvenile leaf bud cuttings. (top) Pretreated with (IBA). (bottom) No pretreatment with IBA.

PBA (1000 mg/liter)				
day 3	0h	0e	0e	1.0h
day 9	28gh	1.6fg	1.0cde	1.3h
day 15	75abcde	9.2bcde	1.3cde	2.2cde
Control	94ab	13.3abc	3.8a	3.2a

[z]Root quality scale ranged from 1 to 4 with 1 = no root system, 2 = small root system, 3 = intermediate root system and 4 = extensive root system.

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

maximum rooting (3) than juvenile LBC. Mature cuttings may have lower endogenous auxin levels and/or other endogenous chemicals needed to stimulate root initiation. When ARF was measured on a daily basis (3), IBA-treated mature cuttings rooted slower than juvenile LBC, but equalled juvenile controls by day 20, giving strong evidence that endogenous auxin levels were acting as a possible limiting factor in root initiation.

IBA increased ARF in both juvenile and mature cuttings by stimulating initiation of cambial activity, root initials and primordia, which agrees with reports that auxins trigger early formation of root primordia (6). However in *F. pumila*, application of auxin above the optimum level reduced root length and quality indicating that primordia elongation was decreased.

In both juvenile and mature cuttings the combination of IBA/GA_3 retarded rooting after primorida were differentiated, since % rooting was not influenced but root length and quality were reduced. The conflicting reports on exogenous gibberellin influence on rooting (1, 7, 12) may be related to species differences. Our results agree with Hassig (7) who reported that initiating primordia were least affected by GA_3 but that cell number was reduced in older established primordia which was deleterious to root formation.

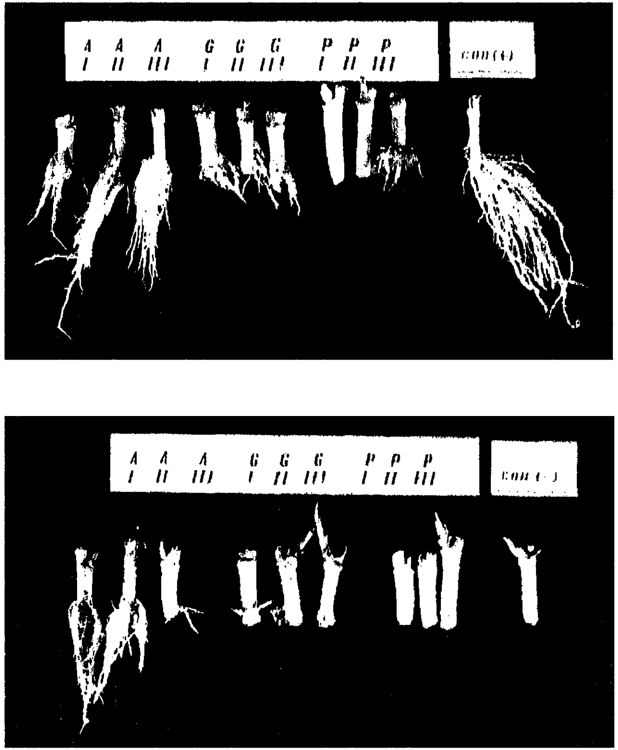


Fig. 6. Effect of IBA, GA_3 and PBA on adventitious root formation when applied at 3 time intervals to mature leaf bud cuttings. (top) Pretreated with IBA. (bottom) No pretreatment with IBA.

Table 3. Stage of adventitious root formation of juvenile leaf bud cuttings of *Ficus pumila* at 3 time intervals.

Treatment	Increased cambial activity	Root initials	Root primordia	Rooting (%)	No. roots	Root length (cm)	Root quality scale[z]
IBA pretreatment at (1000 mg/liter)							
day 3	yes	none	none	0	0	0	1.0
day 5	yes	yes	yes	0	0	0	1.0
day 7	yes	yes	yes	50	6.2	0.7	1.6
No IBA pretreatment							
day 3	none	none	none	0	0	0	1.0
day 5	yes	none	none	0	0	0	1.0
day 7	yes	yes	yes	20	0.4	0.5	1.2

[z]Root quality scale ranged from 1 to 4 with 1 = no root system, 2 = poor root system, 3 = intermediate root system and 4 = extensive root system.

Table 4. Stage of adventitious root formation of mature leaf bud cuttings of *Ficus pumila* at 3 time intervals.

Treatment	Increased cambial activity	Root initials	Root primordia	Rooting (%)	No. roots	Root length (cm)	Root quality scale[z]
IBA pretreatment at (3000 mg/liter)							
day 3	none	none	none	0	0	0	1.0
day 9	yes	none	none	0	0	0	1.0
day 15	yes	yes	yes	20	1.7	0.5	1.2
No IBA pretreatment							
day 3	none	none	none	0	0	0	1.0
day 5	none	none	none	0	0	0	1.0
day 15	yes	none	none	0	0	0	1.0

[z]Root quality scale ranged from 1 to 4 with 1 = no root system, 2 = poor root system, 3 = intermediate root system and 4 = extensive root system.

The rooting inhibition of PBA on juvenile and mature *F. pumila* concur with reports that cytokinins inhibit preinduction phases of rooting (12) with a loss of inhibitory effect at later stages (6).

Differences in adventitious rooting between juvenile and mature cuttings may be partially attributed to endogenous auxin levels, since lower IBA levels were required for optimal rooting in juvenile compared to mature LBC. However, other factors such as auxin/cytokinin and auxin/GA_3 ratios, cofactors and inhibitors may be involved, since exogenous IBA applications did not overcome root formation differences between IBA-pretreated juvenile vs. mature tissue.

Literature Cited

1. Brian, P. W., H. G. Hemming, and D. Lowe. 1960. Inhibition of rooting of cuttings by gibberellic acid. *Ann. Bot.* 24:408-419.
2. Condit, I. J. 1969. Ficus: the exotic species. Univ. of Calif. Div. of Agri. Sci. Berkeley.
3. Davies, F. T., Jr. 1978. A physiological and histological analysis of adventitious root formation in juvenile and mature cuttings of *Ficus pumila* L. PhD Dissertation. Univ. of Florida, Gainesville.
4. ________ and J. N. Joiner. 1978. Adventitious root formation in three cutting types of *Ficus pumila* L. *Proc. Intern. Plant Prop. Soc.* 28:(in press).
5. Eriksen, E. N. 1974. Root formation in pea cuttings III. The influence of cytokinin at different developmental stages. *Physiol. Plant.* 30:163-167.
6. ________ and S. Mohammed. 1974. Root formation in pea cuttings II. Influence of indole-3-acetic acid at different developmental stages. *Physiol. Plant.* 32:158-162.
7. Hassig, B. E. 1972. Meristematic activity during adventitious root promordium development. *Plant Physiol.* 49:886-892.
8. Mohammed, S. and E. N. Eriksen. 1974. Root formation in pea cuttings IV. Further studies in the influence of indole-3-acetic acid at different developmental stages. *Physiol. Plant.* 32:94-95.
9. Mullins, M. G. 1970. Auxin and ethylene in ART in *Phaseolus aureus* (Roxb.). Plant Growth Substances XIV. Proc. Symp. Canberra, Australia.
10. Shiboaka, H. 1971. Effects of indoleacetic, p-chloro-phenoxyisobutyric and 2, 4, 6-trichlorophenoxyacetic acids on three phases of rooting in *Azukia* cuttings. *Plant Cell Physiol.* 12:193-200.
11. Sircar, P. K. and S. K. Chatterjee. 1974. Physiological and biochemical changes associated with adventitious root formation in *Vigna* hypocotyl cuttings: II. Gibberellin effects. *Plant Propagator* 20(2):15-22.
12. Smith, D. R. and T. A. Thorpe. 1975. Root initiation in cuttings of *Pinus radiata* seedlings. II. Growth regulator interactions. *J. Expt. Bot.* 26:193-202.


Aerial view Bailey Nurseries. Photo: Bailey Nurseries

Reprinted with permission from the Bailey Nurseries. Originally printed in the Combined Proceedings of the International Plant Propagators' Society, Vol 57, 2007

Auxin Application via Foliar Sprays©

Samuel R. Drahn
Bailey Nurseries, Inc., 1325 Bailey Rd., Saint Paul, MN 55119 USA
Email: sam.drahn@baileynursery.com

INTRODUCTION

Over the past six years Bailey Nurseries, Inc. has been delivering IBA *(indole-3-butyric acid)* to unrooted cuttings in a couple of ways; manual basal dips before planting and overhead sprays after planting is complete. Careful, repetitive trialing has shown us that many of the varieties respond equally as well to being sprayed with water soluble IBA after sticking instead of the traditional hand dip method that we have used for years. In both our Minnesota and Oregon propagation facilities the shift in delivery method has been driven by a desire to reduce our employees' exposure to chemicals, develop a more streamlined and sanitary approach to propagation and to reduce the labor costs associated with rooting hormone applications. All of these goals need to be met while maintaining our standards of high quality, well rooted cuttings. Using Hortus IBA Water Soluble Salts has helped us reach these objectives with many of our taxa.

MATERIALS AND METHODS

Cuttings harvested from our different production areas or bought from other suppliers are stored in our cold storage facilities and queued for planting. Our coolers are maintained at approximately 34 °F and 90% RH. By using water soluble IBA after sticking instead of dipping by hand this time in storage is reduced. After the cuttings are planted into the propagation trays or beds a single application of between 250 and 2000 ppm Water soluble IBA is made. This is done a variety of ways depending on the size of the area to be treated. For small areas a backpack type sprayer is used. For large areas a hose and reel type sprayer with or without a boom style irrigator is utilized. The product literature recommends to “spray the solution evenly over the cuttings until drops go down to the media”. We believe delivering 1L per 60ft^2 sufficiently meets these guidelines. Approximately 25-30 gal of solution is applied to 6000 ft^2. Mirroring our existing traditional IBA rates has been the starting point for our water soluble IBA trial rates. The product literature suggests using only distilled or de-mineralized water for these treatments to avoid precipitation problems. We feel this is not practical on such a large scale and have used well water since we began exploring this IBA delivery method.

Our results have shown that making these applications within 24 h of sticking is critical to our success. Typically the IBA is applied at the end of each day or first thing next morning when the light levels are low and the plants misting requirements are at a minimum. When cuttings have been treated with IBA during frequent misting cycles in the day no decline in efficacy has been noted. Applications that have been made several days after sticking have resulted in reduced final percentages and weaker, slower rooting in general.

The label identifies a zero re-entry interval and permits applications to be made while people are working in the houses. Waiting to treat the cuttings with IBA until the crews have finished planting and have left the house is a precautionary step that we feel more comfortable with. Each application is made by a specially trained and licensed pesticide applicator. Using only a select group of applicators reduces the number of employees who are in contact with chemicals. This helps ensure consistency and accuracy and limits the amount of chemicals our employees are exposed to. The required personal protection equipment is long sleeve shirt, long pants, shoes, socks and waterproof gloves. Posting the application with signage and/ or cones is unnecessary.

Implementing any new technique requires time and patience to be successful. The switch from manual dips to overhead sprays has proven time consuming but rewarding. Each variety needs to be thoroughly tested before we feel comfortable making a change to our production practices. The first trials consist of a 12-ft^2 section of cuttings to test for phytotoxicity and efficacy. Misting requirements have not changed with the use of this type of method. Blocks of trial plants are within the dipped sections, and are all given the same amount and duration of mist during the root initiation process. The cuttings are all weaned from mist at the same time. As our familiarity with the Hortus IBA Water Soluble Salts on a particular variety increases so does the size of the trial. If the first trial proves effective the trial area will be increased in proportion to the size of the crop, usually about 10%. After a second season of positive results the trial area will normally be increased to approximately one quarter to one half of the crop. Multiple crop locations and sticking times allow us to expedite the trial process. It is only after three separate trials have occurred with successful results that the practice can become standard in our production methods.

RESULTS

As our experience with this application method has grown so has the use of Hortus IBA Water Soluble Salts. Familiarity and repetitive success has given us comfort with this product. Over the last several years the percentage of crops treated with IBA after sticking has risen steadily. This past season the amount of cuttings treated with IBA after sticking increased sharply. Currently 95% of our softwood crops in MN that call for IBA are receiving overhead IBA sprays after sticking. 100% of our MN evergreen propagation is now slated to be treated this way also. In OR we treated approximately 20% in 2007. We anticipate the percentage of cuttings treated with IBA after sticking in Oregon to increase significantly as our trial numbers and confidence in this method build

Table 1. Cuttings treated v. application method from 2003 to 2007 in MN

Treatment	2003	2004	2005	2006	2007
Hand dipped (%)	99.62	95.6	91.95	86.1	5.16
Overhead spraying (%)	0.38	4.4	5.08	13.82	94.84

Using water soluble IBA after sticking has streamlined our propagation process dramatically by reducing the number of employees needed to treat cuttings with IBA. In 2007 approximately 8 million cuttings were propagated in MN from May 15th to Aug 15th. 79% required some form of IBA treatment. Another 5.2 million were produced in OR, of which 100% required an IBA treatment. Crews of 8-10 people have historically been responsible for treating these cuttings with IBA during this time. Using IBA after planting has reduced handling and storage time in the cooler and has freed up members of our propagation team to do other tasks. During the winter and at other times of the year we run similar crews for evergreen propagation and other softwood propagation schedules.

This method has also given us some piece of mind regarding stem burn and the possibility of contamination. Cuttings treated with overhead IBA applications are not exposed to alcohol. Concerns over the years on whether or not exposing the stems to solutions containing alcohol has contributed to some of the rot on some of the cuttings are moot. By using a formulation of IBA that is water soluble we can eliminate the possibility of alcohol burning or drying out the basal portion of the stems. Using water soluble IBA after the cuttings have been placed in the greenhouse provides us some comfort by eliminating the possible cross contamination issues associated with dipping cuttings in a stock solution. The transfer of pathogens in a communal solution of hormones is not a concern with this method.

A majority of the crops treated with Hortus IBA Water Soluble Salts react identically to cuttings treated with traditional IBA. Rooting and top growth are monitored throughout the season and carefully evaluated at harvest time to determine root mass and overall plant quality. Acer, Berberis, Cornus, Diervilla, Euonymus, Forsythia, Hydrangea, Juniperus, Lonicera, Philadelphus, Physocarpus, Rhus, Rosa, Spiraea, symphoricarpos, Syringa, Thuja, Viburnum and Weigela crops are all large genera Bailey Nurseries grow that respond well to overhead IBA applications. They are all currently, or are scheduled to be receiving Hortus IBA Water Soluble Salts as their sole form of IBA in MN. Currently all Hydrangea, Spiraea and symphoricarpos are treated with IBA after sticking in OR. Clethra, Cornus, Forsythia, Hamamelis, Ilex, Philadelphus, Viburnum, and Weigela are all in the final stages of trial and should be added to the treat all after sticking list for the 2008 season in OR.

While similar rooting time and subsequent root and shoot development is most commonly seen, differences have been noted on several varieties. This varies from slight, subtle differences to results that have caused us to discontinue water soluble IBA and continue with the traditional propagation method. Some varieties have shown a preference to the traditional hand dip method in conventional IBA and some vice versa. Several varieties have exhibited growth differences with the over the top spray technique in multiple trials. Amelanchier, Aronia, Rosa, symphoricarpos, et al. tend to slow down their vegetative growth early on following the overhead application method. Vegetative growth and flowering is usually delayed by approximately one to two weeks. This is not discernible later on as plants are grown for several months after rooting and mowed back repeatedly to maintain height and promote branching before harvest. This season Forsythia and Philadelphus crops treated with IBA after sticking in OR looked better than the hand dipped control. Cuttings within the trial blocks initiated roots more quickly and responded with darker green, more vigorous top growth. Root mass increased significantly also. Some Viburnum varieties have developed adventitious aerial roots from leaf nodes above the soil line when Hortus IBA Water Soluble Salts are applied to the cuttings. During the first two seasons all varieties of Betula cuttings in OR responded well to the overhead applications of IBA. This season many petioles were twisted at the 500 and 1000 ppm rates. An explanation as to why this seasons' trial acted differently than in previous years escapes us.

In multiple trials many of the Prunus and Rhododendron varieties have not rooted as well when treated from above after sticking at our Oregon facilities. Root initiation has been slowed and final percentages have been significantly lower in previous trials. Rhododendron and Prunus cuttings in OR have now been removed from the future trial list. Prunus *besseyi 'Pawnee Buttes'* responds well to overhead IBA applications in MN and currently receives IBA in this manner.

Switching IBA delivery from the traditional hand dip method to overhead applications trades relatively high labor costs and low chemical costs for relatively high chemical costs and low labor costs. Treating cuttings with IBA after sticking is helping us reduce hormone application expenses. Wages for 8-10 people working 8-h days, over a ten week period add up quickly. Conversely using kilograms of water soluble IBA is expensive too. One 6000 ft² greenhouse contains approximately 90,000 softwood cuttings when spaced at 2-¾". It takes approximately 8 people

3.75h, or 30-labor hours to treat this many cuttings with IBA by hand. Applying water soluble IBA after the cuttings have been stuck takes an applicator approximately 1h to prepare, transport to and from the application site, apply and clean the spray equipment when finished. Chemical costs of water soluble IBA for an equivalent number of cuttings at 750 ppm equal approximately $74. The cost of traditional IBA needed to dip 90,000 softwood cuttings is approximately $16.

Our next step to further reduce the costs associated with the application of rooting hormones has been to apply lesser rates of water soluble IBA. For the past two seasons we have invested a lot of time evaluating the effect of halving many of the rates we commonly use. Surprisingly we have noticed very little difference in the outcome of these trials. All cuttings are given the same quantity and duration of mist and are grown side by side the cuttings that have been treated with a full rate. It has taken the same time for plants to begin root initiation and the subsequent growth has developed at a similar pace. This year we have looked at reducing rates even further by quartering the initial rate. If the normal rate was 1000 ppm we have begun treating the cuttings with 250 ppm after sticking. To date these trials have looked very promising also. When the trails are complete we hope to have established an optimal IBA rate for each of the varieties we grow. The goal of these trials is to produce the highest quality rooted cutting with the least amount of IBA possible.

DISCUSSION

Using Hortus IBA Water Soluble Salts has helped us reduce our employee's exposure to chemicals. Limiting the number of employees who apply hormones in the greenhouses to a small group of trained, licensed chemical applicators gives us a more consistent, accurate application that we feel more comfortable.

By applying water soluble IBA after sticking our labor hours associated with treating cuttings with IBA have declined significantly. Our cuttings now spend less time in cold storage and in the preparation room where problems associated with lengthened exposure to temperature, humidity and/ or handling can occur. Plants are not grouped and dipped together into a solution where pathogens may be transferred. Cuttings are not exposed to alcohol which may contribute to cuttings drying out and possibly being burned or damaged.

Significant financial savings have resulted from using this method of IBA delivery. Spraying the cuttings after they have been stuck instead of dipping them before frees up planting crews for other work. On average, treating a crop with Hortus IBA Water Soluble Salts after sticking has allowed us to save approximately $0.038 per ft^2. Further rate reduction trials have looked promising and may help increase these savings in the future.