Foliar Application of Plant Growth Retardants to *Coreopsis rosea* 'American Dream'[1]

S.E. Burnett[2], G.J. Keever[3], J.R. Kessler[4], and C.H. Gilliam[3]
Department of Horticulture
Auburn University, Auburn, AL 36849

Abstract

In one experiment conducted in 1998 and two in 1999, *Coreopsis rosea* 'American Dream', or pink coreopsis, were treated with four plant growth retardants (PGRs): B-Nine from 2500 to 7,500 ppm, Cutless from 25 to 150 ppm, Sumagic from 10 to 40 ppm, and Bonzi from 25 to 100 ppm. The study was conducted to determine whether PGRs could be used to suppress growth of pink coreopsis without delaying flowering or causing phytotoxicity. Application of B-Nine, Cutless, or Sumagic suppressed plant growth 13–31% at first flower and when plants were marketable (one-third of flowers open) in all experiments and improved plant quality compared to controls. Plants treated with B-Nine, Cutless, or Sumagic had quality ratings 52–67% higher than those of control plants when marketable; treated plants appeared denser and more floriferous. Time to first flower and to a marketable stage were minimally affected by PGR application, and no phytotoxicity was observed. Bonzi did not significantly control growth or affect flowering of pink coreopsis in any of the three experiments.

Index words: growth retardant, pink coreopsis, perennial plants.

Growth regulators used in this study: B-Nine (daminozide), butanedioic acid mono-(2,2-dimethylhydrazide); Cutless (flurprimidol), α-(1-methylethyl)-α-[4-(trifluromethoxy)phenyl]-5-pyrimidinemethanol; Sumagic (uniconazole), E-1-(4-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)pent-1-ene-3-ol; and Bonzi (paclobutrazol), (2RS,3RS)-1-(4-chlorophenyl)-4,4-dimethyl-2-[1,2,4-triazol-1-yl]pentan-3-ol.

Species used in this study: 'American Dream' pink coreopsis (*Coreopsis rosea* Nutt. 'American Dream').

Significance to the Nursery Industry

Rapid growth of pink coreopsis during production often forces growers to transplant plants to larger containers, prune shoots to keep plants within a manageable size, or both to maintain high quality plants. These options are time-consuming and labor intensive. Application of B-Nine at 2,500 to 7,500 ppm, Cutless at 25 to 150 ppm, or Sumagic at 10 to 40 ppm provided acceptable size control of 'American Dream' pink coreopsis, and with increasing rate resulted in higher quality plants with denser, more attractive foliage and minimal or no effect on time to flowering.

Introduction

Coreopsis rosea or pink coreopsis is a delicate, erect, finely branched herbaceous perennial, growing 30–46 cm (12–18 in) tall and producing 2 cm (3/4 in) pink flowers in spring and summer (3). Rapid growth and upright growth habit of

[1]Received for publication December 13, 1999; in revised form March 3, 2000.

[2]Graduate student.

[3]Professor.

[4]Assistant Professor.

The *Journal of Environmental Horticulture* (ISSN 0738-2898) is published quarterly in March, June, September, and December by the Horticultural Research Institute. Subscription rate is $65.00 per year for educators and scientists; $85.00 per year for others; add $25.00 for international orders. Periodical postage paid at Washington, D.C. and at additional mailing office. POSTMASTER: Send address changes to HRI, 1250 I Street, N.W., Suite 500, Washington, D.C. 20005.

pink coreopsis may be difficult to manage during production in 10 cm (4 in) or smaller containers, requiring time consuming pruning for adequate size control and a narrow window of marketability.

Various plant growth retardants (PGRs) including B-Nine, Cutless, Sumagic, and Bonzi have been used to control growth in horticultural crops (2, 8, 9, 11, 12). B-Nine, Sumagic, and Bonzi are labeled for use on herbaceous crops in greenhouses. Although Cutless is labeled only for turfgrasses, previous research indicates it may be useful in controlling growth of herbaceous perennials (7). Additionally, PGRs have been successfully used to retard growth in the closely related species, *Coreopsis verticillata* L. 'Moonbeam' (7, 10) and *Coreopsis grandiflora* Hogg ex Sweet (13). Specifically, B-Nine at 2,550 to 7,650 ppm and Cutless at 25 to 200 ppm controlled height of *Coreopsis verticillata* 'Moonbeam', with a slight delay in flowering from B-Nine only (10). Both B-Nine at 2,550 to 7,650 ppm and Sumagic at 15 ppm were effective in controlling growth of *Coreopsis grandiflora* 'Sunray' (13). Bonzi applications from 12 to 60 ppm were ineffective in controlling growth of either species, however, higher rates of Bonzi may control growth of *Coreopsis rosea*. To our knowledge, no previous research has been published using PGRs on *Coreopsis rosea*. The objective of this study was to determine the effectiveness of B-Nine, Cutless, Sumagic, and Bonzi in controlling growth of pink coreopsis during greenhouse production in 10 cm (4 in) containers.

Materials and Methods

Experiment 1 was conducted in early spring 1998 and repeated twice in 1999 (treated March and May). All three experiments had similar methodology unless otherwise stated. Terminal cuttings from stock plants were rooted under intermittent mist. Rooted cuttings were transplanted to 10 cm (4 in) pots containing Fafard #3 growing medium (Fafard, Anderson, SC) on January 26, 1998, 28 days after sticking cuttings, and placed pot-to-pot in a glass greenhouse (heat set point: 18.3C (65F), ventilation set point: 25.6C (78F)). For the second and third experiments, rooted cuttings were transplanted to 10 cm (4 in) pots after being removed from propagation and placed pot-to-pot in a glass greenhouse on January 26 and April 14, 1999, respectively (54 and 30 days after sticking cuttings). At transplanting, roots of plants had reached the bottom of cells, and shoots were about 3.8 cm (1.5 in) tall with a growth index [GI = (height + widest width + width perpendicular to first width) ÷ 3] of 1.3 cm (0.5 in). Plants received weekly liquid fertilization of 150 ppm nitrogen using a 20N–8.9P–16.6K fertilizer (20–20–20, Pro-Sol, Ozark, AL) and were watered as needed. On February 14, 1998, March 9, 1999, and April 28, 1999 (Experiment 1, 2 and 3, respectively), plants were sheared to 6.4 cm (2.5 in) above the pot rim and spaced on 20 cm (8 in) centers. Plants were provided night-break lighting from 10:00 p.m. to 2:00 a.m. CST using incandescent lamps with a minimum of 0.93 w/m^2 at average plant height beginning at the time of shearing in the first experiment and at the time of PGR application in the second and third experiments. Growth retardants were applied as foliar sprays using a CO_2 sprayer at 1.4 kg/cm^2 (20 psi) on March 12, 1998, March 15, 1999, and May 7, 1999 (Experiments 1, 2, and 3, respectively). B-Nine at 2,500, 5,000, or 7,500 ppm; Cutless at 25, 50, 75, 100, 125, or 150 ppm; Sumagic at 10, 20, 30, or 40 ppm; Bonzi at 25, 50, 75, or 100 ppm; and an untreated control consisting of distilled water were applied at 0.2 $liter/m^2$ (2 qt/100 ft^2). Temperatures were 20.6C (69F), 29.4C (85F), and 31.1C (88F), and relative humidities were 47%, 39%, and 65% when treatments were applied in the first, second, and third experiments, respectively.

When the first open flower appeared (ray flower petals perpendicular to the peduncle), shoot height, growth index and days to first flower were collected. Each plant was rated for market quality on a 1–4 scale (1 = poor, unmarketable; 2 = marketable; 3 = highly marketable; 4 = superior marketability) when one-third of the flowers were open and the date was recorded. Marketability was based on visual observation of the shoot height to pot size ratio, compactness, canopy fullness, leaf color and flower numbers. In the second and third experiments, but not the first, shoot height and GI were also recorded when plants reached a marketable stage.

Treatments in the first and third experiments were placed in a randomized complete block design with plants blocked by initial size, and in the second, treatments were completely randomized with ten single plant replications for all experiments. Data were analyzed using general linear models and contrasts to test rate responses within a PGR with control plants included in the regression analysis and an accepted probability level of $P = 0.05$.

Results and Discussion

Results of experiment two are presented in detail because it was considered the most representative and complete of the three experiments. Experiment two was conducted in early spring, which would be the optimum production time for pink coreopsis in the Southeast. Additionally, height and GI were collected at a marketable stage in the second year only. Results of experiments one and three that differed from those of experiment two also are presented.

First flower. PGR application had little effect on time to first flower. In the second experiment, time to first flower increased slightly with increasing rates of B-Nine (0–4 days), Cutless (1–4 days), and Sumagic (2–3 days) (Table 1). Previous research has shown this to be a common side effect of B-Nine or Sumagic application (10, 13) in other *Coreopsis* species, and with Cutless in other horticultural crops (1, 4). The maximum increase in time to flower by all PGRs at the rates tested was only 4 days and was not considered important commercially. In the first experiment (Table 2), none of the PGRs increased time to first flower, and in the third (Table 3), only B-Nine and Cutless increased time to first flower (2–3 days and 1–2 days, respectively). During the third experiment, which was conducted later in the season than the other experiments, there was a trend for all plants, both treated and controls, to flower more quickly than plants in other experiments had in early spring. In experiment three, control plants flowered 7 days earlier and treated plants flowered 6 days earlier on average, compared to control plants in experiments one and two. Earlier flowering in experiment three was probably related to plants being exposed to naturally long days prior to the initiation of artificial long days, increased light levels, and higher temperatures.

At first flower, increasing rates of B-Nine, Cutless, and Sumagic reduced shoot height. Shoot heights of plants at first flower were reduced 16–28% with B-Nine, 13–34% with Cutless, and 25–31% with Sumagic, compared to controls in the second experiment, with similar responses in the first

Table 1. Effects of foliar application of PGRs on *Coreopsis rosea* 'American Dream' (Exp. 2).

Growth regulator	Rate (ppm)	First flower			Marketable stage[y]			
		Days to	Height (cm)	GI[z]	Days to	Height (cm)	GI	Quality[x]
Control	0	31	32	29	43	35	35	1.2
B-Nine	2,500	31	27	26	43	29	30	2.5
	5,000	34	25	25	44	26	29	2.8
	7,500	35	23	25	45	25	28	3.1
	Significance[w]	L***	L***Q*	L***Q**	L*	L***Q***	L***	L***Q***
Cutless	25	32	28	26	42	29	31	2.5
	50	33	26	25	42	29	29	2.4
	75	34	25	25	42	27	28	2.8
	100	33	24	25	43	26	29	2.7
	125	35	24	24	43	24	26	3.0
	150	35	21	23	44	22	24	3.6
	Significance	L***	L***	L***	NS	L***	L***	L***
Sumagic	10	33	24	24	41	26	27	2.8
	20	33	24	24	42	27	26	2.5
	30	34	24	25	43	27	27	2.8
	40	34	22	23	42	25	26	3.1
	Significance	L***	L***Q***	L***Q**	NS	L***Q**	L***Q***	L***Q***

[z]GI (Growth index) = (height + widest width + width perpendicular to first width) ÷ 3 at first flower and when plants were marketable; GI in cm.

[y]Marketable stage was when one-third of the flower buds on a plant were open.

[x]Quality rating: 1 = poor and unmarketable; 2 = marketable; 3 = highly marketable; 4 = superior.

[w]Non-significant (NS) or significant linear (L) or quadratic (Q) response at P = 0.05 (*) or 0.001 (***); control included in contrasts.

and third experiments. Bonzi did not significantly control growth or affect flowering of pink coreopsis in any experiment (data not shown). Prior research has shown Bonzi at 12 to 60 ppm ineffective in controlling growth of *Coreopsis verticillata* 'Moonbeam' (10) and *Coreopsis grandiflora* (13). Treatment effects on GI followed trends similar to those of shoot height; growth control increased linearly or quadratically with increasing rates. GI was 10–14% less for plants treated with B-Nine, 10–21% less for Cutless-treated plants, and 17–21% less for those treated with Sumagic when compared to controls.

Marketable stage. PGRs had little effect on time for plants to reach a marketable stage. In the second experiment time to a marketable stage increased two days with B-Nine compared to controls, but was not affected by Cutless or Sumagic. Since B-Nine delayed time to first flower in other research, it was not surprising that it also increased time to reach a marketable stage for pink coreopsis. Time to a marketable stage decreased as much as four days compared to controls with Sumagic in the first experiment, and decreased 1–4 days with application of Cutless in the first experiment. Again, as with time to reach first flower, all plants in the experiment

Table 2. Effects of foliar application of PGRs on *Coreopsis rosea* 'American Dream' (Exp. 1).

Growth regulator	Rate (ppm)	First flower			Marketable stage[y]	
		Days to	Height (cm)	GI[z]	Days to	Quality[x]
Control	0	27	34	34	46	1.4
B-Nine	2,500	26	29	30	50	2.7
	5,000	26	31	29	47	2.6
	7,500	28	28	27	47	2.8
	Significance[w]	NS	L**	L***	NS	L***Q***
Cutless	25	29	33	30	44	2.0
	50	27	32	28	42	2.1
	75	27	27	26	42	2.8
	100	29	31	27	45	2.6
	125	29	28	25	43	3.0
	150	28	27	26	44	3.0
	Significance	NS	L***	L***Q*	Q*	L***
Sumagic	10	27	30	28	45	2.3
	20	26	28	27	41	3.1
	30	26	27	25	42	3.1
	40	26	26	24	42	3.3
	Significance	NS	L***	L***	L***	L***Q***

[z]GI (Growth index) = (height + widest width + width perpendicular to first width) ÷ 3 at first flower and when plants were marketable; GI in cm.

[y]Marketable stage was when one-third of the flower buds on a plant were open.

[x]Quality rating: 1 = poor and unmarketable; 2 = marketable; 3 = highly marketable; 4 = superior.

[w]Non-significant (NS) or significant linear (L) or quadratic (Q) response at P = 0.05 (*) or 0.001 (***); control included in contrasts.

Table 3. **Effects of foliar application of PGRs on *Coreopsis rosea* 'American Dream' (Exp. 3).**

Growth regulator	Rate (ppm)	First flower			Marketable stage[y]			
		Days to	Height (cm)	GI[z]	Days to	Height (cm)	GI	Quality[x]
Control	0	24	32	28	35	33	32	1.7
B-Nine	2,500	26	25	22	35	25	26	2.9
	5,000	26	22	22	36	23	25	3.1
	7,500	27	21	20	36	23	23	3.4
	Significance[w]	L***	L***Q***	L***Q**	L***	L***Q***	L***Q*	L***Q***
Cutless	25	26	28	24	35	30	29	2.5
	50	25	26	23	35	27	27	2.8
	75	25	25	22	35	27	26	3.0
	100	26	24	22	35	25	24	3.1
	125	26	24	21	35	25	24	3.1
	150	26	22	21	35	24	24	3.4
	Significance	L*	L***Q*	L***Q**	NS	L***Q**	L***Q*	L***Q**
Sumagic	10	25	27	24	35	30	29	2.5
	20	25	26	24	34	28	27	2.8
	30	25	24	21	34	26	25	2.9
	40	25	25	22	35	27	26	3.2
	Significance	NS	L***Q***	L***Q**	NS	L***Q**	L***	L***Q*

[z]GI (Growth index) = (height + widest width + width perpendicular to first width) ÷ 3 at first flower and when plants were marketable; GI in cm.
[y]Marketable stage is when one-third of the flower buds on a plant are open.
[x]Quality rating: 1 = poor and unmarketable; 2 = marketable; 3 = highly marketable; 4 = superior.
[w]Non-significant (NS) or significant linear (L) or quadratic (Q) response at P = 0.05 (*) or 0.001 (***); control included in contrasts.

conducted in late spring reached a marketable stage sooner than plants in both early spring experiments.

Shoot height at a marketable stage was reduced 17–29% with application of B-Nine, 17–37% with Cutless, and 25–29% with Sumagic compared to controls. GI at the marketable stage was 14–29% less for plants treated with B-Nine, 11–31% less with Cutless, and 23–26% less with Sumagic compared to GI of control plants in the second experiment, with similar results in the other two experiments. Similarities in percent shoot height and GI reductions at first flower and marketable stage indicate no dissipation in growth retardation over this period.

Plants treated with B-Nine, Cutless, or Sumagic increased linearly or quadratically in quality with increasing application rate. Quality was 52–61% higher for plants treated with B-Nine, 52–67% higher with Cutless, and 57–61% higher with application of Sumagic compared to controls. Highest numerical values for market quality were obtained with B-Nine at 7,500 ppm, Cutless at 150 ppm, and Sumagic at 40 ppm. Control plants were considered unmarketable based on visual observation of the height to pot size ratio, while those treated with all PGR-rate combinations were considered marketable. Plants treated with B-Nine, Cutless, or Sumagic appeared less leggy, and more densely branched with darker green foliage and more flowers than control plants. All of these benefits have been previously reported with PGR application (5, 6).

In summary, the growth retardants, B-Nine at 2,500 to 7,500 ppm, Cutless at 25 to 150 ppm, and Sumagic at 10 to 40 ppm would be useful in the production of superior 'American Dream' pink coreopsis crops in a greenhouse. These PGRs reduced plant size and enhanced plant quality. In addition to improved quality, the compact size of treated plants should facilitate shipping and handling. Bonzi did not suppress growth or affect flowering of pink coreopsis at any time. Growers who wish to use these PGRs in the production of 'American Dream' pink coreopsis should be aware that growing conditions, including light, temperature, soil mix and fertility, and physiological stage of plant development can have a significant effect on PGR activity.

Literature Cited

1. Albrect, M.L. 1987. Growth retardant use with potted anemone and ranunculus. HortScience 112:82–85.

2. Anderson, R.G. and G. Hartley. 1990. Use of growth retardants on satin flower, godetia, for pot plant production. Acta Hort. 272:285–291.

3. Armitage, A.M. 1997. Herbaceous perennial plants: a treatise on their identification, culture, and garden attributes. Stipes Publishing, L.L.C. Champaign, IL. Pg. 293.

4. Criley, R.A. and C. Chia. 1993. Growth retardation of *Narcissus tazetta* during forcing. HortScience 28:548.

5. Davis, T.D. and E. Curry. 1991. Chemical regulation of vegetative growth. Critical Reviews in Plant Sciences 10:151–188.

6. Davis, T.D., N. Sankhla, and A. Upadhyaya. 1986. Paclobutrazol: A promising plant growth regulator. Agro Botanical Publishers (India), Old Ginnani, BIKANER 334 001.

7. Hamaker, C.K., R.D. Heins, A. Cameron, and W. Carlson. 1996. Forcing perennials—crop by crop, *Physostegia virginiana*. Greenhouse Grower 14 (11):43–46.

8. Karlson, M.G. and J.W. Werner. 1991. Growth regulator effects in seed-propagated *Begonia tuberhybrida*. HortScience 26:685.

9. Keever, G.J. and C.H. Gilliam. 1994. Growth and flowering response of butterfly-bush to Cutless. J. Environ. Hort. 12:16–18.

10. Kessler, J.R. and G.J. Keever. 1997. Plant growth retardants affect growth and flowering of *Coreopsis verticillata* 'Moonbeam'. Proc. Southern Nurs. Assoc. Res. Conf. 42:280–282.

11. Pisarczyk, J.M. and W.E. Splittstoesser. 1979. Controlling tomato transplant height with chlormequat, daminozide, and ethephon. HortScience 104:342–344.

12. Whipker, B.E. and S. Dasoju. 1998. Potted sunflower growth and flowering responses to foliar applications of daminozide, paclobutrazol, and uniconazole. HortTechnology 8:86–88.

13. Yuan, M., R.D. Heins, A. Cameron, and W.H. Carlson. 1996. Forcing perennials—crop by crop, *Rudbeckia fulgida* 'Goldsturm'. Greenhouse Grower 14 (12):57–60.