Inhibiting Growth of Flowering Crops with Ancymidol and Paclobutrazol in Subirrigation Water

J.B. Million, J.E. Barrett, T.A. Nell, and D.G. Clark

Department of Environmental Horticulture, University of Florida, Gainesville, FL 32611-0670

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Abstract. Contamination of recirculated subirrigation water with growth retardants poses a potential problem for growers. Eight concentrations of ancymidol or paclobutrazol ranging from 0 to 100 $\mu\text{g}\cdot\text{L}^{-1}$ (0 to 1000 $\mu\text{g}\cdot\text{L}^{-1}$ for petunia) were supplied constantly in subirrigation water to potted plants to identify critical levels at which plant growth is affected. Concentrations of ancymidol resulting in 20% reduction in plant size relative to untreated controls were 3, 10, 98, 80, and 58 $\mu\text{g}\cdot\text{L}^{-1}$ for *Begonia* $\times$ *semperflorens-cultorum* Hort. ‘Gin’, chrysanthemum (*Dendranthema* $\times$ *grandiflora* Kitam.) ‘Nob Hill’, *Impatiens walleriana* Hook f. ‘Super Elfin Coral’, *Petunia* $\times$ *hybrida* Hort. Vilm.-Andr. ‘Madness Pink’, and *Salvia splendens* Sell ex Roem. & Schult. ‘Red Hot Sally’, respectively. Respective values for paclobutrazol were 5, 24, 17, 390, and >100 $\mu\text{g}\cdot\text{L}^{-1}$. The results provide useful information for managing potential growth retardant contamination problems or for applying growth retardants in subirrigation water. Chemical names used: α -cyclopropyl- α -(4-methoxyphenyl)-5-pyrimidinemethanol (ancymidol); $(\pm)$ -(R*,R*)- β [(4-chlorophenyl)methyl]- α -(1,1-dimethyl)-1H-1,2,4-triazole-1-ethanol (paclobutrazol).

Contamination of recirculated subirrigation water with growth regulators is a potential problem for growers. Sources of growth regulator contamination include spray drift, foliage drip, or leachate from pots that have received drench applications. Ancymidol, paclobutrazol, and uniconazole [(E)-(RS)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1H-1,2,4-triazol-1-yl)pent-1-en-3-ol] are of particular concern because they are actively taken up by plant roots and exert their effects at concentrations much lower than those observed with foliar applications (Menhenett, 1984).

Continuous application of plant growth regulators throughout potted plant production has not been reported. However, in a hydroponic system, shoot length of peach (*Prunus persica* L. Batsch.) seedlings was reduced when treated over 2 to 3 weeks with paclobutrazol concentrations as low as 2 $\mu\text{g}\cdot\text{L}^{-1}$ (Tagliavini and Looney, 1991). One-time application of growth retardants in subirrigation water effectively controlled geranium (*Pelargonium* $\times$ *hortorum* L.H. Bail.) and kalanchoe (*Kalanchoe blossfeldiana* Poelln.) growth in ebb and flood irrigation systems (Adriansen, 1989). For one-time application, the amount of paclobutrazol added to the subirrigation water was based upon the amount of water absorbed by each pot and standard drench

rates (mg/pot). Adriansen (1989) reported that residues of ancymidol in subirrigation water were less when applied by subirrigation than by foliar spray, which required a higher concentration to achieve the same effect.

The objective of our experiment was to compare the response of several potted plants to increasing concentrations of ancymidol and paclobutrazol applied constantly by subirrigation.

Materials and Methods

Plugs of begonia ‘Gin’, impatiens ‘Super Elfin Coral’, and salvia ‘Red Hot Sally’ were planted one per 370-mL (10.2-cm) pot on 3 Jan., 17 Apr., 10 Apr., and 17 Apr. 1996, respectively, and petunia ‘Madness Pink’ on 28 Feb. 1997. Chrysanthemums ‘Nob Hill’ were planted, one rooted cutting per 660-mL (11.4-cm) pot, on 8 Mar. 1996. All pots were filled with a peat-based growing medium (Fafard No. 2, Anderson, S.C.). Minimum/maximum greenhouse temperatures were 18/25 °C for begonia, 19/30 °C for impatiens and salvia, 18/27 °C for petunia, and 18/26 °C for chrysanthemum. Chrysanthemums were soft-pinned on 15 Mar. and short-day conditions began on 22 Mar.

After transplants were watered initially with overhead irrigation, all subsequent irrigations were via subsurface irrigation using growth retardant solutions. Treatment solutions consisted of ancymidol or paclobutrazol at eight concentrations: 0, 0.1, 0.5, 1, 5, 10, 50, or 100 $\mu\text{g}\cdot\text{L}^{-1}$. For petunia, which is less sensitive to these growth retardants, six different concentrations were evaluated: 0, 1, 3, 10, 30,

and 100 $\mu\text{g}\cdot\text{L}^{-1}$. Treatment solutions were prepared using a fertilizer solution (20N–4.4P–16.6K with minor elements; O.M. Scotts Co., Marysville, Ohio) with N at 150 $\text{mg}\cdot\text{L}^{-1}$. Subirrigation was accomplished by filling sealed trays (25.4 $\times$ 50.8 $\times$ 5.1 cm) 2 cm deep with treatment solutions. Pots were kept in open-webbed flats that were placed into the treatment solutions and allowed to soak up solutions for 15 to 20 min. After each irrigation, the open-webbed flats were lifted out of the solution and placed back on the bench. The amount of solution taken up at each irrigation was not determined.

Each experiment was arranged in a randomized block design with three blocks and six plants per block. Plant height and two plant width measurements 90° from one another were made on 4 Mar. for begonia, 28 Mar. for petunia, 17 May for impatiens, and 20 May for salvia. Size was calculated as (height + average width)/2. Plant height was measured for chrysanthemum on 15 Mar. (pinch) and 17 Apr. (final) and change in height was calculated as the difference between the two heights. An exponential decay curve was fitted to the data using a nonlinear regression procedure (PROC NLIN) (SAS Institute, 1998). Because chemical $\times$ concentration effect was significant ($P < 0.05$), regression analyses were conducted separately for each chemical. The exponential decay curve was selected over the commonly used quadratic curve because it better fits the asymptotic characteristics of the response. For comparing the response of the different plant species to ancymidol or paclobutrazol, data for each crop and chemical were divided by the mean value of the 0 $\mu\text{g}\cdot\text{L}^{-1}$ rate. Based upon exponential decay curves fitted to the transformed data, concentrations resulting in 10% and 20% reduction in growth were determined. The 10% and 20% reduction levels were chosen arbitrarily with the intention of providing guidelines with practical significance. A reduction of $<10\%$ would not be noticeable, whereas reduction of $>20\%$ would not be acceptable, in most commercial situations.

Results and Discussion

Interaction between growth regulator and growth regulator concentration on plant growth was significant for each plant species (Figs. 1 and 2). Ancymidol was more active than paclobutrazol on begonia (Fig. 1A), chrysanthemum (Fig. 2), salvia (Fig. 1B) and petunia (Fig. 1D). However, paclobutrazol was more active than ancymidol on impatiens (Fig. 1C). The difference in response to ancymidol vs. paclobutrazol was relatively small in begonia and chrysanthemum, and about twice the concentration of paclobutrazol was required to produce the same effect as with ancymidol. Differential response between ancymidol and paclobutrazol was greater for the other crops. For example, a 4- to 6-fold higher concentration of ancymidol was required in impatiens to achieve the same effect as with paclobutrazol. Differential response to these chemicals has been reported. Barrett et al. (1987) observed

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Fig. 1. Response of begonia 'Gin', Salvia 'Red Hot Sally', impatiens 'Super Elfin Pink' and petunia 'Madness Pink' to the concentration of ancymidol or paclobutrazol in subirrigation water. (Size = (height + ave. width)/2) Regression equations for plants treated with ancymidol and paclobutrazol, respectively, were $y = 6.41 + 10.8e^{-1.176x}$, $r^2 = 0.94$, and $y = 6.91 + 8.2e^{-0.855x}$, $r^2 = 0.93$ (begonia 'Gin'); $y = 16.0 + 6.3e^{-0.219x}$, $r^2 = 0.79$, and $y = 18.0 + 4.5e^{-0.0028x}$, $r^2 = 0.13$ (salvia 'Red Hot Sally'); $y = 17.0 + 5.3e^{-0.208x}$, $r^2 = 0.51$, and $y = 12.6 + 9.1e^{-0.366x}$, $r^2 = 0.51$ (impatiens 'Super Elfin Pink'); $y = 10.0 + 6.2e^{-0.081x}$, $r^2 = 0.82$, and $y = 12.1 + 4.5e^{-0.0034x}$, $r^2 = 0.68$ (petunia 'Madness Pink').

Fig. 2. Response of chrysanthemum 'Tara' to the concentration of ancymidol ($y = 6.76 + 19.1e^{-0.276x}$, $r^2 = 0.94$) or paclobutrazol ($y = 3.63 + 20.7e^{-0.108x}$, $r^2 = 0.90$) in subirrigation water.

ancymidol to be more effective on chrysanthemum than paclobutrazol at the same drench concentration. Wilfret (1987) found that up to 5 to 10× higher drench concentration of paclobutrazol was required to give the same effect as ancymidol on Easter lily (*Lilium longiflorum* L.). At the same drench concentration, paclobutrazol was much more effective than ancymidol (63% vs. 15% reduction) in controlling height of *Ficus benjamina* L. (Barrett and Nell, 1983).

The five plants tested varied considerably in their sensitivity to ancymidol and paclobutrazol (Table 1). When placed in decreasing order of sensitivity to ancymidol, the ranking was begonia > chrysanthemum > salvia > petunia > impatiens. The concentration of ancymidol resulting in a 20% reduction in plant size ranged from 3 µg·L⁻¹ for begonia to 98 µg·L⁻¹ for impatiens. For paclobutrazol, the relative order was begonia > impatiens > chrysanthemum > petunia (salvia unknown). The concentration of paclobutrazol resulting in a 20% plant size reduction ranged from 5 µg·L⁻¹ for begonia to >100 µg·L⁻¹ for salvia. Note that begonia and chrysanthemum data were taken 8 and 6 weeks after planting, respectively, while data for impatiens, salvia, and petunia were taken 4 to 5 weeks after planting. The apparent sensitivity of the latter crops to both chemicals might have been greater had they been grown for a longer period of time, as nontreated plants could grow larger while treated plants could continue to be affected. Nonetheless, nontreated plants of all five crops were large and of greater than marketable size, so that the relative response is a general comparison.

These results illustrate that ancymidol and paclobutrazol are active at low concentrations in subirrigation water. Contamination of the water is possible from spray residues on bench surfaces, which can affect growth of nontarget crops irrigated with same water (Al-Badawy et al., 1995). Growers who suspect contamination of subirrigation water with ancymidol or paclobutrazol can use a broccoli (*Brassica oleracea* var. *botrytis* L.) seedling bioassay test (Million et al., 1996) to estimate growth regulator concentrations based upon the values in Table 1. In commercial operations effects of contaminated water could be moderated by using the water on crops tolerant of the chemical. Also, sensitive crops could be grown in a bark-based medium, which reduces the activity of ancymidol (Tschabold et al., 1975) and paclobutrazol (Million et al., 1998).

These results also indicate that application of growth regulators in subirrigation water may be a labor-saving method of application in commercial production. However, the differences in sensitivity of the crops tested demonstrates that this method of application will be difficult except under monoculture situations.

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Table 1. Concentrations of ancymidol and paclobutrazol (μL^{-1}) in subirrigation water required for 10% and 20% reduction in plant growth.^z

Species	Ancymidol		Paclobutrazol	
	Reduction in plant size ^y			
	10%	20%	10%	20%
Begonia	1	3	2	5
Chrysanthemum	4	10	10	24
Impatiens	29	98	7	17
Petunia	30	80	130	390
Salvia	21	58	>100 ^x	>100

^zValues calculated from equations in Figs. 1–5.

^ySize was calculated as the (average width + height)/2.

^x>100 indicates that the reduction was not achieved at the highest concentration tested.

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