The Effect of Daminozide and Chlormequat on the Growth and Flowering of Poinsettia and Pansy

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Abstract. Poinsettia (Euphorbia pulcherrima Willd. Ex Klotzch) ‘Freedom Red’ (FR), ‘Success Red’ (SR), and ‘Winter Rose Dark Red’ (WRDR) were received from a commercial propagator (Paul Ecke Ranch, Encinitas, Calif.) and potted into 10-cm-diameter (454-mL) standard pots using a peat-based medium (Fafard 3B; Fafard Inc., Anderson, S.C.) on 26 July. Unpinched plants were grown at 30.5 × 30.5 cm spacing to simulate commercial methods. One plant was grown per container. Fourteen growth regulator combinations were tested. Three treatments had a 1:1 daminozide (mg L⁻¹)-to-chlormequat (mg L⁻¹) ratio (500/500, 1000/1000, 1500/1500), three treatments had a 2:1 ratio (1000/500, 2000/1000, 3000/1500) and three treatments had a 3:1 ratio (1500/500, 3000/1000, 4500/1500). These five treatments were control groups where the daminozide and/or the chlormequat concentrations should only be applied to stock product label advises to avoid concentrations greater than 2500 mg L⁻¹ daminozide or 1500 mg L⁻¹ chlormequat. The chlormequat product label advises to avoid applications up an incomplete factorial arrangement, with each plant treatment. The experiment was repeated on 2 consecutive days (14 and 15 Aug.) for a total of 14 plants for each chemical combination. Separate PGR solutions were mixed and continued throughout the duration of the experiment. The average daily light integral delivered to the plant canopy during the course of the experiment was 15.3 mol m⁻² d⁻¹, calculated by multiplying outside irradiance by the greenhouse photosynthetic photon flux transmission percentage. A constant liquid fertilization program was used where a 300 mg L⁻¹ N solution from 15N–2.2P–12K Peter’s Excel or 20N–8.6P–16.6K Peat-Lite Special (O.M. Scott, Marysville, Ohio) was alternated weekly. Short days were initiated on the day that the PGR applications were made and continued throughout the duration of the experiment by covering the plants with black cloth at 1700 hr and removing at 0800 hr the following morning. Short days were provided at the time of the PGR treatments since commercial applications typically occur near the time of flower initiation, and applications made near the time of flower initiation have the potential to affect the time to flower and bract size (Bailey and Miller, 1991). The date of first bract color and anthesis...
was recorded for each plant. A destructive harvest was conducted on individual plants as they reached anthesis. Plant height, shoot fresh weight, total bract area, bract petiole length, and transitional bract internode length were recorded at harvest. Shoot fresh weight consisted of all plant tissue above the growing medium. Bract area of the three acropetal transitional bracts and the three primary true bracts was recorded with a leaf area meter (LI-3000; LI-COR, Inc. Lincoln, Neb). Transitional bracts are defined as the green leaves that change to red as the plant matures. True bracts are the three primary bracts that occur in the whorl subtending the cyathium and are red when first visible. Total bract area is the sum of the area of the three true and three transitional bracts. The bract area of WRDR could not be measured with a leaf area meter because of the curved bracts, so the bract canopy diameter was measured as described by Bailey and Miller (1991). Petiole lengths were recorded for the three transitional and three true bracts. Internode length was recorded above the three nodes associated with the three acropetal transitional bracts.

**Pansy.** Plugs (1.9 cm², 9.5 mL) of ‘Colossus Yellow Blotch’ (CYB), ‘Delta Pure Yellow’ (DPY), and ‘Majestic Giants Purple’ (MGP) were received from a commercial grower (Wagner’s Greenhouses, Minneapolis) and were potted on 16 Aug. in the same medium and container types as the poinsettias. Plants were grown at 10 × 10 cm spacing to simulate commercial production methods. The experiment was repeated on 2 consecutive days. On day one of each replication, 168 plants were divided into 14 treatments, each containing 12 plants. In the first replication, growth regulators were applied on 29 Aug., 5 Sept., and 13 Sept., and for the second replication, 30 Aug., 6 Sept., and 14 Sept. Separate PGR solutions were mixed for each application date. Individual plants were completely randomized within each replication. This was an incomplete factorial with 12 plants per treatment and replicated with two different series of application dates.

Liquid fertilization was applied weekly with 20N–8.6P–16.6K Peat-Lite Special (O.M. Scott, Marysville, Ohio) at 300 mg·L⁻¹ N. Clear water was applied as needed the remainder of the week.

A destructive harvest was performed on individual plants when two flowers per plant were fully open. Data collected included primary stem length (i.e., the primary stem was held upright to measure the distance from the medium surface to the shoot apex), shoot fresh weight, total bract area, bract petiole length, and transitional bract internode length. Petiole lengths were recorded for the three transitional and three true bracts. Internode length was recorded above the three nodes associated with the three acropetal transitional bracts.

**Fig. 1.** Effect of daminozide and chlormequat on plant height of poinsettia (A) ‘Freedom Red’, (B) ‘Success Red’, and (C) ‘Winter Rose Dark Red’. Data were collected when individual plants reached anthesis. The surfaces represent the results of stepwise regression analysis. The equation for each surface is shown above each figure, where D indicates daminozide and C indicates chlormequat.

**Fig. 2.** Effect of daminozide and chlormequat on shoot fresh weight of poinsettia (A) ‘Freedom Red’, (B) ‘Success Red’, and (C) ‘Winter Rose Dark Red’. Data were collected when individual plants reached anthesis. The surfaces represent the results of stepwise regression analysis. The equation for each surface is shown above each figure, where D indicates daminozide and C indicates chlormequat.

**Fig. 3.** Effect of daminozide and chlormequat on total bract area of poinsettia (A) ‘Freedom Red’, (B) ‘Success Red’, and (C) ‘Winter Rose Dark Red’. Data were collected when individual plants reached anthesis. The surfaces represent the results of stepwise regression analysis. The equation for each surface is shown above each figure, where D indicates daminozide and C indicates chlormequat.

**A. Freedom**

\[ y = (D^{*} - 1.46E-03) + (C^{*} - 2.72E-03) + 49.5 \]

\[ R^2 = 0.832 \]

**B. Success**

\[ y = (D^{*} - 1.31E-03) + 49.2 \]

\[ R^2 = 0.600 \]

**C. Winter Rose**

\[ y = (D^{*} - 8.26E-04) + (C^{*} - 1.18E-03) + 21.6 \]

\[ R^2 = 0.871 \]
fresh weight (i.e., all tissue above the media surface) and the number of lateral stems >1 cm. Petiole lengths and leaf areas of the three largest leaves per plant were recorded. The date and diameters of first and second fully opened flowers were recorded.

Statistical analysis. Stepwise regression analysis was performed on the means for each replication using PROC REG (SAS Institute, Inc. Cary, N.C.). Terms considered in the analysis were the linear and quadratic components for each chemical and all the possible interactions. Non-significant terms (p > 0.20) were deleted from the model.

Results and Discussion

Poinsettia. Final plant height of FR decreased as daminozide or chlormequat concentration increased, however little additional control of stem elongation occurred when one PGR was added to the other in the tank mix combinations (Fig. 1A). SR height showed an interactive effect of the two PGRs (Fig. 1B). WRDR height decreased linearly as daminozide or chlormequat concentration increased, and no interaction was observed (Fig. 1C). The final plant height was 6.4, 4.4, and 5.5 cm shorter for FR, SR, and WRDR, respectively, for the 4500/1500 mg L\(^{-1}\) daminozide/chlormequat tank mix treatment compared to the control (0/0 mg L\(^{-1}\) daminozide/chlormequat tank mix).

Shoot fresh weight of FR decreased linearly as daminozide or chlormequat increased, while SR and WRDR were affected only by daminozide (Fig. 2A–C). Total bract area of FR and canopy bract diameter of WRDR decreased linearly as daminozide or chlormequat increased, while SR was only by daminozide (Fig. 3A–C).

Petiole length of FR and SR was 4.4 and 6.7 mm shorter, respectively, for the 4500/1500 mg L\(^{-1}\) tank mix treatment compared to the control (data not shown). Petiole length of WRDR was 2.4 mm shorter for the 4500 mg L\(^{-1}\) daminozide application compared to the control, while chlormequat had no significant effect. Internode length of the stem associated with the transitional bracts was not significantly affected by daminozide or chlormequat. Time to first color of SR was delayed by 2 d with the 4500 mg L\(^{-1}\) daminozide application (data not shown), while no other PGR treatment delayed time to first color. Time of anthesis was not significantly affected by daminozide or chlormequat for any of the three cultivars.

A. Colossus Yellow Blotch

\[ y = (D^* - 2.30E-04) + 5.2 \quad R^2 = 0.375 \]

B. Delta Pure Yellow

\[ y = (D^* - 3.98E-04) + 6.7 \quad R^2 = 0.559 \]

C. Majestic Giants Purple

\[ y = (D^* - 1.76E-07) + 7.7 \quad R^2 = 0.226 \]

Fig. 4. The effect of daminozide and chlormequat on the primary stem length of pansy (A) ‘Colossus Yellow Blotch’, (B) ‘Delta Pure Yellow’, and (C) ‘Majestic Giants Purple’. Data were collected when two flowers were fully opened on individual plants. The surfaces represent the results of stepwise regression analysis. The equation for each surface is shown above each figure, where D indicates daminozide and C indicates chlormequat.

A. Colossus Yellow Blotch

\[ y = (D^* - 6.41E-04) + 12.3 \quad R^2 = 0.468 \]

B. Delta Pure Yellow

\[ y = (D^* - 5.44E-04) + (C^* - 7.58E-11) = 15.3 \quad R^2 = 0.698 \]

C. Majestic Giants Purple

\[ y = (D^* - 3.79E-04) + 18.4 \quad R^2 = 0.186 \]

Fig. 5. The effect of daminozide and chlormequat on shoot fresh weight of pansy (A) ‘Colossus Yellow Blotch’, (B) ‘Delta Pure Yellow’, and (C) ‘Majestic Giants Purple’. Data were collected when two flowers were fully opened on individual plants. The surfaces represent the results of stepwise regression analysis. The equation for each surface is shown above each figure, where D indicates daminozide and C indicates chlormequat.

A. Colossus Yellow Blotch

\[ y = (D^* - 2.15E-04) + 3.6 \quad R^2 = 0.741 \]

B. Delta Pure Yellow

\[ y = (D^* - 2.02E-07) + (C^* - 2.12E-04) + (D^* C^* - 3.42E-11) = 4.2 \quad R^2 = 0.765 \]

C. Majestic Giants Purple

\[ y = (D^* - 1.21E-04) + 4.3 \quad R^2 = 0.361 \]

Fig. 6. The effect of daminozide and chlormequat on petiole length of pansy (A) ‘Colossus Yellow Blotch’, (B) ‘Delta Pure Yellow’, and (C) ‘Majestic Giants Purple’. Data were collected when two flowers were fully opened on individual plants. The surfaces represent the results of stepwise regression analysis. The equation for each surface is shown above each figure, where D indicates daminozide and C indicates chlormequat.
For poinsettia, tank mixes applied at the start of short days effectively reduced stem elongation; however, a relatively large reduction in bract area was also observed. The PGR treatments produced shorter bract petioles resulting in a smaller bract canopy diameter. The total bract area of the untreated control demonstrates that FR is a relatively large-bracted cultivar while SR is a relatively small-bracted cultivar. Smaller bract size can be acceptable for large-bracted cultivars; however, little bract reduction is acceptable for small-bracted cultivars. All of the treatments in this study produced total bract areas $>250\text{cm}^2$, which was commercially acceptable. Even though the PGR treatments did not affect the anthesis date, the market date may be delayed by a few days as a result of the decreased bract area since the PGR-treated plants may require more time to achieve a commercially acceptable bract area.

Leaf color data were not collected in this study, but it was apparent that daminozide significantly intensified the dark green pigmentation in poinsettia leaves. Daminozide is not frequently applied alone on commercial poinsettia crops; however, our data suggests that daminozide alone would be a particularly effective treatment on poinsettia stock plants where the focus is to produce a toned cutting with dark green leaves.

In this study, we observed phytotoxicity in the form of chlorotic spots on WRDR leaves occurring 2 d following the 0/1500 mg·L–1 daminozide/chlormequat applications. Treatments with the same chlormequat concentration and varying rates of daminozide, e.g., 1500/1500, 3000/1500, and 4500/1500 mg·L–1 daminozide/chlormequat, displayed no phytotoxicity. Thus, the tank mix appears to reduce poinsettia sensitivity to chlormequat phytotoxicity. It is possible that tank mixing daminozide and chlormequat could allow for the application of higher rates of chlormequat without causing phytotoxicity. Further experimentation is warranted.

**Pansy.** The growth responses of pansies to the PGR treatments was highly dependent on cultivar, while the time to first and second open flower was not affected by the PGR treatments for any of the cultivars. The growth of CYB responded only to daminozide (Figs. 4A, 5A, and 6A). Increasing daminozide from 0 to 4500 mg·L⁻¹ on CYB resulted in a 1.1 cm shorter primary stem length, a 1.0 cm shorter petiole length, and a 3.9 cm² smaller leaf area. Lateral stem number of CYB was not affected by the tank mixes.

The primary stem length of DPY responded to daminozide, while shoot fresh weight and petiole length responded to daminozide and chlormequat (Figs. 4B, 5B, and 6B). Primary stem length was 1.8 cm shorter for DPY as daminozide increased from 0 to 4500 mg·L⁻¹, while the shoot fresh weight decreased 4.8 g for the 4500/1500 mg·L⁻¹ tank mix compared to the control. Leaf area of DPY was 1.9 cm² smaller when treated with 1500 mg·L⁻¹ chlormequat compared to the control (data not shown). Lateral stem number of DPY increased from 3.8 to 4.7 stems per plant as daminozide increased from 0 to 4500 mg·L⁻¹, while chlormequat had no effect (data not shown). MGP displayed statistically significant growth responses to the PGR treatments, however the magnitude of the responses were commercially insignificant and the $R^2$ values were low (Figs. 4C, 5C, and 6C).

Other PGRs, such as paclobutrazol and uniconazole are more effective on pansy than daminozide and chlormequat, however over-application can result in stunting, so daminozide and chlormequat are a viable option for commercial growers. However, the multiple applications required to produce the moderate growth regulating effect observed in this study are likely to make the daminozide and chlormequat tank mix a more expensive application than paclobutrazol or uniconazole. For example, the cost for a single application of 4500 mg·L⁻¹ daminozide/1500 mg·L⁻¹ chlormequat was estimated at $1.40/L compared to $0.25 for 10 mg·L⁻¹ paclobutrazol or $0.64 for 5 mg·L⁻¹ uniconazole (R. Heins, personal communication).

Considering the large number of commercial varieties of poinsettias and pansies and the rate of cultivar turnover from year to year, the criterion for developing a useful preblended product using a 3:1 daminozide-to-chlormequat ratio has the potential to provide a useful commercial product.

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