at the same time when you would root the cuttings in February-March. We have achieved a 90% success rate with this method. With *Sciadopitys verticillata* we have noticed that the scion is often rooted after one growing season. This is often called, "nurse-root grafting"

Every so often in an organization like ours we make a mistake. Instead of having some potted understock ready for grafting we find ourselves ready to graft and lacking understock. We have found with red, Scotch, Austrian and white pines that understock can be fresh dug and immediately grafted. In some cases the understocks have literally been chopped out of ice. The understock is grafted bareroot with a side veneer graft and placed in peat. After union formation, the rootstock is pruned back and the grafts are potted up.

The third grafting type, "cutting-grafting", is useful with new clones that are difficult to root. We have used this technique on rhododendrons. Cuttings of an easy to root cultivar, such as R. 'Roseum Elegans', are made and the scion is then attached with a side veneer graft After tying, the easy-to-root cultivar is treated with hormone and stuck in the bench under a polytent. When the cuttings are rooted and graft union formation has occurred the understock is cut back and the grafts are potted up.

The last grafting technique, single-node grafting, is useful when you have a shortage of grafting material. We have used this technique with Japanese maples. In single node grafting a small scion piece, about one inch in length, is grafted to the rootstock. To show you the stock buildup potential of this method, we were able to take one Japanese maple cultivar in 4 years to 20,000 plants

THE EFFECT OF GIBBERELLIC ACID AND BENZYLADENINE IN INDUCING BUD BREAK AND OVERWINTERING OF ROOTED SOFTWOOD CUTTINGS

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Abstract. Gibberellic acid (GA_3) and a cytokinin, N-6-benzyladenine (BA) were applied to softwood cuttings of *Salix pentandra* L (laurel willow) and *Viburnum lantana* L (wayfaring tree) in an attempt to promote shoot growth and subsequently increase overwinter survival of the cuttings through a buildup of photosynthetic carbohydrate reserves Gibberellic acid caused fewer but significantly longer shoots on laurel willow while reducing overwinter survival Wayfaring tree reacted to GA_3 treatment by an increase in the number of bud breaks, no increase in shoot length and reduced overwintering ability. Benzyladenine stimulated bud initiation on laurel willow, reduced average shoot length, and increased overwinter survival Benzyladenine had little measurable effect on wayfaring tree other than slightly increasing overwinter survival

INTRODUCTION

Poor overwinter survival rates of rooted softwood cuttings from woody plants is a perplexing problem. The rooting process results in a drain of photosynthetic food reserves from a cutting, leaving it in a depleted nutritional state to overwinter and break dormancy the following spring. Cuttings of such genera as *Acer, Berberis, Betula, Cornus, Viburnum,* and cuttings of many other genera, when rooted late in the growing season, serve to illustrate the magnitude of this propagation problem.

It is commonly observed that cuttings which can be induced to initiate new shoot growth the same season in which they are rooted, survive overwinter better than those which have not initiated new growth. Even small amounts of growth will improve overwintering ability of a rooted cutting due to the manufacture of reserve carbohydrates. Thus, treatments that encourage new growth and carbohydrate replenishment before the onset of dormancy would be expected to improve overwinter survival percentages. Of the hormonal growth regulators available today, two classes have shown an effect on breaking the dormancy of buds and inducing growth. Those classes of regulators are the gibberellins and cytokinins.

With varying degrees of success, gibberellic acid has been used to stimulate shoot growth on a wide variety of plant materials. It has been found that gibberellic acid can at least partially overcome the rest period of buds, a process normally accomplished by prolonged chilling. By overcoming the physiological rest of a bud, new growth commences and photosynthetic nourishment can begin. It has been noted, however, that GA leads to the expansion of the apical buds while inhibiting lateral bud development. A study by Loach and Whalley (9) on the effects of gibberellic acid on rooted cuttings of *Betula pendula,* however, showed that GA promoted irregular bud breaks, produced weak growth and only marginally improved overwinter survival. Similar results were also observed in cuttings of certain species of *Berberis, Acer, Cornus* and *Weigela,* where only weak and etiolated growth was found after GA application. Furthermore it has been speculated that exogenous applications of gibberellic acid are partially responsible for the inhibition of lateral shoot development (7).

Cytokinins induce growth of dormant buds by overcoming the inhibitory influence of auxin and by the induction of cell division. Experimentally, cytokinins have been used successfully to overcome apical dominance in axillary buds of Japanese holly (6,11), apple shoots (1,7), pines (3,4), roses (2,10) and numerous herbaceous plants. Cytokinins have also been analyzed for use in overcoming the rest period of such deciduous woody plants as apple (12), birch and poplar (5). It is commonly observed that the number of shoots developing on a stem increase with the application of a cytokinin; however, a reduction in growth rate of those stimulated shoots also occurs.

The intent of this experiment was to study the effects of gibberellic acid (GA_3) and benzyladenine (BA) in stimulating new growth and subsequent overwintering ability on rooted cuttings of *Salix pentandra* L. and *Viburnum lantana* L.

METHODS AND MATERIALS

Softwood terminal cuttings of *Salix pentandra* L. and *Viburnum lantana* L. were cut approximately six inches long. The basal ends of half the cuttings were treated with indolebutyric acid (IBA) at 5000 ppm while the other half remained untreated. The cuttings were placed in six compartmented cell-packs containing 50% peat:50% perlite and immediately set into intermittent mist propagation beds.

Gibberellic acid was applied as both a spray and as a direct bud application at two concentrations: 1000 and 4000 ppm to equal numbers of cuttings of both plant species. Benzyladenine at 200 and 1000 ppm was applied in an identical manner to another group of cuttings. To determine if timing of application of the hormones was critical, certain cuttings were given GA_3 and BA treatments immediately after being placed into the rooting medium. Others were treated two weeks after being placed in the rooting medium and a third group was given three applications of hormones starting two weeks after being stuck and at two week intervals thereafter. The application timing trials involved equal numbers of cuttings as well as an equal group of untreated controls which were used for comparison purposes.

The data collected on laurel willow was taken in late fall after dormancy had been initiated and consisted of the number of dormant buds breaking dormancy and shoot length. The data collected on wayfaring tree included simply the total number of buds breaking dormancy. Overwinter survival data were collected on both species in early spring as the cuttings began to grow. The overwinter survival data reflects the percentage of survival of the original number of cuttings stuck.

Cuttings were overwintered in a lath shade structure. The cell-packs containing the cuttings were covered with ¼″ microfoam insulation blankets and an additional layer of 6 mil white polyethylene plastic.

A completely randomized factorial design was used to test the effect of the hormonal treatments. Analysis of variance procedures were used to test data for significance and Duncan's Multiple Range Test was used to identify significant differences in mean values at the 5% level.

RESULTS AND DISCUSSION

Laurel willow. The effects of the rooting hormone IBA were difficult to assess on laurel willow since this species readily produces a prolific root system. Unpublished data reveals that the shoot inducing hormones, GA_3 and BA, when applied to laurel willow cuttings treated with IBA, resulted in very minimal interactions such as enhancing or depressing shoot length, number of buds breaking dormancy or overwinter survival.

Statistically significant difference in average shoot lengths are noted between those cuttings that were treated with gibberellic acid and those treated with benzyladenine (Table 1)

Table 1. Effect of gibberellic acid and benzyladenine treatments on average shoot length, mean number of shoots and percent overwinter survival of laurel willow

Treatment (ppm)	Year 1			Year 2		
	Ave shoot length (cm)	Mean No shoots	Percent over-wintering	Ave shoot length (cm)	Mean No shoots	Percent over-wintering
GA_3 1000	4 4^{a}	62^{b}	37 0^{b}	9 2^{a}	90^{bc}	95 8
GA_3 4000	5 6^{a}	53^{b}	19 9^{c}	8 8^{a}	81^{c}	96 8
BA 200	1 8^{b}	91^{a}	59 1^{a}	6 3^{b}	1 02^{b}	96 8
BA 1000	1 7^{b}	96^{a}	56 0^{a}	6 0^{b}	1 21^{a}	98 6
Control	2 1^{b}	1 02^{a}	52 8^{a}	6 5^{b}	95^{b}	98 4

(Data based on 216 cuttings per treatment)

Note Means with the same letter are not significantly different at the 5% level

Gibberellic acid caused a marked increase in shoot length of treated cuttings while reducing the number of shoots produced by those cuttings. Gibberellic acid may be involved in mobilizing the plant's nutrients to a single shoot whereupon the newly developing shoot takes over apical dominance and supresses the growth of other buds. A harsh first year winter revealed a significant reduction in overwintering ability of those GA_3-treated cuttings. It is quite possible that GA_3 causes the plant tissues of laurel willow to remain in a more succulent state and freezing temperatures could cause tissue damage.

The benzyladenine treatments on laurel willow caused an increase in the number of shoots produced per cutting while slightly reducing the length of each shoot (Table 1). If a larger number of shoots form on a single cutting, competition for nutrients would logically reduce the size each can attain.

Two methods of applying the shoot inducing hormones, BA and GA_3, were tested. Spraying as a means of application proved to be equally as effective as direct bud application. The direct bud application method proved to be time consuming and laborious and for this reason the spray method is recommened as the simplest method of treatment.

Timing, as well as number of applications of gibberellic acid and benzyladenine, were varied to determine the most appropriate sequence to follow when treating cuttings for stimulation of bud break. Statistically significant results were not obtained from this analysis; however, repeated applications of the hormones caused the greatest increases in the number of bud breaks. Repeated applications were begun two weeks after the cuttings were placed in the rooting medium. The two week delay was intended to allow at least partial rooting to begin. The rooting process should be at least partially completed prior to bud break since both processes compete for the available food reserves in the cutting.

Wayfaring tree. Indolebutyric acid somewhat aided the rooting of wayfaring tree. As in the case of laurel willow, however, the interactions between IBA and the shoot inducing hormones, BA and GA_3, were not significant.

Gibberellic acid was found to significantly promote more bud breaks of wayfaring tree than either the untreated controls or benzyladenine treatment (Table 2). Shoot lengths were not recorded since extension growth on buds breaking dormancy were too short to be measured in a practical manner. Gibberellic acid significantly reduced the percent overwinter survival of wayfaring tree the second year.

Table 2. Effect of gibberellic acid and benzyladenine treatments on mean number of bud breaks per cutting and percent overwinter survival of wayfaring tree

Treatment (ppm)	Year 1		Year 2	
	Mean No bud breaks	Percent over-wintering	Mean No bud breaks	Percent over-wintering
GA_3 1000	0 08[a]	29.9[b]	0 63[a]	85 2[bc]
GA_3 4000	0.14[a]	29 9[b]	0 51[a]	81 0[c]
BA 200	0 08[a]	38 8[a]	0 32[b]	89 4[ab]
BA 1000	0 05[b]	39 3[a]	0.26[b]	87 5[abc]
Control	0 05[b]	24 5[b]	0 31[b]	93 1[a]

(Data based on 216 cuttings per treatment)

Note Means with the same letter are not significantly different from each other at the 5% level

Benzyladenine showed very little effect on wayfaring tree. Only in the first year of experimentation did BA at 200 ppm produce significantly more bud breaks than the untreated controls. During that same year the overwinter survival due to BA treatment was significantly increased as well. A possible explanation of this result might be that BA, as is characteristic of cytokinins in general, mobilizes nutrients and may offer some protection against nutrient leaching and cutting degradation.

CONCLUSIONS

Little research has been done to improve the overwinter survival of newly rooted cuttings of woody plants, which often have a high mortality rate during or immediately after their first dormant period Stimulation of growth of the cuttings is a logical practice since building up carbohydrate reserves should enhance overwinter survival The use of gibberellic acid and benzyladenine have proven to be partially effective in achieving shoot growth of rooted cuttings A suggested treatment to be researched in the future is to use the two hormones in combination. A synergistic response could result in increased numbers of shoots with sufficient extension growth to provide larger leaf area. If larger leaf areas can be produced, more photosynthetic products will be manufactured and stored. Another possible alternative could be the use of hormonal combinations plus supplemental artificial light to extend the photoperiod during and after the rooting process. Long days promote vegetative growth and in some cases have been shown to enhance the rooting process as well.

The overwinter survival of rooted cuttings is dependent on many factors, not the least of which is the stored nutrient status of the cutting prior to the onset of dormancy. The applicaiton of gibberellic acid and/or benzyladenine to promote shoot growth and thereby increase food reserves may become a practical nursery practice but further work is needed to determine optimal times, rates of application, and effectiveness on each species to be treated If higher overwinter survival rates can be obtained through the use of applied hormones plus extended photoperiods, this will definitely be of great economic significance to the nursery industry.

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CLAYTON CARL: Did I understand you correctly when you said that you treated the cuttings before sticking in the propagation medium?

JAMES McCONNELL: Yes. We did use a sticker and did allow the cuttings to dry before placing them under the mist.

CLAYTON CARL: We have been using GA_3 on sugar maple cuttings but after coming out of the propagation bench.

JAMES McCONNELL: That is what we were trying with the repeated applications. We still had 1 or 2 more treatments after the cuttings came out of the propagation bench.

CAMERON SMITH: Would you like to speculate on the use of these chemicals to produce lower branching on plants such as columnar buckthorn?

JAMES McCONNELL: I can only speculate. Some research has been conducted in this area. For example, 'Crimson Pygmy' barberry often produces a spindly plant but treatment with benzyladenine has increased branching and made a more saleable plant.