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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-(1,2,4-triazol-1-yl)-1-pentan-3-ol (uniconazole); (1RS, 3RS)-1-1-(4-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)-1-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.

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 27°C/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 bud-ded sprouts were 3 cm long. Control plants were sprayed only with water including 0.1% 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)
Taiyoh	0	25.2
	25	17.8
	50	15.2
Hanakisoi	0	2%
	25	16.2
	50	12.2
Linear		*

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

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.

Fig. 1. Shoot growth of 'Taiyoh' (left) and 'Hanakisoi' (right) after foliar sprays of uniconazole at 0, 25, or 50 ppm. The first spray and second spray were conducted at 0 and 5 days, respectively. Vertical bars indicate s.e.

Fig. 2. Shoot length at flowering time with uniconazole treatment: 'Taiyoh' (upper), 'Hanakisoi' (lower). Control (left), 25 ppm (middle), 50 ppm (right). Arrow indicates the base of the current shoots.

ing did not reduce shoot growth at all (data not shown), probably because large tuberous graft-roots of herbaceous peony diluted the effect of the chemical or inhibited its upward movement.

For uniconazole treatment on 'Taiyoh', shoots at flowering were 29% shorter at 25

ppm and 40% shorter at 50 ppm when compared with shoot length of the control (25.2 cm) (Figs. 1 and 2). Flowering rate was 100% in both treatments. Days to flowering and flower diameter did not differ significantly between the two treatments and the control for either cultivar (Table 1). Flower diameter

was between 14 and 15 cm for 'Taiyoh' and between 11 and 12 cm for 'Hanakisoi'; the corresponding values for days to flowering were 23 or 24 and 19 or 20. Treatment with the 50 ppm spray induced slight leaf-tip wrinkling, although it did not seriously detract from the appearance. Similar results were obtained for 'Hanakisoi', where shoot length was reduced by 23% with a 25 ppm spray and 41% with 50 ppm compared with the shoot length of the control (21.0 cm) (Figs. 1 and 2). Phytotoxic injury was not observed in 'Hanakisoi', even at the 50-ppm treatment.

In a bioassay using rice seedling (Takeuchi et al., 1987), shoot growth retardation by uniconazole was 100 times as strong as that of paclobutrazol at equivalent molecular concentrations. In our study on tree peony, uniconazole also was more effective at low concentrations than paclobutrazol. Paclobutrazol treatment was phytotoxic at 1000 ppm, where the retardation effect on shoot growth was inadequate.

Uniconazole treatment at 25 ppm was slightly less effective on 'Hanakisoi' than on 'Taiyoh'. Cultivar differences have been reported in potted chrysanthemum and azalea (Oosio et al., 1981; Shinozaki et al., 1987).

In conclusion, two uniconazole foliar sprays applied at budbreak retarded shoot growth of tree peony. This would be a valuable commercial practice to obtain a pleasing aesthetic balance in pot plants.

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HORTSCIENCE 25(2):200-202. 1990.

Rooting Softwood Cuttings of *Acer griseum*: Promotion by Stockplant Etiolation, Inhibition by Catechol

Brian K. Maynard and Nina L. Bassuk

Department of Floriculture and Ornamental Horticulture, Cornell University, Ithaca, IVY 14853

Additional index words. adventitious root formation, auxin, banding, light, paperbark maple, phenolics, propagation

Abstract. Effects of stockplant etiolation, stem banding, exogenous auxin, and catechol on the rooting response of softwood cuttings of paperbark maple (*Acer griseum* Pax.) were studied. Etiolated cuttings rooted better than light-grown cuttings, while stem banding did not affect rooting percentage (light-grown, 10%; light-grown + banding, 18%; etiolated, 41%; etiolated + banding, 37%). IBA did not promote, but catechol inhibited rooting (control, 31%; IBA, 37%; catechol, 17%; IBA + catechol, 21%). Root number was increased by IBA and unaffected by catechol. The distance from the cutting base to the first emerged root was measured as an indication of auxin toxicity. IBA interacted with etiolation and stem banding to increase this distance, which was greater in catechol-treated cuttings. Chemical names used: 1,2-benzenediol (catechol); 1H-indole-3-butyric acid (IBA).

Paperbark maple is a desirable ornamental trees species that has presented a challenge to plant propagators for many years. Seed germination is normally poor (Fordham, 1969), grafting success is limited, and cuttings are generally considered difficult to root (Dirr and Heuser, 1987). However, several studies have reported some success with softwood cutting propagation of seedling material (Dirr and Heuser, 1987, p. 83). Of special interest is a study by Ming and Meyer (1983) in which cuttings from 2-year-old seedlings were soaked for 24 hr in 1H-indole-3 acetic acid (IAA) and the phenolic compound catechol. Up to 100% rooting was obtained after a 24-hr pre-sticking soak in a 2% aqueous ethanol (EtOH) solution of 1.1×10^{-3} M IAA plus 4.5×10^{-3} M catechol (193 and 495 mg·liter⁻¹, respectively). Their study suggested that catechol might have acted as rooting cofactor which, in conjunction with exogenous IAA, promoted rooting of several difficult-to-root maple species.

Stockplant etiolation and stem banding with Velcro have been used to stimulate rooting of softwood cuttings from both young (1-year-old seedling) and mature (30-year-old specimen) stockplants of *Acer griseum* (Maynard and Bassuk, 1987). Though im-

provements in rooting response were demonstrated, the best rooting percentages observed were markedly lower than those of Kling and Meyer (34% vs. 100%).

The objective of the present study was to investigate a combination of the methods used in the studies described above, specifically, the influences of etiolation and exogenously applied auxin and catechol on adventitious root formation in cuttings. The study was designed as a $2 \times 2 \times 2$ factorial to test the effects of stockplant etiolation, Velcro-banding with IBA, and auxin or catechol soaks on the rooting of softwood basal stem cuttings of *A. griseum*. This study was undertaken to incorporate certain aspects of the work of Kling and Meyer (1983), not to replicate their study. Based on the assumption that IAA is more readily degraded than IBA in the course of a 24-hr soak (Dirr and Heuser, 1987, p. 37), we chose to substitute IBA for IAA.

Twenty 5-year-old field-grown seedling stockplants of *A. griseum* (Schichtel's Nursery, Orchard Park, N. Y.; provenance unknown) were potted into 2-liter plastic containers in a medium of 1 sandy loam soil: 1 sphagnum peatmoss: 1 perlite (by volume) and placed in cold storage at 5C for 8 weeks. On 1 Dec. 1987, all plants were placed in a greenhouse maintained at an average day/night temperature of 20C. Incandescent lamps (100 W), suspended $\approx$ 3 m above the stockplants and spaced 1 m apart, were used from 4:00 PM to 12:00 PM to extend the natural photoperiod to $\approx$ 16 hr (irradiance not deter-

mined). Stockplants were fertilized weekly with 200 mg 20N-10P-20K/liter. Ten of the stockplants were forced under black cloth (> 98% shade) to produce typical etiolated growth (lack of color, lengthened internodes, succulence). Remaining stockplants were grown without shade. Two weeks later, shoots from one-half of the light-grown and etiolated plants were basally banded using 2.5-cm wide strips of Velcro coated with 0.8% IBA in talc, the standard procedure for stem banding developed by Maynard and Bassuk (1987). Etiolated plants were then acclimated to full sunlight over 4 days by first removing the cover on the north side, and then gradually rolling the cloth back each day until all 10 plants were in full sun. Basal shoot cuttings were taken 4 weeks later from positions throughout the stockplant crown and cut to a length of 7 to 10 cm with one pair of leaves. The terminal growth was removed. Banded shoots were cut immediately proximal to the Velcro bands and the bands removed. Four types of softwood cuttings were taken: 1) light-grown, nonbanded shoots (controls); 2) light-grown, banded shoots (banded); 3) etiolated shoots that had greened for 4 weeks (etiolated); and 4) etiolated and banded shoots, which yielded a cutting with an etiolated base (etiolated and banded).

All the cuttings were wounded along one side ($\approx$ 2 cm) by scraping to remove the bark, and the basal 1 cm of each cutting was soaked for 24 hr at room temperature in one of four solutions containing 2% ethanol: 2% ethanol only (control); 4.9×10^{-4} M IBA (100 mg·liter⁻¹); 9.1×10^{-4} M catechol (100 mg·liter⁻¹); or 4.9×10^{-4} M IBA and 9.1×10^{-4} M catechol. Cuttings of each treatment were then distributed randomly into five groups of six cuttings each before insertion to a depth of $\approx$ 1 cm in a medium of 2 perlite : 1 sphagnum peatmoss (v/v) in a completely randomized design. Rooting took place under mist (6 sec every 4 min from 6:00 AM to 8:30 PM), with bottom heat (25 C), and a 16-hr photoperiod (see above) provided by 100 W incandescent lamps suspended 1 m above the medium and spaced 1 m apart. Cuttings were evaluated for rooting after 38 days. Cuttings were considered rooted if they possessed one or more roots >1 mm long. Rooting percentage, the number of roots per rooted cutting, and the distance from the cutting base to the first emerged root were recorded. Data were analyzed using the PROC GLM option of SAS (SAS Institute, 1985); percentage data were transformed to arcsin square root before analysis (Snedecor and Cochran, 1980).

An analysis of variance (Table 1) shows main effects and interactions among treatments. All third- and fourth-order interactions were nonsignificant and were pooled in

Received for publication 27 Feb. 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.