



Efficacy of Paclobutrazol Drench Treatments to *Petunia* and *Impatiens* Is Affected by Application Method and Irrigation Method

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Paclobutrazol is used to control size of annuals and other greenhouse crops and is often applied as a drench to the media surface. Previous research indicates that paclobutrazol binds to the organic components and slowly moves down through the media profile. The use of subirrigation systems is expanding, but the movement of paclobutrazol within the growing substrate in subirrigation is not fully understood. Given this information, a set of experiments were carried out with *Impatiens wallerana* and *Petunia ×hybrida* to determine the efficacy of paclobutrazol when application is to the media surface or applied through the bottom of the container (bottom application) and subsequent irrigation is either overhead or by subirrigation. For petunia in 12.5-cm pots using a peat-based media, paclobutrazol in bottom application treatments had greater efficacy when followed by subirrigation compared to irrigation from above. When paclobutrazol was applied as a drench to the media surface, irrigation method had little effect on efficacy. For impatiens in taller, gallon containers, greater efficacy was found when subsequent irrigation was in the same direction as the paclobutrazol application. When paclobutrazol was coated on vermiculite and placed in the middle of the container, there was greater efficacy with subirrigation compared to overhead irrigation. These results illustrate that both application technique and irrigation method can affect paclobutrazol efficacy.

Paclobutrazol [(2RS,3RS)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1H-1,2,4-triazol-1-yl)pentan-3-ol] is a plant growth regulator commonly used on ornamental crops. It decreases the internode length by reducing the production of gibberellins (Gianfagna, 1995), which results in a compact finished plant with thick dark green leaves. Floriculture production operations have adopted the use of paclobutrazol due to its ability to perform over a wide range of species.

The application of paclobutrazol directly to the growing media is increasing. A drench to the media surface is most common, but it is sometimes applied through the bottom of the container in a subirrigation system. Paclobutrazol is a non-polar compound with low water solubility (Davis, 1988) and it binds to organic media components. The work of Million et al. (1999) and Bolt (2008) indicates that, in a drench application, paclobutrazol binds to the media in the upper layers of the container and then it moves down through the media during overhead irrigation. We have observed that efficacy of paclobutrazol is reduced when applied as a drench to the media surface of poinsettias that are on subirrigation. We also have reports of reduced efficacy from commercial growers who applied paclobutrazol to the surface of crops on subirrigation.

Our understanding of paclobutrazol movement through the substrate profile of organic container growing media is not complete. A series of experiments were developed to evaluate how site of application and direction of irrigation affect the efficacy of the paclobutrazol. With further research and understanding,

a perception can be formulated to create the most efficient, economical procedure for controlling plant size using applications to the growing substrate.

Materials and Methods

Seedlings of petunia and impatiens were obtained as plugs from commercial sources. Plants were transplanted into a commercial peat and perlite growing substrate (Fafard 2, Conrad Fafard, Inc., Agawam, MA). Plants were grown in a naturally ventilated greenhouse with heating set point of 18 °C and venting at 20 °C. Plants were fertilized at each irrigation with a 20–4.4–16.6 (Peters 20–10–20 Florida Special, The Scotts Co., Marysville, OH). For plants irrigated by hand and for plants on subirrigation, the N concentration was 150 and 75 mg·L⁻¹, respectively.

EXPERIMENT 1. This experiment was set up to compare the efficacy of paclobutrazol applied through the bottom of the container when subsequent irrigation was applied either to the surface or by subirrigation. On 21 Jan. 2009, petunia ‘Dreams Midnight Blue’ plugs were transplanted into containers with diameter of 12.5 cm and depth of 10 cm and were irrigated by hand. Paclobutrazol application was on 6 Feb. For this, plants were allowed to dry over a 24-h period to insure adequate uptake of the paclobutrazol solution. Eight plants at a time were set in trays with 4 L of paclobutrazol solution. After 5 min, the plants were removed and the remaining volume measured. The average solution volume taken up was 293 mL per container, which contained 1.17 mg of active ingredient.

All of the plants were grown together on the same bench and separated for each irrigation. There were two irrigation method treatments. Half the plants were irrigated by hand with water applied to the media surface, and the other half were watered by subirrigation.

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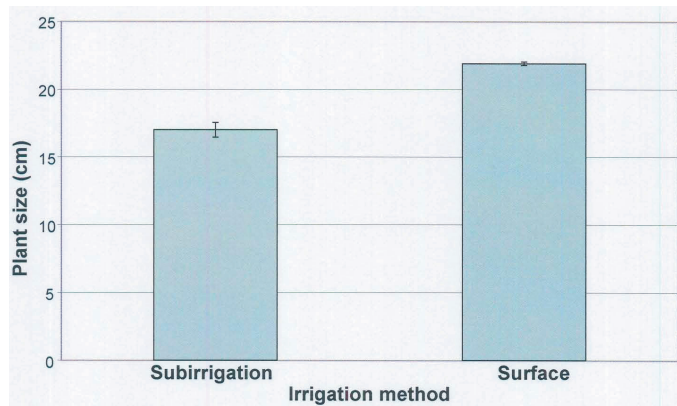


Fig. 1. Paclobutrazol was applied to the growing media through the bottom of the container and irrigation was either applied by subirrigation or to the media surface. Petunia plant size is (height + width)/2. ANOVA indicated irrigation treatments were significantly different. Means are shown with standard error bars. Expt. 1.

On 20 Feb., plant height and two widths perpendicular to each other were determined. Plant size was calculated as (height + width)/2. Plants were placed in a completely randomized block design with four blocks and two plants of each cultivar per block. Data were analyzed using SAS 9.1 (SAS Institute, Cary, NC) for analysis of variance. Means are shown in Figure 1 with standard error bars.

EXPERIMENT 2. This experiment compared irrigation methods when paclobutrazol was applied as a drench to the substrate surface. Petunias were started as described in Experiment 1 and paclobutrazol was applied on 6 Feb. Paclobutrazol was applied in 90 mL of solution at a concentration of 1 mg·L⁻¹. Plants were then grown and irrigated as described in Experiment 1. Experimental design, data analysis, and presentation in Fig. 2 were similar to those described in Experiment 1.

EXPERIMENT 3. This was a factorial experiment with two paclobutrazol application locations and two methods of irrigation. Seedlings of impatiens ‘SuperElfin XPPink’ were transplanted on 20 Mar. 2009 into containers with diameter of 15.5 cm and depth of 17.5 cm and were irrigated by hand. On 3 Apr., paclobutrazol was applied as either a surface drench or as a subsurface appli-

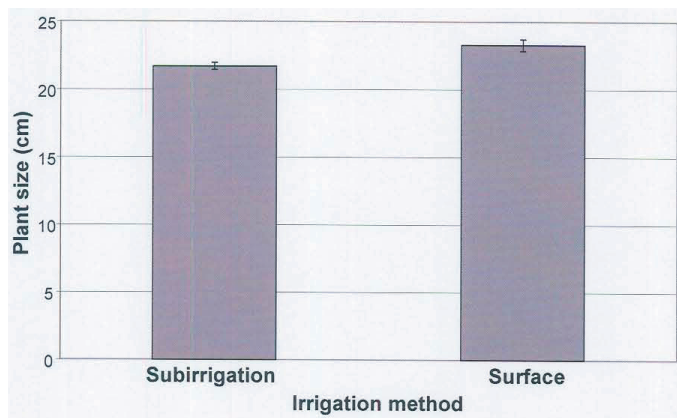


Fig. 2. Paclobutrazol was applied as a drench to the surface of the growing media and irrigation was either applied by subirrigation or to the media surface. Petunia plant size is (height + width)/2. ANOVA indicated irrigation treatments were significantly different. Means are shown with standard error bars. Expt. 2.

cation through bottom of container. Paclobutrazol concentration was 1 mg·L⁻¹ for both. Drench to surface was applied in a volume of 180 mL. The subsurface application was administered by placing each individual plant in a saucer of 350 mL of solution for 5 min. Average volume of solution taken up was 176 mL per container. Then half of the plants received surface irrigation and half received subirrigation as described in Experiment 1. Control plants not treated with paclobutrazol were included in each irrigation group.

Plant size was determined using the techniques described in Experiment 1. Control plants on surface irrigation were larger than those on subirrigation, so results are expressed as a percent of control plants (Fig. 3). Data were analyzed as described in Experiment 1.

EXPERIMENT 4. An emerging research area is applying paclobutrazol in a solid form that is added to the container at planting. The objective of this experiment was to evaluate the effect of irrigation method on efficacy of paclobutrazol placed in the growing substrate. Paclobutrazol was coated onto vermiculite by making a thin layer of vermiculite spread out in plastic trays. The vermiculite was then sprayed with paclobutrazol. The vermiculite was allowed to dry for 16 h after spraying and then was stored in plastic bags in a controlled environment. Vermiculite was prepared that contained 0.09 mg or 0.18 mg of paclobutrazol per 15 mL. The 0.09-mg and 0.18-mg amounts were developed to apply the same amount of active ingredient as applied when 1 and 2 mg·L⁻¹ solutions are applied as a drench in 90 mL.

This experiment was a 3 × 2 factorial and was started on 12 Feb. 2009. The paclobutrazol amounts were 0, 0.09, and 0.18 mg per container. Seedlings of petunia ‘Dreams Burgundy’ were transplanted into same container used in Experiment 1. The pots were first filled to a depth of 4 cm, the 15 mL of vermiculite was added and then pots were filled with substrate. The depth of 4 cm ensured the vermiculite would be above the water level on the subirrigation bench. Half of plants were irrigated by hand and half were on subirrigation as described in Experiment 1.

Data were collected on 25 Mar. Experimental design and data analysis were same as in Experiment 1.

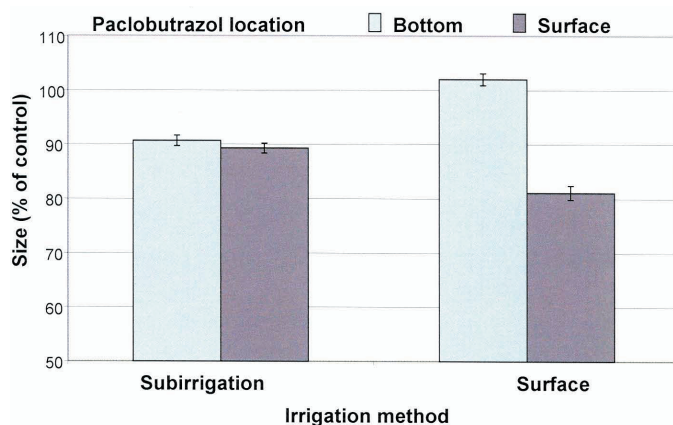


Fig. 3. Impatiens were grown in containers with diameter of 15.5 cm and depth of 17.5 cm. Paclobutrazol was applied either through the bottom of the container or to the surface of the growing media and irrigation was either applied by subirrigation or to the media surface. Plant size is (height + width)/2 and is expressed as percent of control plant size in each irrigation method. ANOVA indicated the paclobutrazol location × irrigation method interaction was significant. Means are shown with standard error bars. Expt. 3.

Results and Discussion

A series of experiments were conducted to evaluate how site of application and direction of irrigation affects the efficacy of the paclobutrazol. In Experiment 1, paclobutrazol was applied through the bottom of the container. Paclobutrazol efficacy was greater when plants were irrigated through the bottom of the container as plant size for petunias on subirrigation and on surface irrigation was 17 and 22 cm, respectively (Fig. 1).

For Experiment 2, paclobutrazol was applied to the media surface. Paclobutrazol efficacy (Fig. 2) was slightly greater with subirrigation, as was the case in Experiment 1. Plant size was 21.5 and 23.5 cm for plants on subirrigation and surface irrigation, respectively. The size difference between plants on subirrigation and ones on surface irrigation was less in Experiment 2 compared to Experiment 1. In addition to the difference in location of the paclobutrazol application, some of the variation between Experiments 1 and 2 might be explained by plants in Experiment 1 receiving a higher dose of active ingredient than in Experiment 2.

Experiment 3 brings together the different application sites of Experiment 1 and 2 with the same irrigation methods. A control treatment was added for each irrigation, and in Fig. 3 data are expressed as a percentage of the control plant size. The amounts of paclobutrazol applied by surface drench and through the bottom of the container were the same in this experiment. ANOVA analysis of the data indicated that the application procedure and irrigation method interaction was significant. For plants on subirrigation there was little difference in size for plants in the two paclobutrazol application methods. However, there were larger differences between the bottom and top application treatments when plants were irrigated from the top.

The application of paclobutrazol to the media surface followed by irrigation to the surface produced the smallest plants. The least amount of efficacy was observed where application was to bottom of the container and plants received surface irrigation. The latter treatment resulted in plants slightly larger than the control plants. In growth regulator studies a slight stimulation in growth is occasionally seen at very low chemical concentrations.

The plants in Experiment 3 were growing in taller containers than used in Experiments 1, 2, and 4. The lack of efficacy for paclobutrazol applied to the bottom of containers irrigated from above was likely because of the depth of the container. In this situation, the paclobutrazol probably was bound to the bottom layer of media and stayed there out of the region where most plant roots were growing. Paclobutrazol applied to bottom of the containers had better efficacy when followed by subirrigation. In which case, the water movement upwards through the media probably moved the paclobutrazol up into the region where more roots were growing.

For Experiment 4, vermiculite loaded with paclobutrazol was placed 4 cm above the bottom of the container. Paclobutrazol does not bind to vermiculite (Million, et al., 1998) and applications by this procedure may lead to paclobutrazol being added to a targeted location within the root zone.

The interaction between paclobutrazol concentration and irrigation method was significant. Control plants in the two irrigation methods had similar sizes (Fig. 4). All plants receiving paclobutrazol were smaller than the control plants. However, differences in plant size due to paclobutrazol were greater for plants on subirrigation compared to plants irrigated from above. The increased efficacy due to subirrigation was probably caused by the upward movement of water carrying the paclobutrazol closer to

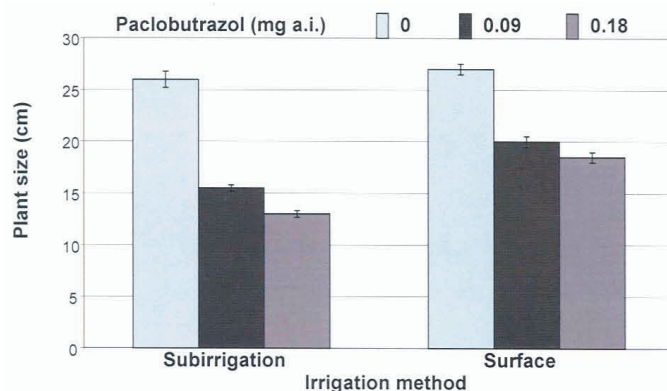


Fig. 4. Petunias were planted in containers with a layer of vermiculite that had been coated with paclobutrazol. Amounts of active ingredient were 0, 0.09, or 0.18 mg, which corresponds to amount of paclobutrazol applied in 90-mL drench of 0, 1, or 2 ppm, respectively. Irrigation was either applied by subirrigation or to the media surface. ANOVA indicated the paclobutrazol amount \times irrigation method interaction was significant. Means are shown with standard error bars. Expt. 4.

the root system. With top irrigation the paclobutrazol would have the tendency to move down from the vermiculite. This situation would possibly result in the roots of plants on subirrigation being exposed to paclobutrazol sooner and at a higher concentration compared to plants irrigated from above.

Paclobutrazol applied through the bottom of the container had greater efficacy on subirrigation compared to irrigation from above in Experiments 1 and 3. For paclobutrazol application to the media surface, the results of Experiments 2 and 3 were not consistent. In Experiment 2 there was slightly greater efficacy with subirrigation, while in Experiment 3 there was significantly less efficacy with subirrigation. Results of Experiment 4 where paclobutrazol was applied on vermiculite indicated slightly greater efficacy with subirrigation.

The results from this series of experiments support the original hypothesis that the efficacy of paclobutrazol is affected by both the method of application to the media and by the method of irrigation. Most recommendations for optimum amounts of paclobutrazol to use in drench applications are based on research where the chemical was applied to the surface and irrigation also was to the media surface. Further research is needed to develop a full understanding of the factors that affect the efficacy of paclobutrazol applied to media.

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