

Growth Regulators

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Section Editor

Flurprimidol and Paclobutrazol Drench Applications Influence Growth of *Helianthus simulans*

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Significance to Industry Swamp sunflower is a perennial native sunflower with potential for wider use as an ornamental in the southeastern U.S. Research is lacking on optimal practices for its nursery and greenhouse management and shipping protocol. Due to its vigor, plant growth regulator (PGR) application would enhance its production and widespread use as a southeastern fall-blooming ornamental. Optimal rates applications of paclobutrazol and flurprimidol as a drench were evaluated in this study.

Nature of Work Swamp sunflower is an underutilized fall-blooming native in the Asteraceae family producing a swath of eye-catching bright yellow inflorescences [1, 2]. Swamp sunflower grows 1-1.8 m tall but can reach 2.5 m and is native to the southeastern U.S. As a facultative wetland plant it can be found in non-wetland habitats. It grows best in full sun to part shade and tolerates a variety of growing conditions. In addition to aesthetics, the flowers and seeds are valuable to wildlife [3, 4]. Swamp sunflower is a strong candidate for perennial beds and landscapes, and research on nursery protocol would aid its wider use. To feasibly and economically ship and sell plants, size and shape need to be within certain dimensions and aesthetics. A less labor-intensive approach than pruning is the use of PGR's which control growth [5]. Paclobutrazol is the most widely used PGR to control excessive plant growth and reductions in height of annual sunflower have been demonstrated [6-10]. Application method, particularly of paclobutrazol, in precedent literature has largely been by foliar spray or substrate drench with more favorable results from drench [11-13]. Flurprimidol is another popular plant growth retardant for ornamentals and is a highly cost-effective drench [5]. Flurprimidol has reduced plant height and diameter of potted sunflower [14]. The objective of this study was to evaluate the effects of paclobutrazol and flurprimidol as drench application on the growth and reproductive parameters of swamp sunflower.

Materials and Methods Sub-terminal 3-4 node cuttings were rooted from clonal material of *Helianthus simulans* at the University of Georgia (UGA). Plants were then transplanted to 2.8 L pots with potting media (pine bark, peat and sand mix; Oldcastle, Shady Dale, GA), top-dressed with slow-release fertilizer at 10 g/pot (16N-2.6P-10.0K Harrell's Polyon, Lakeland, FL) and moved to a greenhouse at UGA Trial Gardens in Athens, GA. Each experiment was a completely randomized design with 12 replicates per treatment level. Four days prior to application, plants were cut back to 2 nodes/

stem. The evening prior (6:00 PM) to application, plants were watered to field capacity. Treatments were applied 25 June 2018 for Expt. 1 and 7 Sept. 2018 for Expt. 2 at 8:15 AM as a 120-mL-substrate drench of paclobutrazol (Piccolo 10 XC; Fine Americas, Walnut Creek, CA), flurprimidol (TopFlor; SePRO, Carmel, IN) or water (untreated control). PGR treatment was delivered as 1, 2, 4, or 6 mg a.i. paclobutrazol or 0.5, 1, 2, or 4 mg a.i. flurprimidol/ pot for Expt. 1. For Expt. 2, PGR treatment was 4, 6, or 8 mg a.i. paclobutrazol or 2, 4, or 6 mg a.i. flurprimidol/ pot. Plants were hand watered as needed and fertigated weekly with 20N-4.37P-16.6K fertilizer at 200 mg·L⁻¹ nitrogen (Jack's Professional; J.R. Peters, Allentown, PA). Expt. 1 terminated 6 weeks (6 Aug. 2018) and Expt. 2 terminated 8 weeks after treatment (2 Nov. 2018). Height and width measurements were taken following treatment application (Day 1) and 2, 4 and 6 weeks after treatment for both experiments with an additional measurement of height at 8 weeks after treatment for Expt. 2. Width was the average of the 2 widest perpendicular dimensions. Chlorophyll meter (SPAD-502; Minolta Camera Comp., Osaka, Japan) indices taken between the mid-vein and margin of 3 random leaves were averaged to evaluate leaf greenness. Dry weight was obtained by cutting stems at the soil line and oven-drying for ≈3 d at 60°C. Dry weight and SPAD were measured at termination of Expt(s). 1 and 2. At termination of Expt. 2, flowers and buds were counted to obtain total flower count. Flower diameter was measured of 3 random mature flowers/ rep., where a mature flower had disc flowers at anthesis. Data was analyzed by a one-way ANOVA, where $p = 0.05$, for each week collected to obtain significance and means comparisons of PGR treatments were corrected with Bonferroni adjustment using the R program (R Core Team, 2016).

Results and Discussion Drench application of paclobutrazol (pac.) and flurprimidol (flur.) at the aforementioned rates had an effect on the vertical growth, horizontal growth, dry weight and flower diameter of *Helianthus simulans* (Table 1, 2 and Fig. 1,2). For Expt. 1 plants applied with pac. at 4 and 6 and flur. at 2 and 4 mg a.i./ pot (mg a.i.) were shorter than untreated control after 2, 4, and 6 weeks of growth (Table and Fig. 1). At end of Expt. 1 (6 wks), application of pac. and flur. at 4 and pac. at 6 mg a.i. were shorter than all other treatments, except for flur. at 2 mg a.i., and ranged from 53.6-73.1% of the control. For Expt. 2, all PGR rates had reduced height compared to untreated control at each week of data collection (Table 2). After 8 weeks of growth for Expt. 2, plants treated with pac. 8 mg a.i. were shorter than pac. at 4 mg a.i., which was 73.5% the height of the control (Table and Fig. 2). Width was reduced as compared to control at 6 weeks after application of pac. 6 and flur. 2 and 4 mg a.i. for Expt. 1 at 88.6, 89.0, and 81.3% of the control, respectively. For Expt. 2, pac. at 6 and 8 mg a.i. were not as wide as control at 73.7 and 70.7 %, respectively (Tables 1 and 2). Dry weight was less than that of control for pac. at 4 and 6 and flur. at 1, 2, and 4 mg a.i. for Expt. 1 and pac. at 8 mg a.i. for Expt. 2. For chlorophyll index, Exp. 1 had higher SPAD readings for pac. at 6 and flur. at 4 mg a.i. than control. This indicates a stronger green foliage due to the higher amount of chlorophyll. Flower diameter from Expt. 2 had no differences between untreated control and PGR-treated plant. However, plants treated with flur. at 6 mg a.i. had wider flowers than those treated with pac. at 6 mg a.i. (Table 3). While the ANOVA found treatment to have a significant effect on flower and bud

count, the means separation method did not find differences among treatment levels. In summary, height, width, and dry weight of *Helianthus simulans* plants were affected by PGR treatment and the optimal chemical/rate combinations for growth control for nursery production appear to be paclobutrazol at 4 and 6 and flurprimidol at 4 mg a.i./pot.

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Table 1. Expt. 1 data as percentage of control by PGR treatment level. Means separation analyzed by pairwise comparison tests excluding control with Bonferroni adjustment ($p=0.05$). Letters within column indicate statistical similarity.

Treatment (mg a.i./pot)		Width Increase (Week 6)	Dry Weight	Chlorophyll Index
Paclobutrazol	1	98.7% a	98.6% a	100.7% b
	2	92.3% ab	92.1% ab	104.3% b
	4	91.9% ab	82.4% bc	109.1% ab
	6	88.7% bc	74.5% cd	121.0% a
Flurprimidol	0.5	97.6% ab	92.3% ab	99.7% b
	1	98.9% a	88.2% b	103.9% b
	2	88.9% ab	83.9% bc	105.8% b
	4	81.2% bc	69.4% d	117.0% a
Significance		***	***	***

***, ** indicate significance at $p \leq 0.001$ or 0.01 , respectively.

Table 2. Expt. 2 data as percentage of control by PGR treatment level. Means separation analyzed by pairwise comparison tests excluding control with Bonferroni adjustment ($p=0.05$). Letters within column indicate statistical similarity.

Treatment (mg a.i./pot)		Width Increase (Week 6)	Dry Weight	Chlorophyll Index
Paclobutrazol	4	92.3% a	92.4% a	108.1%
	6	70.7% a	86.8% a	106.3%
	8	73.7% a	81.1% a	105.2%
Flurprimidol	2	89.6% a	88.5% a	106.9%
	4	92.0% a	93.0% a	106.2%
	6	84.4% a	84.6% a	106.8%
Significance		**	*	NS

***, **, * indicate significance at $p \leq 0.001$, 0.01 , or 0.05 , respectively. NS indicates nonsignificance at $p > 0.05$.

Table 3. Expt. 2 flower data as percentage of control by PGR treatment level. Means separation analyzed by pairwise comparison tests excluding control with Bonferroni adjustment ($p=0.05$). Letters within column indicate statistical similarity.

Treatment (mg a.i./pot)	Flower Diameter	Flower and Bud Count
Paclobutrazol	4	105.2% ab
	6	98.3% b
	8	101.1% ab
Flurprimidol	2	102.8% ab
	4	103.5% ab
	6	105.6% a
Significance	*	*

* indicates significance at $p \leq 0.05$, NS indicates nonsignificance at $p > 0.05$.

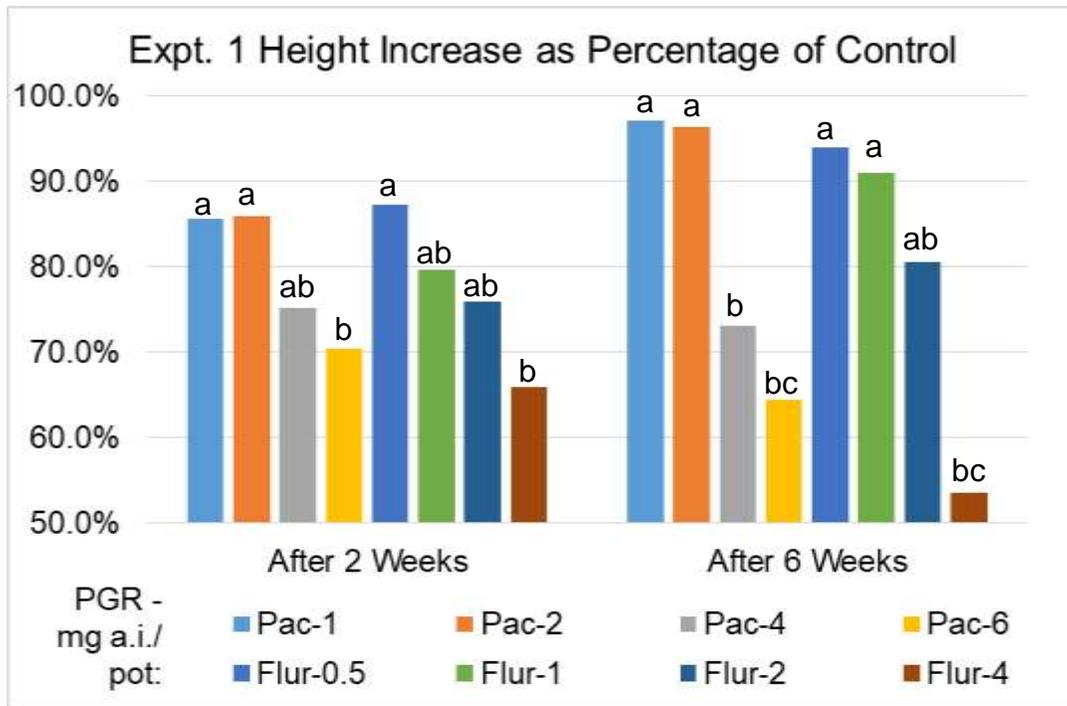


Figure 1. Height increase from Day 1 to weeks 2 and 6 for Expt. 1 as percentage of untreated control. Means separation analyzed by pairwise comparison tests with Bonferroni adjustment ($p=0.05$). Treatment levels within week having same letter are statistically similar.

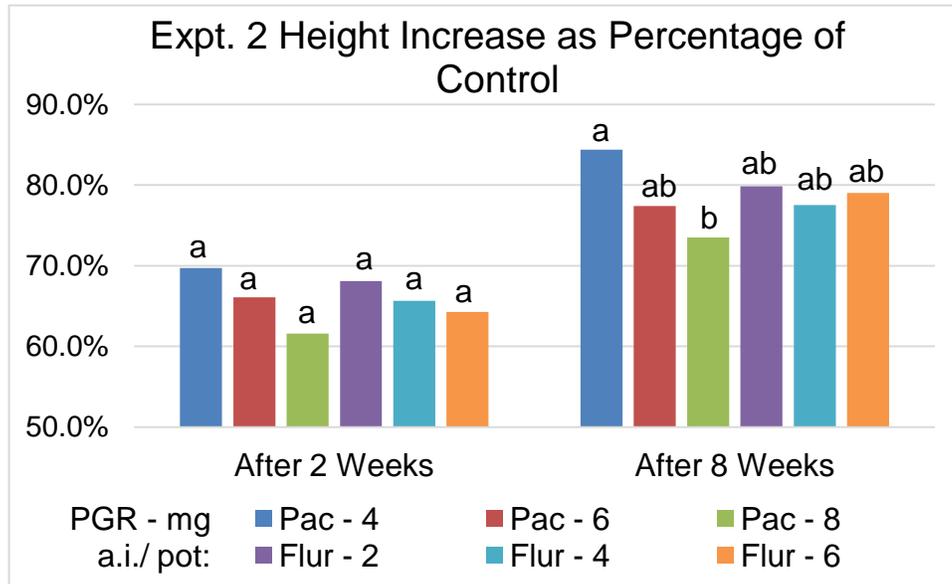


Figure 2. Height increase from Day 1 to weeks 2 and 8 for Expt. 2 as percentage of untreated control. Means separation analyzed by pairwise comparison tests with Bonferroni adjustment ($p=0.05$). Treatment levels within week having same letter are statistically similar.