Paclobutrazol Drenches Control Growth of Potted Sunflowers

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Summary. Paclobutrazol drenches were applied at 0, 2, 4, 8, 16, or 32 mg a.i./pot to potted sunflowers (*Helianthus annuus* L. 'Pacino') to determine its effect on growth. Plant height was shorter as paclobutrazol dose increased up to 16 mg; however, additional increases in dose had little effect on height. Severe height retardation of 'Pacino' plants was evident at 16 and 32 mg. Plants treated with 2 mg of paclobutrazol were 17% and 25% smaller in diameter than untreated plants in Expts. 1 and 2, respectively. Plant diameter was smaller as paclobutrazol dose increased up to 16 mg, with additional increases in dose having little effect on plant diameter in Expt. 2. Plants treated with 16 or 32 mg of paclobutrazol exhibited phytotoxicity symptoms including crinkled leaves and stunted growth, and smaller and greener leaves. Sunflower plant growth was greater in the summer (Expt. 1) than in winter (Expt. 2). In the summer higher doses of paclobutrazol will be required than in winter for growth control. Marketable sized plants grown in 15- to 16.5-cm-diameter pots were produced with doses of paclobutrazol at 2 and 4 mg in both seasons, and doses up to 8 mg can also be used in summer for growth control.

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Sunflower is an important agronomic crop in the world due to its high value as an oil and forage plant (Carter, 1978). The attractive inflorescence and foliage make it an ideal ornamental plant. However its tall-growing nature has limited its ornamental use. New shorter-growing cultivars have expanded the possible ornamental uses for sunflowers. Plant growth retardants (PGRs) are commonly applied to container-grown plants to limit stem elongation and produce a more compact plant (Barrett et al., 1994; Tayama et al., 1992). The height of 'Pacino' potted sunflower plants was significantly shorter when treated with foliar sprays of daminozide (2,2-dimethylhydrazide) at 4000 to 8000 mg·L^{-1} or uniconazole ((E)-1-(p-chlorophenyl)-4-,4-dimethyl-2-(1,2,4-triazol-1-yl-1-pentan-3-ol)) at 16 to 32 mg·L^{-1}, but foliar applications of paclobutrazol ((2R, 3R+ 2S, 3S)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl) pentan-3-ol)) at concentrations of 5 to 80 mg·L^{-1} produced no significant reduction in plant height (Whipker and Dasoju, 1998). Paclobutrazol is active when applied to the growing substrate, but may have little efficacy as a chemical growth retardant when applied as a foliar spray because it is not translocated out from treated leaves (Barrett and Bartuska, 1982; Davis et al., 1988). This study was conducted to determine the effectiveness of drench doses of paclobutrazol as a chemical height control for 'Pacino' potted sunflowers.

Materials and methods

Experiment 1. 'Pacino' sunflower seed were sown into cell packs (8 × 4 × 5.5 cm cells) on 18 May. On 8 June, seedlings were transplanted into 1.2-L (16.5-cm-diameter) round plastic containers. The growing substrate contained 2 soil : 5 sphagnum peat : 3 perlite (by volume) and was amended with ground dolomitic limestone to pH 5.1. Plants were fertilized at each watering (mg·L^{-1}) with 155N–21P–127K. Greenhouse day/night set points were 24/18 °C and the plants were grown under natural daylength. However, day temperatures often exceeded 33 °C and light levels averaged 550 µmol·m^{-2}·s^{-1} at 12:00 HR. Paclobutrazol drench treatments (mg a.i./pot) were applied 12 d after potting using 133 mL/pot at 2, 4, 8, 16, or 32; and an untreated control. The experiment was a completely randomized design with 12 single-plant replications of the six treatments. At anthesis, the number of days from seeding until anthesis, total plant height (measured from the pot rim to the top of the inflorescence), and inflorescence and plant diameter (measured at the widest dimension and turned 90°, and averaged) were recorded. Data were tested by analysis of variance by general linear model and Proc Reg procedures (SAS Institute, Cary, N.C.).

Experiment 2. The same procedures used in Expt. 1 were repeated, except as noted. 'Pacino' seeds were sown into cell packs on 18 Dec. 1996, and seedlings were transplanted into 1.0-L (15-cm-diameter) round plastic pots on 5 Jan. 1997. Greenhouse day/night set points were 24/18 °C and the plants were grown under natural daylength and light levels averaged 250 µmol·m^{-2}·s^{-1} at 12:00 HR. Drench treatments of paclobutrazol were applied 15 d after potting at the same doses as in Expt. 1. A completely randomized design of eight single-plant replications of the six treatments was used.

Results and discussion

The PGR drench treatments significantly affected total plant height, plant diameter, inflorescence diameter, and number of days until anthesis.

Total height. All doses of paclobutrazol significantly reduced plant height of potted sunflowers. There was a significant quadratic relationship between paclobutrazol dose and total height in Expts. 1 and 2. Plant height was shorter as paclobutrazol dose increased up to 16 mg, however, additional increases in dose had little effect on height (Fig. 1a). Plants treated with 2 mg paclobutrazol were 27% shorter than the untreated plants in both experiments, and those treated with 4 mg were 36% and 26% shorter than the untreated plants in Expts. 1 and 2, respectively. Severe height retardation of 'Pacino' plants was evident at 16 and 32 mg.

Untreated control plants were 30% taller in Expt. 1 than in Expt. 2. In both experiments, the plants were grown under natural daylengths. Robinson et al. (1967) and Schuster (1985) found sunflowers had a short day response, but quantitative varietal differences existed. Although the photoperiodic response of 'Pacino' has not been determined, the shorter daylength during the winter may have resulted in earlier flower initiation which resulted in a shorter plant

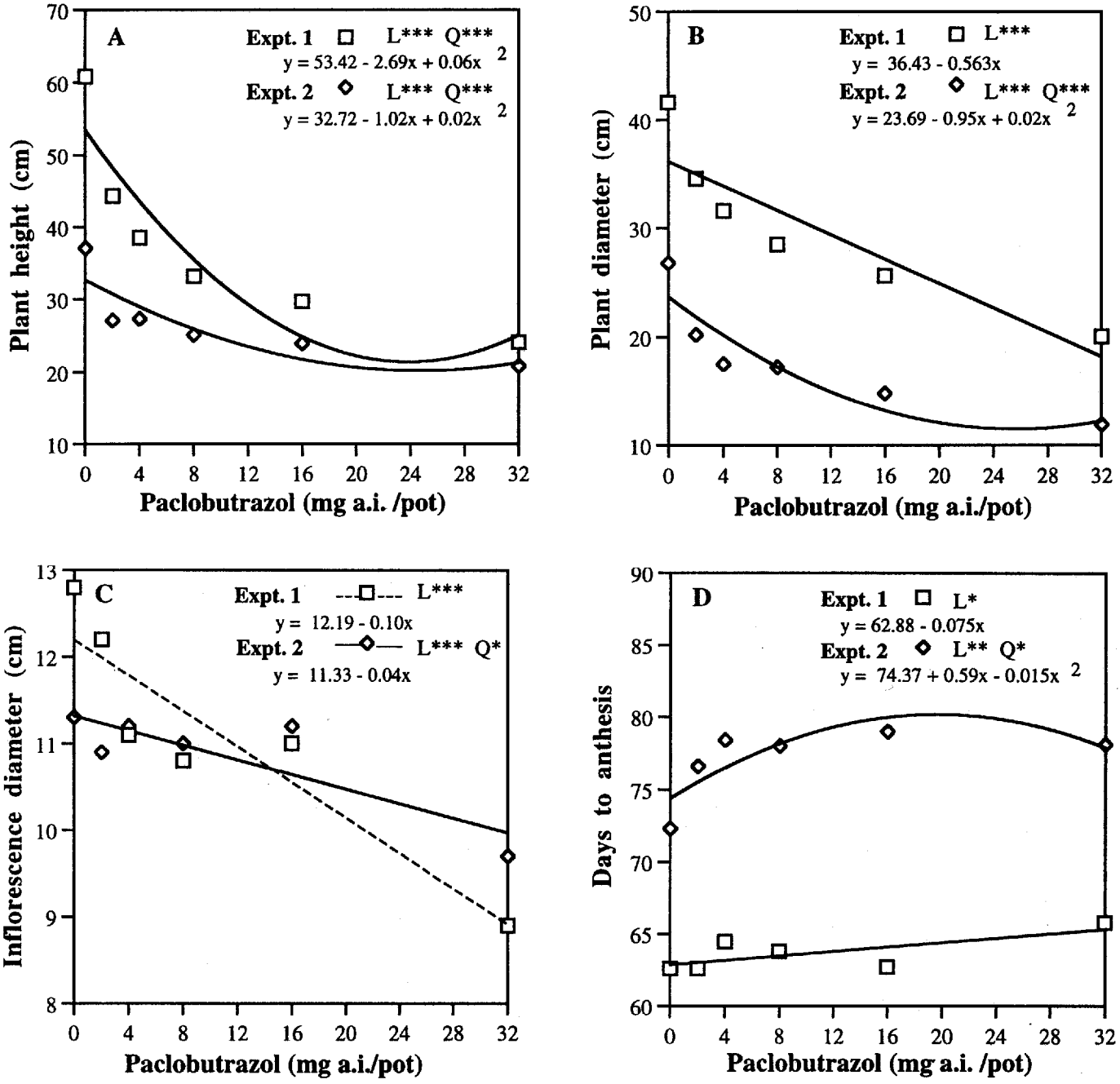

Fig. 1. Paclobutrazol drench effects on 'Pacino' potted sunflowers. (Expt. 1 = May planting and Expt. 2 = December planting). *,,***Significant at $P \leq 0.05$, 0.01, or 0.001, respectively; L = linear and Q = quadratic. (a) Plant height. Regression lines were generated from means of the treatments, and points are means for each treatment (n = 12 and 8, respectively, for Expts. 1 and 2). The adjusted r^2 for Expts. 1 and 2 are 0.80 and 0.58, respectively. (b) Plant diameter. Regression lines were generated from means of the treatments, and points are means for each treatment (n = 12 and 8, respectively, for Expts. 1 and 2). The adjusted r^2 for Expts. 1 and 2 are 0.82 and 0.73, respectively. (c) Inflorescence diameter. Regression lines were generated from means of the treatments, and points are means for each treatment (n = 12 and 8, respectively, for Expts. 1 and 2). The adjusted r^2 for Expts. 1 and 2 are 0.44 and 0.29, respectively. (d) Days to anthesis. Regression lines were generated from means of the treatments, and points are means for each treatment (n = 12 and 8, respectively, for Expts. 1 and 2). The adjusted r^2 for Expts. 1 and 2 are 0.07 and 0.14, respectively.**

height. Greenhouse day/night set points were 24/18 °C during both experiments, but the ability to control the upper limit of day temperature in the greenhouse during the summer months was not always possible. Stem elongation increases as the day temperature under which plants are grown increases (Erwin et al., 1989). Warmer day temperatures during the summer months may also of contributed to the taller plant height during Expt. 1.

PLANT DIAMETER. Plant diameter exhibited a linear dose effect for Expt. 1 and a quadratic dose effect in Expt. 2

(Fig. 1b). Plants treated with 2 mg of paclobutrazol were 17% and 25% smaller in diameter than untreated plants in Expts. 1 and 2, respectively. Paclobutrazol at 4, 8, 16, and 32 mg reduced plant diameter in Expt. 1 by 24%, 31%, 38%, and 51%, respectively, and in Expt. 2 the reduction was 35%, 36%, 45%, and 55%, respectively, compared to untreated plants. Plant diameter was smaller as paclobutrazol dose increased up to 16 mg, with additional increases in dose having little effect on plant diameter in Expt. 2. Plants treated with 16 or 32 mg of paclobutrazol exhibited phytotoxicity symptoms including crinkled leaves and stunted growth, and smaller and greener leaves. Wood (1984) showed the intensification of foliage color on plants treated with paclobutrazol results from an increase in total chlorophyll content per unit leaf area.

Inflorescence diameter. Inflorescence diameter exhibited a linear response to dose in both experiments (Fig. 1c), with increasing doses of paclobutrazol resulting in additional control of inflorescence diameter. Drench applications of paclobutrazol at 4, 8, 16, and 32 mg reduced inflorescence diameter by 12%, 15%, 13%, and 30%, respectively, when compared to the untreated control in Expt. 1. Only the highest rate of paclobutrazol (32 mg) significantly reduced inflorescence diameter (14%) when compared to untreated control for Expt. 2. Whipker and Dasoju (1998) found no difference in inflorescence diameter of 'Pacino' potted sunflower treated with foliar sprays of paclobutrazol at 5 to 80 mg·L^{-1}. Plants treated with 16 and 32 mg of paclobutrazol developed flowers that were oriented upwards (perpendicular to the stem) instead of parallel to the stem. Whipker and Dasoju (1998) also reported a similar upward oriented sunflower heads for plants treated with foliar sprays of daminozide at 16,000 mg·L^{-1}.

Days to anthesis. The effect of paclobutrazol on number of days from seeding to anthesis was significant for paclobutrazol in both experiments (Fig. 1d). Plants treated with 32 mg of paclobutrazol reached anthesis 3 days later than the untreated plants in Expt. 1 (summer) and there was no significant delay for the plants treated with the lower doses. Anthesis was delayed by 4 to 6 days with paclobutrazol doses of 2 to 32 mg, when compared to untreated control in Expt. 2 (winter), however, the delay in anthesis was more pronounced as the dose of paclobutrazol applied increased. Whipker and Dasoju (1998) reported a 2 to 3 day delay in anthesis with foliar sprays of paclobutrazol (80 mg·L^{-1}) and uniconazole (32 mg·L^{-1}), and with daminozide concentrations ≥8,000 mg·L^{-1}. Benary Seed Co. (personal communication) also reported a 10- to 18-d delay when three foliar applications of daminozide at 1,500 mg·L^{-1} were used during winter and early spring production in Germany.

The number of days from seeding to anthesis was longer in Expt. 2 (winter) than in Expt. 1 (summer). Schuster (1985) found the number of days until anthesis for sunflowers was shorter when grown at a mean day temperature of 22 °C when compared to 12.5 °C, but the effects of the daylength on the number of days until anthesis varied by cultivar. The warmer day temperatures experienced during the summer may of contributed to the shorter number of days until anthesis for Expt. 1.

Conclusions

The new shorter cultivars of sunflowers can be adapted to pot culture by controlling the plant growth with the application of PGRs. Paclobutrazol drenches were effective in controlling total height, plant diameter, and inflorescence diameter of potted sunflowers, although seasonal differences were evident. Sunflower plant growth was greater in Expt. 1, which was conducted during the summer than in Expt. 2, which was conducted in the winter. Seasonal differences in growth and flowering date should be considered when determining the appropriate paclobutrazol drench dose. Higher day temperature than night temperature commonly causes plants to be taller and in the summer higher doses of paclobutrazol will be required than in the winter for growth control. Sachs et al. (1976) recommend optimal plant height for potted plants should be 1.5 to 2 times the container height. In this study, marketable sized plants grown in 15- to 16.5-cm-diameter pots were produced with doses of paclobutrazol at 2 and 4 mg in both seasons, even though the plants were two to three times taller than the pot height. Paclobutrazol at 8 mg can also be used in summer for growth control.

Growers have a number of PGRs available for controlling plant growth. The choice of PGRs to control the growth of potted sunflowers should be based on the response of the plant and the cost of the PGR. In foliar PGR experiments, Whipker and Dasoju (1998) recommended daminozide foliar sprays between 4,000 and 8,000 mg·L^{-1} at the cost of less than $0.01/1.2-L pot. Based on the cost of $102/qt, the 2 mg paclobutrazol drench would cost $0.05/1.2-L pot, which was five times more expensive than the daminozide foliar sprays. Even though a similar degree of growth control is available with either paclobutrazol drench doses of 2 to 4 mg and daminozide foliar sprays between 4,000 and 8,000 mg·L^{-1}, growers would find daminozide foliar sprays more economical.

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