SEASON, GENOTYPE, AND APPLICATION METHODS AS THEY AFFECT PACLOBUTRAZOL-INDUCED ROOTING OF CUTTINGS OF SEVERAL HARDWOOD SPECIES

HARRY JAN SWARTZ, NABIL EL-SHIRBINI, ROBERT BORS,
DAVID MAAS, S. KRISTINE NAESS,
FOUAD MOHAMED AND FRANK R. GOUIN

Department of Horticulture
University of Maryland
College Park, Maryland 20742

Abstract. Paclobutrazol was effective in increasing the percentage rooting, or root numbers, for some species but not others The effectiveness of paclobutrazol was greater in the spring and summer and less in the fall Paclobutrazol-treated *Euonymus kiautschovica* cuttings grew only slightly less than control plants in early- and mid-summer; however, late summer paclobutrazol-treated *Prunus serrulata* 'Kwanzan' and *Forsythia* × *intermedia* propagules did not elongate. At least one hour of paclobutrazol immersion of leafy cuttings is necessary to observe plant growth regulator effects.

REVIEW OF LITERATURE

Paclobutrazol, a gibberellin synthesis inhibitor, has many effects on plant growth including reduction of shoot elongation and leaf size, and altering flower production and leaf water loss (2, 4). Paclobutrazol has also increased the number of roots and percentage rooting of herbaceous and hardwood cuttings (1, 3). In these experiments, the basal ends of the plants were dipped in solutions of paclobutrazol for at least 36 hours. This method of application would be too costly to be feasible unless large differences in success were demonstrated. In addition, the seasonal effect of paclobutrazol on rooting has not been fully investigated. Theoretically, the effectiveness of paclobutrazol should be minimal when gibberellins are at lower concentrations, e.g. in the late summer and fall. The information presented in this report was designed to address these questions and expand the information available on the effect of paclobutrazol on rooting of a wider range of woody species.

MATERIAL AND METHODS

All cuttings were taken from outdoor-grown plants, trimmed to 15 cm length (except *Chionanthus*, 6 cm), stripped of excess leaves or leaf surface, treated, then placed in perlite-peat (3:1, v/v) in plastic nursery tubes (4 cm dia x 9 cm depth; 67 per tray). The cuttings were then placed in an outdoor plastic-covered

intermittent mist chamber supplied with bottom heat (25°C). Except for *Chionanthus virginicus* and *Cornus kousa*, where 24 cuttings were used per treatment; all root data represent more than 60 cuttings per treatment level. Other species tested included: *Acer palmatum* 'Bloodgood', *Euonymus kiautschovica, Prunus serrulata* 'Kwansan', *Syringa reticulata, Rhododendron* sp. and *Forsythia* × *intermedia*.

Paclobutrazol and control (water and Tween 20) treatments were applied for 40 min. to an hour, unless otherwise noted, by immersing the leafy cuttings in the test solution (immersed) or by immersing only the basal end of the cutting in the test solution (basal dip). Cuttings were allowed to dry for 5 min. after treatment. Paclobutrazol 50WP was used as supplied by ICI Americas Inc. (Goldsboro, NC). Initial experiments inadvertently used concentrations above the normal solubility of paclobutrazol in water (35 mg/liter); thereafter, saturated solutions were used by adding >50 mg/l paclobutrazol to water and mixing. Wood's formulation of auxin (1.03% IBA and 0.51% NAA; Wood's Nursery, Portland, OR) was used (1/4 for *Euonymus*, or 1/20 strength for other species) on all cuttings except as specified. The cuttings were basal-dipped in the Wood's solution for 30 sec. and allowed to dry for 2 min.

The number of roots per cutting and root length were counted after 1 to 2 months in the propagation chamber. For *Euonymus*, rooting was also scored using the following general scale: 1 = no roots; 2 = 1 root per plant; 3 = 2 to 5 roots per plant; 4 = >5 roots per plant, but only a loose root ball; 5 = >5 roots per plant but with a firm root ball. Chi-square analysis was performed on these data at the 1% level.

Twenty *Euonymus* plants per treatment from a March experiment were allowed to grow in 15 cm clay pots in the greenhouse until October, when shoot length was recorded. August-treated *Prunus* and *Forsythia* cuttings were also potted and shoot growth was observed in October.

RESULTS AND DISCUSSION

In the initial experiments, both auxin and paclobutrazol enhanced the percentage of *Euonymus* cuttings that rooted, from near 40% to near 70%, as well as the number of roots per rooted cutting (Table 1). A mid- to late- summer 1-hr immersion application of paclobutrazol to leafy cuttings also enhanced rooting in four of six species; however, their percentage rooting was increased by an average of only 12% (Table 2). Except for *Prunus*, the number of roots per cutting was not enhanced.

Table 1. The effect of paclobutrazol on the number of roots per rooted cutting of *Euonymus kiautschovica*. Two experiments were conducted, each using a 10-min. saturated paclobutrazol (paclo) immersion. Auxin treatment was a quarter-strength Wood's formulation (ANOVA P=5% for auxin and paclobutrazol effects)

Treatment	Number of roots		Mean
	Expt. 1	Expt. 2	
Control	8.8	12.4	10 6
Control + auxin	8.7	30.9	19.8
Paclo	25.2	39.4	32.3
Paclo + auxin	26.7	33.8	30.5
LSD P=5%	11 0	9.6	

The results from previous experiments indicated differences in uptake from basal cuttings may have caused genotypic variation in response to paclobutrazol (3); however, after five to ten minutes, leaves of immersed cuttings of some species became waterlogged. A positive rooting response to paclobutrazol of *Euonymus* cuttings was obtained after a 1-hour immersion (Table 3).

Table 2. Effect of a 1-hour June-August immersion application of paclobutrazol (paclo) on the percentage rooting and number of roots per rooted cutting (in parentheses) of six species of woody plants.

Genera	Control (%)	Paclo (%)
Syringa	58 (9)	53 (8)
Chionanthus	16 (3)	27 (2)
Acer	23 (2)	40 (3)
Prunus	47 (11)	58 (17)
Cornus	8 (2)	18 (3)
Rhododendron	95 (4)	87 (4)

Applications of paclobutrazol by basal dips were less effective when treated for up to 24 hours. Pre-spraying the stock plant with a saturated solution of paclobutrazol four days before cuttings were taken was effective (Table 3). The enhancement of rooting in these experiments was generally less than previously reported for herbaceous plants using a >36 hr basal dip (1, 3); however, immersion for one hour, or pre-spraying source plants, requires much less work.

Table 3. The effect of various application methods on the root score of *Euonymus kiautschovica* cuttings treated with saturated paclobutrazol (paclo) solutions Significances are from chi-square comparisons of proportions of paclobutrazol-treated root scores with the control

Application treatment	Control	Paclo	Significance
10 sec immersion	3 7	3 5	NS
1 hr immersion	2 7	4.1	1%
6 hr basal dip	2 4	2.8	5%
24 hr basal dip	3 1	3 2	NS
Spray source plants	3 3	4 0	1%

NS = not significant

Unless there were variations in plant absorption of paclobutrazol, there may be other reasons for the observed genotypic variation (Table 2). When *Euonymus* cuttings were treated with paclobutrazol throughout the growing season, the amount and direction of the response varied (Table 4). Later season applications were less effective; theoretically, gibberellin activity is reduced and/or endogenous inhibitor concentrations would be greater at this time. If paclobutrazol enhances rooting because it inhibits gibberellin synthesis, this reduced late season effectiveness would be expected.

Table 4. The effectiveness of paclobutrazol on the root score of *Euonymus* cuttings treated by immersion during various months. Numbers given are (root score of paclobutrazol treatment/control treatment root score) × 100%. All values of paclobutrazol treatments are significantly different (P = 1%) from controls using a chi-square analysis of root score data for each experiment.

Month of treatment	Effectiveness
February	150
March	117
June	154
August	113
September	79

There is an additional caution regarding the use of paclobutrazol in August or September. Early season application of paclobutrazol to *Euonymus* did not significantly reduce total growth, although flowering occurred in the fall on 29% of the treated plants (Table 5). Most of the (mathematical) difference in growth occurred early (data not shown). Some early growth inhibition was found in some species in a previous early season experiment (3); but most recovered within weeks. In contrast, mid- to late- season application of paclobutrazol resulted in reduced growth of *Forsythia* (Table 6) and a 75% reduction in bud break of *Prunus* (data not shown).

Table 5. The effect of spring application of paclobutrazol on the subsequent growth of *Euonymus kiautschovica* cuttings after 7 months Shoot length differences were not significantly different.

Application	Shoot length (cm)	Plants with flowers (%)
Control	31 6	0
Paclobutrazol, 10 sec immersion	28 8	0
Paclobutrazol, 1 hr immersion	25.6	29

In summary, early season application of paclobutrazol can enhance rooting with little reduction in plant growth, although in some species it may not be worth the extra expense. Late season application may not enhance rooting but the effect on shoot elongation may be substantial. An immersion of one hour, or prespraying stock plants, are effective methods for application of paclobutrazol to enhance rooting in some species

Table 6. The effect of paclobutrazol (paclo) immersion time on the percentage rooting and shoot elongation in cm (in parentheses) of *Forsythia* cuttings taken in August.

	Treatment time		
Treatment	10 min	1 hr	6 hr
Control	73 (24)	93 (27)	69 (17)
Paclo	82 (20)	73 (12)	74 (4)

LITERATURE CITED

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BILL INTVEN: When soaking plant material in liquid, the humidity of the air may have an influence on the amount of auxin taken up. I base this on experience in Holland and Canada. I had seen all kinds of success rooting with auxins in Holland. When I moved to Canada the first year I almost failed and had tip burn. I came to the conclusion that the amount of liquid and chemicals absorbed by cuttings depends on how much water the cuttings absorb. The air was more humid in Holland and they absorbed much less while the tips burned in Canada. I assumed they absorbed more chemical in Canada.

HARRY SWARTZ: I agree with you that you can concentrate more material by moving more water through the cuttings. The basal dip was done in the summer when temperatures were around 100 °F so there was a lot of transpiration. We had to replace the water on the 24 hour soaks. The 24 to 36 hour periods are just too long for use and the one hour dip was the easiest for me.

BRUCE BRIGGS: What was the concentration of spray on stock plants?

HARRY SWARTZ: A saturated solution of 30 ppm.

BRUCE BRIGGS: Did time of day for spraying have any effect? I ask this question because we know hormone actions are influenced by temperature.

HARRY SWARTZ: We did not repeat it at different temperatures but hope to study that point.

MIKE ANDERSON: What is the toxicity of the product?

HARRY SWARTZ: It is relatively nontoxic. It is a fungicide, and we handle it with gloves. It does not act as a fungicide because much higher concentrations are needed for such action. It's a triazole with very low acute dermal, toxicity (LD) of > 1000 mg/kg on rats.

PETER VERMEULEN: What is the residual effect?

HARRY SWARTZ: On most of the species the effect lasts less than 6 weeks. In my treatment I have noticed effects up to 18 months. Therefore you need to be careful with stock plants. In tissue-cultured plants I have noticed that it decreases stomatal water loss. Also it has been reported to increase waxiness of the tissue culture plants.