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HortScience 22(3):444–445. 1987.

Effects of Paclobutrazol on Growth and Flowering of *Bouvardia humboldtii*

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Additional index words. ICI-paclobutrazol, daminozide, chlormequat, CCC, growth retardants, pine bark

Abstract. **Plant height of potted *Bouvardia humboldtii* Hort. was controlled effectively by foliar or drench applications of paclobutrazol. Three foliar applications of 250 mg·liter^{-1} paclobutrazol or a drench of 2 mg/100-mm-diameter pot reduced plant height by ≈30% and increased the total number of flowers per plant by ≈35%. Overall, paclobutrazol significantly reduced total plant dry weight, and sprays were more inhibitory than drenches. Paclobutrazol altered the shoot : root ratio in favor of the shoot. Foliar sprays of daminozide (5000 mg·liter^{-1}) or chlormequat (2000 mg·liter^{-1}) were ineffective in controlling growth or flowering. It is concluded that paclobutrazol application may be a useful technique in the commercial production of *Bouvardia* as a flowering pot plant. Chemical name used: β-[(4-chlorophenyl)methyl]-α-(1,1-dimethylethyl)-1*H*-1,2,4-triazole-1-ethanol [paclobutrazol (ICI-PP333)].**

Bouvardia humboldtii, with its large terminal clusters of white fragrant flowers (2), offers great potential as a flowering pot plant. However, if the natural growth habit is permitted, the long flowering stems droop under the weight of the flowers. To exploit fully the potential of *B. humboldtii* as a pot plant, stem length must be controlled. Paclobutrazol has been reported to retard stem elongation of a broad range of ornamental plant species (8, 9). The purpose of this investigation was to test the efficacy of paclobutrazol to control stem drooping and compactness in *B. humboldtii*.

Although the growth retardant α-cyclopropyl-α-(4-methoxyphenyl)-5-pyrimidinemethanol (ancymidol) has been used successfully to restrict stem extension of *B. longiflora* (5), it was not used in this experiment. Unlike paclobutrazol, registration of ancymidol in Australia is not imminent and, therefore, it is unlikely to be used extensively in ornamental production in the near future. The growth retardants butanedioic acid mono(2,2-dimethylhydrazide) (daminozide, Alar) and 2-chloro-*N,N,N*-trimethylethanaminium chloride (chlormequat chloride, Cycocel), however, are used regularly in commercial production and therefore were included for comparison with paclobutrazol.

In early spring (30 Sept.), rooted tip cuttings were pinched to induce lateral shoot development, potted (one plant per 100-mm-diameter pot) and held under 50% shade cloth (maximum light level of 850 μmol·s^{-1}·m^{-2}) for 11 weeks (mean maximum/minimum temperatures were 20.5°/10.4°C). The potting medium was composed of 66 pine bark : 17 coarse sand : 17 brown coal (lignite) (by volume) with slow-release fertilizer added at a rate of 1 kg Osmocote (15N–5.2P–12.5K), 2 kg Osmocote (18N–4.8P–8.3K), 2 kg dolomite, 0.5 kg Micromax, and 0.5 kg iron oxide per cubic meter of mix. In early summer (16 Dec.), when the plants were ≈60–70 mm high and new shoots were 30–40 mm long, each pot was top-dressed with an additional 6 g of Osmocote (15N–5.2P–12.5K), and plants were transferred to a polyethylene greenhouse where they remained for the duration of the experiment (until 3 Mar.). The mean maximum/minimum temperature for this period was 35.0°/10.8°.

Treatments were imposed on 18 Dec. and consisted of either foliar sprays or drenches of paclobutrazol. The spray rates were three applications of 250 mg·liter^{-1}, two applications of 500 mg·liter^{-1}, and one application of 100 mg·liter^{-1}. These rates were chosen on the basis of preliminary summer trials and were applied to run-off using ≈5 ml of solution per plant. For comparison, some plants were treated with daminozide at 5000 mg·liter^{-1} or chlormequat at 200 mg·liter^{-1}, both applied as three sequential foliar sprays. For all spray treatments, the first spray was applied on 18 Dec., the second on 10 Jan., and the third on 24 Jan. For the drench treatments, an 80-ml solution of paclobutrazol was applied to moist media at rates of 1, 2, or 4 mg/pot. Control plants were not treated with any growth regulators.

Experimental design was a randomized block with seven single plant replicates per treatment. Plant height, flower number, and shoot and root dry weight were measured at the completion of the experiment (3 Mar., 11 weeks after treatment).

Plant height of *B. humboldtii* was reduced significantly by all paclobutrazol treatments but not by daminozide or chlormequat (Table 1). The 250 mg·liter^{-1} and 1000 mg·liter^{-1} spray and the 1- and 2-mg drench treatments all reduced plant height by ≈30%. These application rates thus resulted in growth re-

Fig. 1. The effect of three foliar applications of 250 mg·liter^{-1} of paclobutrazol on growth and flowering of *Bouvardia humboldtii* after 11 weeks. Control plant (**left**) illustrates the stems drooping from the weight of the flowers.

Received for publication 6 June 1986. We thank ICI-Australia for providing paclobutrazol and D. Fontana for technical assistance. 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.

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Table 1. The effect of paclobutrazol, daminozide, and chlormequat on growth and flowering of *Bouvardia humboldtii* after 11 weeks.

Treatment		No. applications	Final ht (cm)	Flower no.	Dry wt (g) Shoot	Root	Plant	Shoot : root ratio
Control		0	30.8 a[z]	76.8 b	9.34 ab	1.81 a	11.15 a	5.31 cd
Drench (mg/pot)								
Paclobutrazol	1	1	22.9 b	90.7 ab	9.10 abc	1.19 b	10.29 ab	7.75 ab
	2	1	20.6 bc	101.0 a	8.75 abc	1.17 b	9.92 ab	7.57 b
	4	1	15.9 c	90.7 ab	7.04 d	1.13 b	8.17 bc	6.48 bc
Sprays ($mg \cdot liter^{-1}$)								
Paclobutrazol	250	3	21.5 b	109.6 a	8.45 bc	1.66 ab	10.20 ab	5.15 d
	500	2	16.3 c	106.0 a	6.80 d	0.79 c	7.59 c	8.91 a
	1000	1	22.0 b	94.2 ab	6.33 d	0.86 c	7.19 c	7.68 ab
Daminozide	5000	3	29.6 a	91.8 ab	7.63 cd	1.18 b	8.81 bc	6.50 bc
Chlormequat	2000	3	32.0 a	76.6 b	10.11 a	1.31 b	11.41 a	7.79 ab

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

ductions and a plant height considered commercially acceptable. The compact appearance of the treated plants and the absence of stem drooping are clearly shown in Fig. 1. A larger, but unacceptable, growth reduction (by 50%) was obtained with the 500 $mg \cdot liter^{-1}$ spray and the 4-mg drench treatments. A comparison of two applications of 500 $mg \cdot liter^{-1}$ with a single 1000 $mg \cdot liter^{-1}$ foliar spray indicated that two sprays were more effective than one in reducing plant height. In addition, three sprays of 250 $mg \cdot liter^{-1}$ resulted in a height reduction similar to the 1000 $mg \cdot liter^{-1}$ treatment, even though less active ingredient was applied per plant. The present results thus support other findings that frequent low-dose applications of growth retardants are the most effective means of controlling stem elongation (7).

Overall, the paclobutrazol treatments significantly reduced total plant dry weight, and sprays were more inhibitory than drenches (Table 1). Generally, for woody plants, paclobutrazol application either does not affect or slightly increases root growth (4, 11, 12). There are a number of observations, however, that at very high drench rates (e.g., 1 g per 2.5-liter pot), root growth can be severely reduced and morphology altered (1, 4). Whatever the effect on root growth, there is consensus that shoot growth is reduced to a greater extent, and, therefore, the shoot : root ratio of treated plants usually declines (1, 4, 12). The present results for *Bouvardia* do not show this trend. In all instances, paclobutrazol reduced root growth more than shoot growth and thus shoot : root ratio increased (Table 1). Since the rates of paclobutrazol applied here are not exceptionally high, these observations indicate that root systems of *Bouvardia* may be particularly sensitive to applied paclobutrazol, even when the retardant is applied to the leaves. It should be noted that for the foliar treatments, runoff from leaves onto the pine bark media was not prevented, so that roots were also exposed directly to small but highly concentrated doses of paclobutrazol.

Daminozide significantly reduced the shoot, root, and total plant dry weight, but, unlike the paclobutrazol, did not alter the shoot : root ratio. The only effect of chlormequat was a small but significant decrease in root dry weight, resulting in an increased shoot : root ratio.

The potting medium used in this experiment was dominated by pine bark, which would be expected to reduce the activity and effectiveness of drench-applied growth retardants such as ancymidol and paclobutrazol (3). The drench concentrations used here were all effective in controlling growth in pine bark-based media; thus, a greater growth reduction would be expected in any pine bark-free media.

Paclobutrazol has been reported to increase flower number in some fruit tree species (6, 10). The present results also showed that there was substantial increase in flower number on *B. humboldtii* after paclobutrazol treatment (Table 1). The most effective treatments were the two low spray concentrations (250 and 500 $mg \cdot liter^{-1}$) and the medium drench rate (2 mg/pot), where flower numbers were $\approx$35% greater than on control plants. Analysis of the dry weight distribution data suggests that paclobutrazol may result in a diversion of assimilates into flower development, possibly due to the reduced demand by the roots. Although assimilate redistribution would seem a likely explanation for the overall effect of paclobutrazol on the flowering response, the possible alteration of the hormonal balance of the plant by paclobutrazol cannot be overlooked. Paclobutrazol is known to reduce gibberellic acid biosynthesis in other plants (7) and this effect, by itself, conceivably could promote flower formation and development in *Bouvardia*.

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