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Research Report

Control Growth of *Euphorbia pulcherrima* Willd. ex Klotzsch 'Sonora Jingle' and 'Sonora White' Using Ethephon

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Abstract. Ethephon was sprayed on *Euphorbia pulcherrima* Willd. ex Klotzsch (poinsettia) 'Sonora Jingle' and 'Sonora White' to control their height and produce more compact potted plants. The results showed that Ethephon could effectively control the growth of 'Sonora Jingle' and 'Sonora White' poinsettia. Height was reduced by was 33.4 ± 0.8% for 'Sonora Jingle' and 30.8 ± 1.3% for 'Sonora White' poinsettia, when 700 $mg \cdot L^{-1}$ Ethephon was sprayed three times on 29 August, 20 September, and 13 October 2005, respectively. Similar to other plant growth retardants, side effects including phytotoxicity and delays to first bract color were also observed on Ethephon treated poinsettia. However, all plants produced were still of a marketable quality.

***Additional key words*:** foliar spray, height control, phytotoxicity, poinsettia

Introduction

Euphorbia pulcherrima Willd. ex Klotzsch (poinsettia), native to tropical America, is a small tree with strikingly colored bracts and contrasting foliage color. Poinsettia has been used as a traditional Christmas decoration for many years. It is commercially grown in all 50 states and the national annual gross value of poinsettias is over $220 million in the United States alone (University of Illinois Extension, 2010). After 100 years of breeding and cultivation, more than 100 varieties of poinsettias are now in existence (University of Illinois Extension, 2010). Two new commercially grown cultivars are 'Sonora White' and 'Sonora Jingle', introduced by the Fischer Company (Boulder, CO). 'Sonora Jingle' poinsettias have excellent branching habit and red bracts with pink flecks, while 'Sonora White' poinsettias have puckered, droopy, creamy-white bracts with extensively lobed margins (Cole et al., 2002).

Under greenhouse conditions, poinsettias usually grow too tall and leggy, which leads to lower-valued products and increasing transport expenses. Many plant growth factors challenge commercial growers to control poinsettia stem elongation. For instance, plants usually elongate more when day temperatures exceed night temperatures, compared with plants grown where night temperatures exceed day temperatures. Keeping a negative difference between day and night temperatures (DIF) reduces stem elongation, compared with zero and positive DIFs. This regime can be used to successfully control plant height (Bailey and Whipker, 1998). But, growing a crop at a strongly negative DIF for a long time is neither economical nor necessary. Strongly negative DIF causes carbohydrate depletion, which is the primary reason that poinsettias drop their cyathia (flowers) (Yates, 2010).

In recent years, biological, physical, and chemical controls have become available to growers, thus enabling the production of a desirable product. With the use of these agents, height control of poinsettias through photoselective filters (Clifford et al., 2004), irradiance control (Bailey and Miller, 1991), and plant growth retardants (Bailey and Whipker, 1998; Ecke et al., 1990) have been documented. Removing the far-red light using $CuSO_4$-filled panels reduced internode length in 'Celebrity White' hybrid petunia plants (*Petunia* × *hybrida* Hort. Vilm-Andr.) by 27% and 40%, respectively, compared with the absence of filters or clear panel controls (Bachman and McMahon, 2006). High light intensity tends to reduce plant elongation and plants grown in higher irradiance are shorter at maturity (Bailey and Whipker, 1998). However, the cost of this method (including equipment and labor) and its influence on crop timing and plant quality continue to challenge commercial poinsettia growers.

Preplant root zone soaks of uniconazole {(βE)-β-[(4-chlorophenyl)methylene]-α-(1,1-dimethylethyl)-1H-

1,2,4-triazole-1-ethanol} was an effective height control, but it required careful regulation of the concentration and volume of solutions in order to achieve the desired height reduction without excess reduction of bract area (Bearce and Singha, 1992). Drench applications of paclobutrazol [(2RS, 3RS)-1-(4-Chlorophenyl)-4,4-dimethyl-2-(1H-1,2,4-triazol-1-yl)-pentan-3-ol] on 'Freedom Red' poinsettias in late production effectively reduced their height and had the least risk for negatively affecting bract size (Faust et al., 2001). Moreover, Niu et al. (2002) reported that drench applications of paclobutrazol resulted in plant height reduction and smaller bract area when applied after flower initiation. Therefore, drench applications of paclobutrazol should be delayed as long as possible in order to limit reduction in bract size. Chlormequat (2-chloro-*N*,*N*,*N*-trimethylethanaminium) and ancymidol [α-cyclopropyl-α-(4-methoxyphenyl)-5-pyrimidinemethanol] were also documented to effectively control poinsettia height as foliar sprays and soil drenches (Tjia et al., 1976; White and Holcomb, 1974). Although soil drenches of these materials are more effective in height retardation of poinsettia and produce more consistent plant size, foliar sprays are most commonly used for height control in commercial practice of poinsettia due to ease of application and lower costs.

Most of plant growth retardants are anti-gibberellins, which inhibit gibberellin biosynthesis within the plants. However, Ethephon [(2-chloroethyl) phosphonic acid)] is not an anti-gebberellin. It releases ethylene to reduce cellular elongation. Therefore, it is a feasible alternative to height control because of lower cost than all other plant growth retardants listed above (Latimer, 2001). However, it is still labeled as a growth retardant for only a very few crops, including daffodil and hyacinth (Bailey and Whipker, 1998). To control poinsettia height and produce higher quality compact potted plants, 'Florel' (3.9% Ethephon, 96.1% inert ingredients; Southern Agricultural Insecticides, Inc., Palmetto, FL) was applied as foliar spray to the recent cultivars, 'Sonora Jingle' and 'Sonora White'. The aim of this study was to determine the effects of foliar spray of Ethephon on the growth and flowering of two poinsettia cultivars.

Materials and Methods

Rooted cuttings (~5 cm) *of Euphorbia pulcherrima* Willd. ex Klotzsch 'Sonora Jingle' and 'Sonora White' poinsettia were received from Fischer Horticulture LLC (Miramar, FL) on 29 July 2005. Upon arrival, they were potted into 14.8-cm-diameter (1.3 L) Azalea Thinwall round green pots (Dillen Products Inc., Sparks, NV) with a commercial substrate containing 35-45% bark, 20-30% coir, 10-20% Canadian sphagnum peat moss, 5-15% horticultural grade perlite, 5-15% processed bark ash, starter nutrient charge, dolomitic limestone, and wetting agent (Metro-Mix 560 Coir, Scotts-Sierra Horticultural Products Company, Marysville, OH). All plants were grown in a glass greenhouse at the University of Maine in Orono, ME. Temperature and light intensity were recorded by using 21X Micrologger (Campbell Scientific Inc., North Logan, Utah). Temperatures ranged from 18℃ to 32℃ (day/night temperature: 22.6 ± 2.5/20.9 ± 3.8℃) and the maximum light intensity was 961 $\mu mol \cdot m^{-2} \cdot s^{-1}$. All plants were pinched 20 days after transplanting. Plants were watered as necessary with 20 N-2.2 P-15.8 K solution (Poinsettia Miracle-Gro®, 20-5-19; The Scotts Company, Marysville, OH) at a concentration of 100 $mg \cdot L^{-1}$ through 23 August, 200 $mg \cdot L^{-1}$ from 24 August to 30 September, and 300 $mg \cdot L^{-1}$ thereafter. Peters Professional Water Soluble Fertilizer S.T.E.M. (Soluble Trace Element Mix) (The Scotts Company, Marysville, OH) at a concentration of 1.0 $g \cdot L^{-1}$ was applied with fertilizer on 2 September. To control fungi and insects, plants were drenched with Marathon® 1% Granular Greenhouse & Nursery Insecticides (1/2 teaspoon/pot) (Olympic Horticultural Products, CO., Mainland, PA) on 15 August, sprayed with 0.6 $g \cdot L^{-1}$ Banrot® 40% Wettable Powder (The Scotts Company, Marysville, OH) on 15 August, 3.0 $g \cdot L^{-1}$ Talstar® GH (Whitmire Micro-Gen. Research Laboratories, Inc., St. Louis, MO) on 25 October, and 36.4 $g \cdot L^{-1}$ Endeavor (50.0% Pymetrozine; Syngenta Crop Protection, Inc., Greensboro, NC) on 23 November.

Plants were arranged in a randomized complete block design with four blocks, 2 plants per block per treatment. The experimental treatments were: A: control (No Ethephon); B and C: 500 and 700 $mg \cdot L^{-1}$ Ethephon sprayed twice, each sprayed on 29 August and 30 September, respectively; D, E, and F: 300, 500 and 700 $mg \cdot L^{-1}$ Ethephon sprayed three times, each sprayed on 29 August, 20 September, and 13 October, respectively. Height from the media level to the tallest point of the plant was measured weekly. Only five randomly selected plants from all treatments were recorded before 4 September, while all plants were recorded from 4 September through the end of the experiment. The date of first bract color was recorded for each plant. The number of nodes of each plant was counted and their plant diameters at the top of the canopy perpendicular to each other were measured at the end of experiment. A destructive harvest was conducted on four plants per treatment per block on 10 December. Bract area of the six biggest primary true bracts was measured using a leaf area meter (LI-3100; LI-COR, Lincoln, NE). True bracts are the primary bracts that occur in the whorl subtending the cyathia and are red or white when first visible. All plant tissue above the growing medium was harvested and dried in a soil-drying room and dry mass was noted.

Mean height of each treatment was plotted against days after Ethephon application from 29 August through the end of experiment. Average internode length was calculated by the following equation: (height ÷ number of nodes). Canopy size was calculated as a multiplication of two diameters per plant. Bract size was 1/6 of total bract area of the six biggest primary true bracts. All data including average internode length, bract size, canopy size, dry weight, days of first bract color, and height were analyzed using ANOVA in Statistical Analysis Systems (SAS Version 9.1; SAS Institute, Inc., Cary, N.C.) and mean separations by Student-Newman-Keuls (SNK) test at $P < 0.05$ were applied.

Results and Discussion

Poinsettia height was measured weekly after Ethephon application. All poinsettias grew at a similar rate until 37 days after Ethephon application, followed by differentiated growth rates. Compared with poinsettias in treatment D, 'Sonora Jingle' poinsettias without Ethephon application grew at a similar rate in 0-37 day, faster in 37-65 day, again at a similar rate in 65-79 day and then much slower in 79-93 day, however, 'Sonora White' poinsettias without Ethephone application grew at a similar rate in 0-37 day, faster in 37-79 day, and then at a similar rate in 79-93 day. Furthermore, 'Sonora Jingle' and 'Sonora White' poinsettias in treatment F grew much slower in 51-72 day while the growth rate was similar in 0-51 and 72-93 day, compared with those in treatment D.

It seems an interesting phenomenon that effects of Ethephon do not clearly appear until 37 day after treatment. This might be an important stage for the application of Ethephon to control poinsettia growth. At this stage, Ethephon at 300, 500, and 700 $mg \cdot L^{-1}$ was only sprayed for poinsettias assigned into treatment D, E, and F. It was not surprising that these plants had a slower growth rate compared with those in treatment B and C. As the concentration of Ethephon increased, poinsettias have a lesser growth rate, except 'Sonora White' poinsettias in treatment D and E.

Plant height at the end of experiment was significantly different among all treatments ($P < 0.0001$). However, no significance was observed between cultivars ($P = 0.88$). The ANOVA results also suggested that there were no interactions between treatments and cultivars ($P = 0.34$). Compared with the control (no Ethephon), all other Ethephon-treated 'Sonora Jingle' and 'Sonora White' poinsettias were shorter at the end of experiment (Figs. 1 and 2). Ethephon at 700 $mg \cdot L^{-1}$ sprayed three times (treatment F) dramatically inhibited both 'Sonora Jingle' and 'Sonora White' poinsettias, whose heights were reduced by 33.4 ± 0.8% and 30.8 ± 1.3% of control, respectively (Fig. 2). Other treatments had less inhibitory influences. Height reduction of 'Sonora Jingle' poinsettia, expressed as % of control, was 12.8 ± 0.8%, 11.6 ± 1.2%, 17.9 ± 3.0%, and 23.7 ± 1.0 % for treatments B, C, D, and E, respectively, while that of 'Sonora White' poinsettia

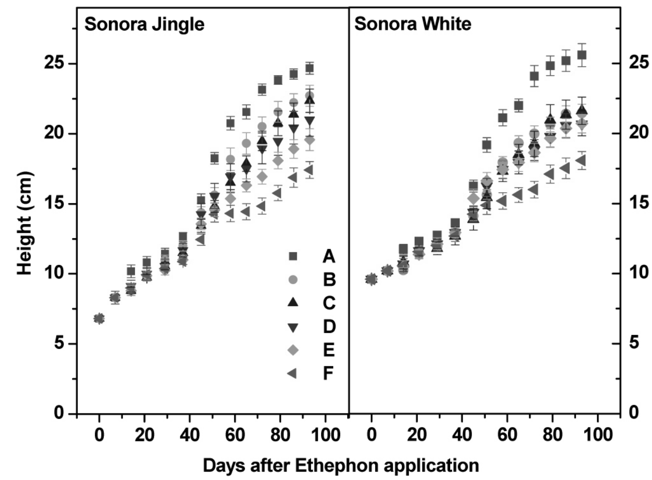

Fig. 1. The growth of 'Sonora Jingle' (Left) and 'Sonora White' (Right) poinsettias was affected by different Ethephon treatments, (A) control (No Ethephon), (B and C) 500 and 700 $mg \cdot L^{-1}$ Ethephon sprayed twice, each sprayed on 29 August and 30 September, respectively, (D, E, and F) 300, 500, and 700 $mg \cdot L^{-1}$ Ethephon sprayed three times, each sprayed on 29 August, 20 September, and 13 October, respectively. Height was measured routinely during the entire experiment and data after Ethephon application are shown. Height (mean ± standard error) of eight plants per treatment is presented.

was 17.1 ± 0.7%, 21.7 ± 3.0%, 19.4 ± 2.3%, and 21.4 ± 0.9% for treatments B, C, D, and E, respectively (Fig. 2). These results were comparable to previous research on the height control of poinsettia using plant growth retardants. Niu et al. (2002) reported that height of 'Freedom' poinsettia was reduced by 15-23% when 1 or 2 mg/L paclobutrazol was applied as a drench. Height of 'Annette Hegg Supreme' poinsettia was reduced by 17%, 39%, and 41% of control for the granular, drench, and spray applications, respectively, of 0.5 mg ancymidol active ingredient per pot (Wilfret, 1978).

Height reduction was more closely correlated with the average internode length ($P < 0.0001$) than the number of nodes ($P = 0.09$). This is very similar to other plant growth retardants, such as chlormequat chloride (Bailey and Whipker, 1998) and paclobutrazol (Faust et al., 2001). These growth retardants have a long-term impact on poinsettia stem elongation. Similar to the height, average internode length varied from treatment to treatment ($P < 0.0001$), but this was not the case for both cultivars ($P = 0.07$) and for interaction between treatment and cultivar ($P = 0.34$). The average internode length of 'Sonora Jingle' and 'Sonora White' poinsettia at 700 $mg \cdot L^{-1}$ sprayed three times (treatment F) was 42.5% ± 0.7 and 37.3 ± 1.9% shorter than the control (Fig. 2). Other treatments reduced the average internode length of 'Sonora Jingle' and 'Sonora White' poinsettia by 22.1 ± 2.5%-37.8 ± 1.2% and 18.7 ± 0.4%-34.5 ± 1.9%, respectively.

Canopy and bract area of 'Sonora Jingle' and 'Sonora White' poinsettias that were sprayed with Ethephon were significantly

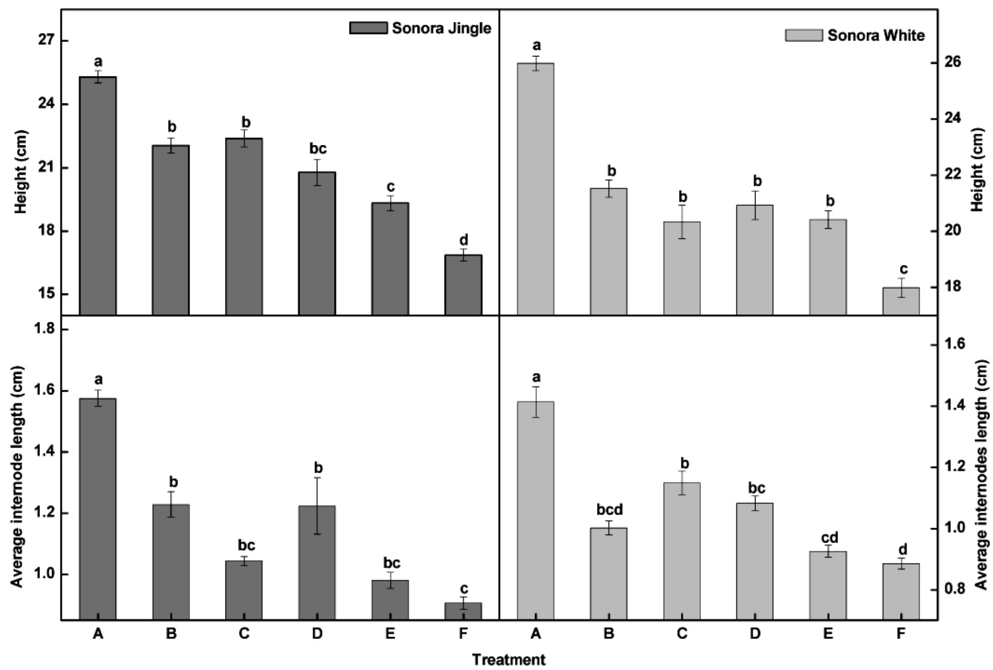

Fig. 2. Height and average internode length of 'Sonora Jingle' (left) and 'Sonora White' (right) poinsettia at different treatments (n = 8). (A) control (No Ethephon), (B and C) 500 and 700 mg·L^{-1} Ethephon sprayed twice, each sprayed on 29 August and 30 September, respectively, (D, E, and F) 300, 500, and 700 mg·L^{-1} Ethephon sprayed three times, each sprayed on 29 August, 20 September, and 13 October, respectively. Different letters in the column indicate that they are significantly different at P < 0.05 according to Student-Newman-Keuls mean separation. Vertical error bars represent ± standard error.

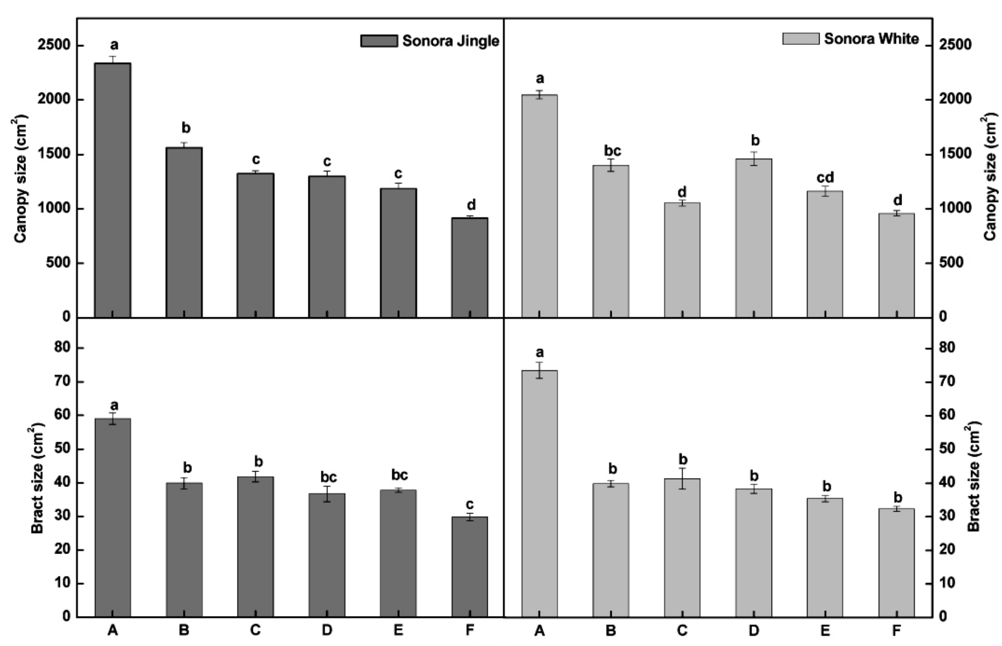

Fig. 3. Influence of different treatments on the canopy size (n = 8) and bract size (n = 4) of 'Sonora Jingle' (left) and 'Sonora White' (right) poinsettia, (A) control (No Ethephon), (B and C) 500 and 700 mg·L^{-1} Ethephon sprayed twice, each sprayed on 29 August and 30 September, respectively, (D, E, and F) 300, 500, and 700 mg·L^{-1} Ethephon sprayed three times, each sprayed on 29 August, 20 September, and 13 October, respectively. Different letters in the column indicate that they are significantly different at P < 0.05 according to Student-Newman-Keuls mean separation. Vertical error bars represent ± standard error.

reduced in comparison to that of the control (Fig. 3). ANOVA results showed that canopy area differed significantly among treatments (P < 0.0001), but not between cultivars (P = 0.07), and there was no interaction between treatment and cultivar

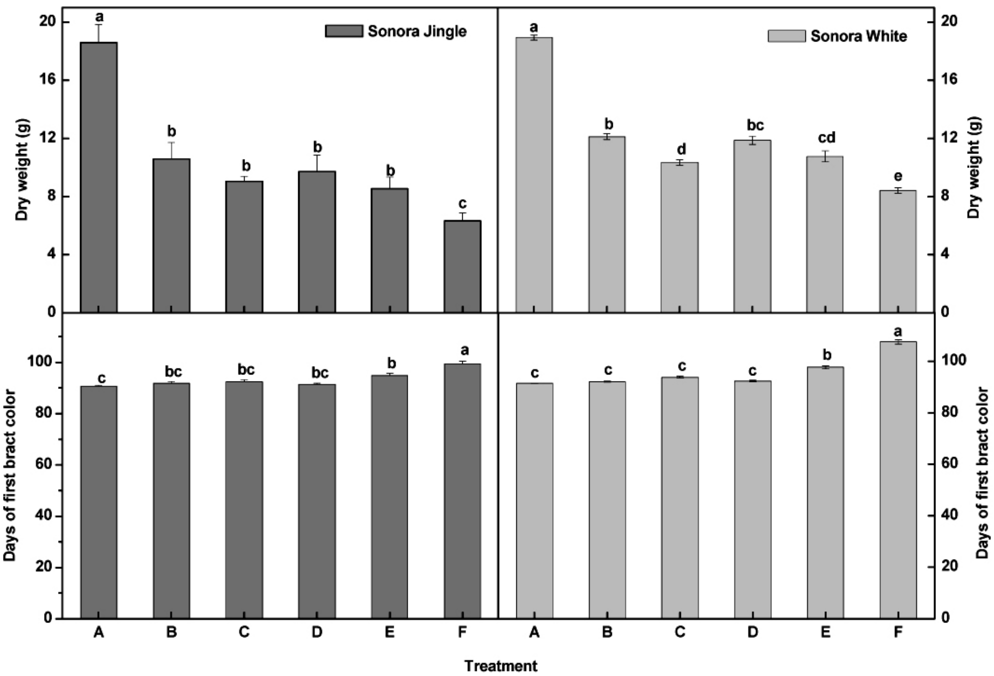

Fig. 4. Dry weight (n = 4) and days of first bract color (n = 8) of 'Sonora Jingle' (left) and 'Sonora White' (right) poinsettia at different treatments, (A) control (No Ethephon), (B and C) 500 and 700 mg·L^{-1} Ethephon sprayed twice, each sprayed on 29 August and 30 September, respectively, (D, E, and F) 300, 500, and 700 mg·L^{-1} Ethephon sprayed three times, each sprayed on 29 August, 20 September, and 13 October, respectively. Different letters in the column indicate that they are significantly different at P < 0.05 according to Student-Newman-Keuls mean separation. Vertical error bars represent ± standard error.

(P = 0.06). The maximum relative reductions of canopy area, as % of control, were 60.9 ± 0.3% and 53.2 ± 0.7% for 'Sonora Jingle' and 'Sonora White' poinsettia, respectively, when 700 mg·L^{-1} Ethephon was applied three times (treatment F) (Fig. 3). Other treatments yielded less reduction, 33.2 ± 0.2%-49.3 ± 1.4% for 'Sonora Jingle' poinsettia and 28.7 ± 3.5%-48.6 ± 0.6% for 'Sonora White' poinsettia. Therefore, foliar spray of Ethephon could produce more compact poinsettias. Similarly, a significant difference of bract area among treatments was recorded (P < 0.0001), but no difference was found between cultivars (P = 0.17) or between treatment and cultivar (P = 0.15). The maximum relative reductions of bract area were 49.6 ± 0.7% and 56.0 ± 0.9% for 'Sonora Jingle' and 'Sonora White' poinsettia, respectively, when 700 mg·L^{-1} Ethephon was applied three times (Fig. 3). The bract area of the poinsettias from other treatments was smaller than those of control, 29.2 ± 1.2%-37.8 ± 4.1% for 'Sonora Jingle' poinsettia and 43.8 ± 5.0%-51.8 ± 0.7% for 'Sonora White', respectively. In previous research reports, reduction in bract area was also observed (Bailey and Miller, 1991; Faust et al., 2001; Niu et al., 2002). However, quality at all treatments was still in an acceptable range. In fact, there was a significance of the ratio of bract to canopy among all tested treatments (P = 0.04); however, the ratio of bract to canopy area for most of treatments, such as treatment B, C, E, and F, was insignificant compared with the control. Even for the poinsettias in treatment D, the ratio of bract to canopy area was only 2% less than that of the control.

Like other plant growth retardants, such as daminozide, Chlomequat (Lewis et al., 2004), and paclobutrazol (Bailey and Whipker, 1998), Ethephon has inhibitory effects on biomass accumulation, or foliar phytotoxicity. In terms of dry weight, there was a significance among all treatments (P < 0.0001) and between cultivars (P = 0.0007), but no significant interaction between treatments and cultivars (P = 0.77). All Ethephon-treated 'Sonora Jingle' and 'Sonora White' poinsettias had significantly less biomass gain (Fig. 4). Compared with the control, the dry weight of 'Sonora Jingle' and 'Sonora White' poinsettia that received foliar sprays of Ethephon at 700 mg·L^{-1} three times (treatment F) decreased by 66.0 ± 0.8% and 55.5 ± 1.4%, respectively. Other treatments displayed less inhibitory influences on dry mass. But dry weight of 'Sonora Jingle' and 'Sonora White' poinsettia were still 43.0 ± 2.3%-54.0 ± 1.3% and 36.0 ± 1.0%-45.4 ± 1.0% less than control, respectively.

Ethephon also affected number of days of first bract color (Fig. 4). ANOVA indicated that there were differences among the treatments (P < 0.0001) and cultivars (P = 0.0007). An interaction between treatments and cultivars was also observed (P = 0.019). Poinsettias began to develop bract color 90 days after transplant and full bract color was achieved 113 days after transplant (data not presented). First bract color of 'Sonora

Jingle' poinsettia treated with 700 mg·L^{-1} Ethephon sprayed three times (F) was 9 days later than the control, while first bract color of 'Sonora White' was delayed 16 days (Fig. 4). Plants in treatment E (500 mg·L^{-1} Ethephon sprayed three times), were delayed 4 and 6 days for 'Sonora Jingle' and 'Sonora White' poinsettia, respectively. Other Ethephon treatments displayed very similar effects on bract color change. Delayed timing of first bract color was an undesirable side effect of Ethephon, and was also reported for other plant growth retardants (Ecke et al., 1990). Bailey and Miller (1991) reported that an application of 2500 mg·L^{-1} daminozide and 1500 mg·L^{-1} chlormequat spray made to poinsettias one week before start of short days delayed anthesis by 3 days. Although time to first bract color of 'Success Red' poinsettia was delayed by 2 days with a 4500 mg·L^{-1} daminozide application, no other daminozide or chlormequat treatments delayed time to first color for 'Freedom Red', 'Success Red', and 'Winter Rose Dark Red' poinsettia (Lewis et al., 2004).

In conclusion, foliar spray application of Ethephon could effectively control height of 'Sonora Jingle' and 'Sonora White' poinsettias. The maximum height reduction was 33.4 ± 0.8% and 30.8 ± 1.3% for 'Sonora Jingle' and 'Sonora White' poinsettia, respectively, when 700 mg·L^{-1} Ethephon was sprayed three times on 29 August, 20 September, and 13 October 2005, respectively. More compact plants could also be produced using Ethephon as a foliar spray. Although some side effects, such as phytotoxicity and delay of bract color development, occurred with a foliar spray of Ethephon, the plants were still of commercially acceptable quality.

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