Literature Cited

Allen, S. E., G.L. Tennan, and H.G. Kennedy. 1978. Nutrient uptake by grass and leaching losses from soluble and sulfur-coated urea, and KCl. Agron. J. 70:264-268.

Allison, F.E. 1958. Soil fertility studies in lysimeters containing Lakeland sand. USDA Tech. Bul. 1199:1-62.

Barker, A.V. 1974. Nitrate determinations in soil, water, and plants. Mass. Agr. Expt. Sta. Brd. 611.

Bates, T.E. and S.L. Tisdale. 1957. The movement of nitrate-nitrogen through columns of coarse-textured soil materials. Soil Sci. Soc. Proc. 21:525-528.

Benson, N. and R.M. Barnette. 1938. Leaching studies with various sources of nitrogen. J. Amer. Soc. Agron. 31:44-54.

Brown, K.W., R.L. Duble, and J.C. Thomas. 1977. Influence of management and season on fate of N applied to golf greens. Agron. J. 69:667-671.

Brown, K. W., J.C. Thomas, and R.L. Duble. 1982. Nitrogen source effect on nitrate and ammonium leaching and runoff losses from greens. Agron. J. 74:947-950.

Chancy, A.L. and E.P. Marbach. 1962. Modified reagents for determination of urea, and ammonia. Clin. Chem. 8(2):130-132.

Chichester, F.W. 1977. Effects of increased fertilizer rates on N content of runoff and percolate from monolith lysimeters. J. Environ. Qual. 6:211-217.

Dowdell, R.J. and C.P. Webster. 1980. A lysimeter study using nitrogen-15 on the uptake of fertilizer nitrogen by perennial ryegrass swards and losses by leaching. J. Soil Sci. 31:65–75.

Hall, J.R. 1980. Sand top-dressing—look before you leap. Proc. Fifteenth Annu. Wisconsin Golf Turf Symp. Milwaukee.

Holmes, J.L. 1980. Sand greens–sand top-dressing. Proc. Fifteenth Annu. Wisconsin Golf Turf Symp. Milwaukee.

Jones, M. B., J.E. Street, and W.A. Williams. 1974. Leaching and uptake of N applied to annual grass and clover-grass mixtues in lysimeters. Agron. J. 66:256-258.

Mancino, C.F. 1983. Studies of the fate of NO_3^- and NH_4^+ nitrogen from various fertilizers on turfgrasses grown on three different soil types. MS thesis. Univ. of Massachusetts, Amherst.

Mitchell, W.H., A.L. Morehart, L.J. Cotnoir, B.B. Hessekine, and D.N. Langston, III. 1978. Effect of soil mixtures and irrigation methods on leaching of N in golf greens. Agron. J. 70:29-35.

Petrovic, A. M.. and N.W. Hummel. 1985. Nitrogen source effects on nitrate leaching from late fall nitrogen applied to turfgrass. Agron. Abstr. p. 120.

Petrovic, A. M., N.W. Hummel, Jr., and M.J. Carroll. 1986. Nitrogen source effects on nitrate leaching from late fall nitrogen applied to turfgrass. Agron. Abstr. p. 137.

Rieke, P.E. and D.E. Ellis. 1974. Effects of N fertilization on nitrate movements under turfgrass. Proc. 2nd IntL Turfgrass Res. Conf. Madison, Wis.

Smika, D. E., D.F. Heermann, H.R. Duke, and A.R. Bathchelder. 1977. Nitrate-nitrogen percolation through irrigated sandy soil as affected by water management. Agron. J. 69:623-626.

Starr, J.L. and H.C. DeRoo. 1981. The fate of nitrogen fertilizer applied to turf. Crop Sci. 21:531-536.

Volk, G.M. and C.E. Bell. 1945. Some major factors in the leaching of calcium, potassium, sulfur, and nitrogen from sandy soils. Fla. Agr. Expt. Sta. Bul. 416.

HORTSCIENCE 25(2):196-198. 1990.

Vegetative Propagation of Mexican Redbud, Larchleaf Goldenweed, Littleleaf Ash, and Evergreen Sumac

Jimmy L. Tipton[1]

Texas A&M Research and Extension Center, 1380 A&M Circle, El Paso, TX 79927

Additional index words. Cercis canadensis var. *mexicana, Ericameria laricifolia, Fraxinus greggii, Rhus virens, woody* plants, IBA

Abstract. **Effect of cutting age (weeks after budbreak) and K-IBA concentration on percent rooting of Mexican redbud *[Cercis canadensis* var. *mexicana* (Rose) M. Hopkins], larchleaf goldenweed *[Ericameria laricifolia* (Gray) Shinners], littleleaf ash *(Fraxinus greggii* Gray), and evergreen sumac *(Rhus virens* Gray) were investigated. For cuttings treated with K-IBA, maximum predicted percent rooting from regression analysis was 88% for cuttings of Mexican redbud taken 4 weeks after budbreak and treated with 21 g·liter^{-1}, 99% for larchleaf goldenweed taken 6 weeks after budbreak and treated with 16 g·liter^{-1}, 86%, for littleleaf ash taken 16 weeks after budbreak and treated with 17 g·liter^{-1}, and 24% for cuttings of evergreen sumac taken 16 weeks after budbreak and treated With 5 g·liter^{-1}. Chemical names used: potassium salt of 1H-indole-3-butanoic acid (K-IBA).**

Mexican redbud, larchleaf goldenweed, littleleaf ash, and evergreen sumac are southwestern shrubs with potential as adapted ornamental for the area (Duffield and Jones, 1981; Miller, 1978; Nokes, 1986). Germplasm collections of all four species exhibit variability in floral color (Mexican redbud) or growth habit (larchleaf goldenweed, littleleaf ash, evergreen sumac) that could be exploited through vegetative propagation to provide superior plants. I found no reports regarding rooting of stem cuttings of these species, but studies on related species indicate timing and IBA concentration are critical. Despite an early report that nontreated stem cuttings of eastern redbud *(Cercis canadensis* L.) taken in June and July rooted 75% to 90% in 4 weeks (Thomas, 1936), other authors report little success in rooting softwood or semi-hardwood cuttings (Dirr and Heuser, 1987; Hartmann and Kester, 1975; Nokes, 1986). Ashes *(Fraxinus* spp.) are considered very difficult to propagate from stem cuttings (Dirr and Heuser, 1987). One percent of softwood cuttings of fragrant ash *(Fraxinus cuspidata* Torrey) treated with an auxin–tale preparation of 0.8g IBA/g rooted (B.J. Simpson, personal communication). Softwood and semi-hardwood cuttings of fragrant sumac *(Rhus aromatica* Ait.), a deciduous species, rooted after treatment with IBA at 1 g·liter^{-1} (Tracz, 1983). According to Nokes (1986), semi-hardwood cuttings of evergreen sumac treated with an auxin-tale preparation of IBA at 0.8 g·g^{-1} have rooted. It appears that no attempts to root cuttings of larchleaf goldenweed have been published.

This study was conducted to determine the effect of timing and K-IBA (potassium salt) concentration on the rooting of stem cuttings of the four species. To avoid ambiguity in softwood and semi-hardwood terminology, leafy terminal stem cuttings 10 to 15 cm long were taken from single cultivated plants 4, 8, 12, and 16 weeks after budbreak for each plant. Test plants were selected based on desirable characteristics—a dark flower color for Mexican redbud and an apparent rapid growth rate for the remaining species. Except littleleaf ash, all plants were at least 7 years old, had bloomed for several years, and were in the adult growth phase. The littleleaf ash was also 7 years old, but had not bloomed. Cuttings from each collection date were wounded by pressing the basal 10 mm against a replacement blade for an electric razor, producing eight parallel cuts ≈1.2 mm apart perpendicular to the stem axis. Cuttings from each collection date were divided into six groups of 20 cuttings each and each group was dipped for 5 sec in one of six solutions containing K-IBA at 0 to 25 g·liter^{-1} in deionized water, at 5 g·liter^{-1} increments.

Table 1. Analysis of variance for the effect of K-IBA concentration on percent rooting of cuttings of Mexican redbud taken 4 weeks after budbreak.

Source	df	Mean square
Model	3	2172.78**
Total error	7	16.22
Lack of fit	2	37.45^{NS}
Pure error	5	7.32

^{NS},**Nonsignificant or significant at P = 0.01, respectively.

Received for publication 27 Dec. 1988. All programs and information of the Texas Agricultural Experiment Station are available without regard to race, ethnic origin, religion, sex, and age. 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.

[1]Present address: Dept. of Plant Science, Univ. of Arizona, Tucson, AZ 85721.

Table 2. Analysis of variance for the effect of cutting age (weeks after budbreak) and K-IBA concentration on percent rooting of cuttings of larchleaf goldenweed, littleleaf ash, and evergreen sumac.

Source	df	Larchleaf goldenweed	Littleleaf ash	Evergreen sumac
		Mean squares		
Model	5	5016.7**	2004.5**	798.7**
Total error	29	46.2	97	86.1
Lack of fit	12	60.1^{NS}	125.7^{NS}	124.3^{NS}
Pure error	17	36.4	76.8	59.2

^{NS,**}Nonsignificant or significant at P = 0.01, respectively.

Cuttings were then stuck in individual 0.3-liter containers with a medium of 1 perlite : 1 vermiculite (v/v) previously drenched with a solution of methyl [1-[(butylamino)carbonyl]-1H-benzimidazol-2-yl] (benomyl) at 250 mg·liter^{-1} a.i. The containers were placed in a ventilated high-humidity chamber (Milbocker, 1983; Milbocker and Wilson, 1979). The quonset chamber measured 5.2 × 9.1 × 2.4mhigh at the center and was covered with polyethylene and 50% shade fabric. A Humidifan Model 110 (Jaybird Manufacturing, Centre Hall, Pa.) provided the necessary fog and one 61 × 61-cm motorized inlet shutter and two 41 × 41-cm exhaust fans rated at 1.3 $m^3 \cdot s^{-1}$ provided ventilation when ambient temperature at cutting level reached 37C. The experimental design for each species was a randomized complete block with two blocks and 10 cuttings per plot (cutting age). Cuttings of Mexican redbud, larchleaf goldenweed, and littleleaf ash were evaluated after 4 weeks and cuttings of evergreen sumac after 6 weeks. Cuttings with a minimum of two roots each at least 2 cm long were considered to have rooted. Percent rooting was determined for each block and transformed to SIN-l (percent rooting/100)$^{1/2}$. Cuttings of Mexican redbud rooted only 4 weeks after budbreak, so the transformed response was related to K-IBA concentration by polynomial regression. The transformed response of the remaining three species was related to cutting age (weeks after budbreak) and K-IBA concentration by a quadratic. polynomial response surface. However, lack of fit mean square was significant for all three species. No rooting occurred in 12-week-old cuttings of larchleaf goldenweed or 4-week-old cuttings of littleleaf ash or evergreen sumac. Restricting the data sets to exclude these data resulted in nonsignificant lack of fit mean squares and was preferable to increasing the degree of polynomial response surface (Tables 1 and 2). Nonsignificant lack-of-fit sum-of-squares were combined with pure error sum-of-squares to test regression and estimate confidence limits as described by Neter et al. (1983). Untransformed results are reported.

Rooting of cuttings of Mexican redbud taken 4 weeks after budbreak followed a cubic response to K-IBA concentration (Fig. 1). The maximum predicted response was 88% rooting at 21 g-liter-l. The lower 99% mean confidence limit for the maximum response was 76% rooting, which is predicted to occur at concentrations >15 g·liter^{-1}. Maximum predicted percent rooting was 99% for cuttings of larchleaf goldenweed taken 6 weeks after budbreak and treated with K-IBA at 16 g·liter^{-1}, 86% for cuttings of littleleaf ash taken at least 16 weeks after budbreak and treated with 17 g·liter^{-1}, and *24%* for cuttings of evergreen sumac taken at least 16 weeks after budbreak and treated with 5 g·liter^{-1}. The lower 99% mean confidence limits for the maximum response of larchleaf goldenweed, littleleaf ash, and evergreen sumac were 92%, 67%, and 11% rooting, respectively. For larchleaf goldenweed, this response is predicted to occur in 5- to 8-week-old cuttings treated with K-IBA at 6 to 25 g·liter^{-1} (Fig. 2). Corresponding values for littleleaf ash and evergreen sumac are 12- to at least 16-week-old cuttings treated with 10 to 25 g·liter^{-1} and 8-to at least 16-week-old cuttings treated with <15 g·liter^{-1}, respectively. Rooting response of littleleaf ash and evergreen sumac increased with increasing cutting age, indicating the maxima might be beyond 16 weeks.

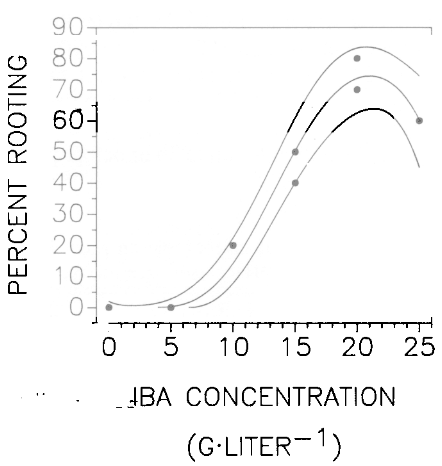

Fig. 1. Rooting response of cuttings of Mexican redbud taken 4 weeks after budbreak to K-IBA concentration with 99% mean confidence belts. The model for the response is SIN-' (percent rooting/100)$^{1/2}$ = – 0.65 – 1.8X + 0.58X^2 – 0.02X^3, where X = K-IBA concentration in g·liter^{-1}.

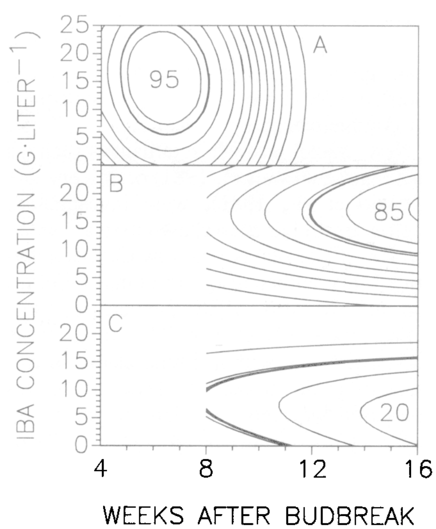

Fig. 2. Larchleaf goldenweed **(A),** Littleleaf ash **(B),** and evergreen sumac **(C)** percent rooting contours in response to cutting age (weeks after budbreak) and K-IBA concentration. Bold contours are lower 99% mean confidence limits for the maximum predicted response. Remaining contours are at 10% **(A** and **B)** or *5%* **(C)** intervals from maxima. Models for the responses are: (A) SIN^{-1}(percent rooting/100)$^{1/2}$ = – 34.64 + 2.19X + 26.87Y – 0.06X^2 – 2.03Y^2 – 0.06XY; (B) SIN^{-1}(percent rooting/100)$^{1/2}$ = –39.43 + 4.43X + 5.75Y – 0.15X^2 – 0.15Y^2 + 0.04XY; and (C) SIN-' (percent rooting/l00)$^{1/2}$ = – 2.81 + 1.91X + 2.21Y – 0.09X^2 – 0.03Y^2 - 0.06XY, where X = K-IBA concentration in g·liter^{-1} and Y = cutting age (weeks after budbreak).

Percent rooting was high for cuttings of Mexican redbud, larchleaf goldenweed, and littleleaf ash, but low and variable for evergreen sumac. Timing was most critical for Mexican redbud; apparently, cuttings should be taken as soon as possible after budbreak. Timing was less critical for larchleaf goldenweed, but cuttings taken 5 to 8 weeks after budbreak were still softwood because the stem was still growing. Cuttings of littleleaf ash and evergreen sumac taken 12 weeks after budbreak, or later, were semi-hardwood because growth had stopped and the stem was firm. Cuttings of evergreen sumac taken between 8 and 12 weeks after budbreak were not quite semi-hardwood because growth was continuing. Evergreen sumac also often begins a second growth flush between 12 and 16 weeks after the initial budbreak, and cuttings from this flush, avoided in this test, would be softwood.

The geographical distributions of all four species are characterized by highly isolated, disjunct populations in a variety of habitats—conditions suitable for ecotypic variation among populations. While this experiment represented a limited genetic base and future tests may be influenced by environmental and cultural conditions, the results nevertheless prove the potential for vegetative propagation of all four species and suggest starting points for future endeavors such as treating softwood cuttings of Mexican redbud and larchleaf goldenweed, and semi-hardwood cuttings of littleleaf ash with moderate to high K-IBA concentrations and semi-hardwood cuttings of evergreen sumac with low K-IBA concentrations.

Literature Cited

Dirr, M.A. and C.W. Heuser, Jr. 1987. The reference manual of woody plant propagation: from seed to tissue culture. Varsity Press, Athens, Ga.

Duffield, M.R. and W.D. Jones. 1981. Plants for dry climates. H.P. Books, Tucson, Ariz.

Hartmann, H.T. and D.E. Kester. 1975. Plant propagation, principles and practices. 3rd ed. Prentice-Hall, Englewood Cliffs, N.J.

Milbocker, D.C. 1983. Ventilated high humidity propagation. Combined Proc. Intl. Plant Prop. Soc. 33:384-387.

Milbocker, D.C. and R. Wilson. 1979. Temperature control during high humidity propagation. J. Amer. Soc. Hort. Sci. 104:123-126.

Miller, J.D. 1978. Design and the desert environment. Univ. Ariz., Office Arid Lands Studies, Arid Lands Resource Info. Paper 13.

Neter, J., W. Wasserman, and M.H. Kutner. 1983. Applied linear regression models. Irwin, Homewood, 111.

Nokes, J. 1986. How to grow native plants of Texas and the southwest. Texas Monthly Press, Austin.

Thomas, C.C. 1936. The propagation of some deciduous trees from softwood cuttings. Natl. Hort. Msg. 15:103-107.

Tracz, T. 1983. In: Alexander, J. and G. Keller (moderators). New plant forum.Comb. Proc. Intl. Plant Prop. Soc. 33:489-490.

HORTSCIENCE 25(2):198-200. 1990.

Shoot Length Control of Tree Peony *(Paeonia suffruticosa)* with Uniconazole and Paclobutrazol

Morihiko Hamada, Takashi Hosoki, and Toshiyuki Maeda

Laboratory of Vegetable and Ornamental Horticulture, Faculty of Agriculture, Shimane University, Nishikawatsu-cho 1060, Matsue 690, Japan

Additional index words. growth retardant, triazol compounds, flower forcing

Abstract. **Potted plants of 'Taiyoh' and 'Hanakisoi' tree peony *(Paeonia suffruticosa* Andr.) were treated with a foliar spray of uniconazole or paclobutrazol for shoot length control. Uniconazole sprays at 25 or 50 ppm upon sprouting effectively reduced shoot length in both cultivars. The retarding effect was greater in 'Taiyoh' than in 'Hanakisoi' at 25 ppm. Uniconazole treatment did not influence flower diameter or days to flowering in either cultivar. Paclobutrazol sprays at 500 and 1000 ppm were less effective in reducing 'Hanakisoi' shoot length than uniconazole sprays at 25 and 50 ppm. Chemical names used: E-1-(4-chlorophenyl)-4,4-dimethyl-2-(l,2,4-triazol-l-yl)-l-pentan-3-ol (uniconazole); (1RS, 3RS)-1-1-(4-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-l-yl) -l-pentan-3-ol (paclobutrazol).**

Tree peonies have long been cultivated as garden landscape plants in the United States, Europe, and Japan (Gratwick, 1979; Everett, 1981). Nearly 2 million plants are' produced in Japan every year and > 10% are shipped to the United States (Hosoki, 1985). While demand for garden plants decreased in the past 10 years, consumers are purchasing more potted plants or cut flowers (Hosoki, 1985). Some tree peony growers are concentrating on forcing potted plants or cut flowers (Hosoki et al., 1984) because of the high market price ($10 to $20 per pot plant compared to $3 to $4 per nursery plant). Tree peony is propagated by grafting onto the herbaceous peony *(Paeonia lactiflora* Pall.) and grown for at least 2 years (Reath, 1979; Everett, 1981). The plants bloom in the spring on 3-year-old shoots. Apical dominance of tree peony is strong, since a solitary flower is formed without branching on the top of the current shoot (Everett, 1981). A major problem in pot flower production is control of excessive shoot growth. In previous experiments we conducted for 6 years, common growth retardants, such as daminozide, chlormequat, and ancymidol, did not retard shoot growth of tree peony at all or retarded it only by 18% at best. This was inadequate for commercial use.

Received for publication 1 May 1989. 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.

New triazol growth retardants, such as paclobutrazol (Wilfret, 1981) or uniconazole (Ooshio et al., 1981), were investigated. Paclobutrazol has been shown to retard shoot growth of pot plants, such as *Camellia* hybrids, chrysanthemum, and zinnia (Wilkinson and Richards, 1988; Sanderson et al., 1988; Cox and Keever, 1988). Uniconazole ($C_{15}H_{18}ClN_3O$), with a similar chemical formula to paclobutrazol ($C_{15}H_{20}ClN_3O$), has been used for control of plant height in *Camellia, Rhododendron,* and azalea (Kiyosawa and Hirata, 1986; Kunishige et al., 1985; Shinozaki et al., 1987). In *Camellia*, uniconazole strongly reduced shoot growth; 50% to 55% height reduction with a spray application at 25 or 50 ppm when compared with the control. In *Rhododendron* and azalea, the reduction of shoot length was 20% to 37%. In rice seedling tests, uniconazole strongly retarded shoots when compared with paclobutrazol (Takeuchi et al., 1987).

The objective of the present study was to investigate the control of shoot length of tree peony using paclobutrazol and uniconazole.

All the experiments were conducted from March to April, when flower forcing is most frequently practiced among tree peony growers. A popular pink cultivar Hanakisoi (Floral Rivalry), grown at the Shimane Univ. field, was used to test paclobutrazol. Plants were lifted and potted into plastic containers (24 cm in diameter, 4.5 liters) containing a sandy-soil medium mixed with 30% bark. Plants were then grown in a glasshouse where temperature set points were ≈ 22 to 27C/day and 15 to 18 C/night. Plants were watered almost every day.

For the paclobutrazol treatment, 500 and 1000 ppm aqueous solutions including 0.1% surfactant (Tween-20) were sprayed on the foliage three times, beginning when the budded sprouts were 3 cm long. Control plants were sprayed only with water including O. 1% surfactant, The second and third sprays were applied 5 and 10 days after the first treatment. Seven replicates were used for each treatment. For the uniconazole treatment, a red cultivar Taiyoh (Sun) and 'Hanakisoi' were used. Twenty-five and 50 ppm aqueous solutions, including the surfactant, were sprayed on the foliage twice at a 5-day interval; the first spray when the sprout was 3 cm long. Seven and five replicates were used for 'Taiyoh' and 'Hanakisoi', respectively. For both chemical treatments, shoot length at flowering, flowering rate, days to flowering after treatment, flower diameter, and phytotoxic injury to the leaves were recorded.

At flowering time, paclobutrazol treatment on 'Hanakisoi' reduced shoot length only by 18% with 500 ppm and by 17% with 1000 ppm when compared with the shoot length (22 cm) of the control. Flowering was not delayed by paclobutrazol treatments compared with those of the control. Flower diameter was not affected by the treatments (13.3 cm at 500 ppm, 13.3 cm at 1000 ppm, and 12.0 cm for the control). Leaf tips of plants treated at 1000 ppm were wrinkled. Plant root immersion into 200 or 400 ppm aqueous solution for up to 36 hr before plant-

Table 1. Effect of uniconazole on shoot length of 'Taiyoh' and 'Hanakisoi' tree peony.

Cultivar	Foliar-spray concn (ppm)	Shoot length (cm)
	0	25.2
Taiyoh	25	17.8
	50	15.2
Linear		
	0	2%
Hanakisoi	25	16.2
	50	12.2
Linear		*

NS,*Nonsignificant or significant at $P = 0.05$, respectively.