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Effects of Primo on Selected Bedding and Woody Landscape Plants[1]

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Abstract

Primo (cimectacarb), applied as a foliar spray, suppressed shoot growth of four of six bedding plants and all four woody landscape species tested. However, phytotoxic symptoms occurred on the foliage of all bedding plants and two woody species and to flowers of three bedding plants and one woody species. Foliage and flowers of affected plants exhibited a loss of pigmentation that increased at higher rates of Primo, resulting in a bleached appearance.

Index words: growth retardant, growth inhibition, cimectacarb, CGA 163935.

Growth regulator used in this study: Primo (cimectacarb), 4-(cyclopropyl-alpha-hydroxy-methylene)-3,5-dioxo-cyclohexanecarboxylic acid ethyl ester.

Species used in this study: 'Pinkie' Madagascar periwinkle (*Catharanthus roseus* (L.) G. Don 'Pinkie'); 'Jazz Bronze' coleus (*Coleus* x *hybridus* Voss. 'Jazz Bronze'); 'Goldcrest' yellow cosmos (*Cosmos sulphureus* Cav. 'Goldcrest'); 'Accent Deep Pink' impatiens (*Impatiens wallerana* Hook.f. 'Accent Deep Pink'); 'Celebrity Lilac' petunia (*Petunia* x *hybrida* Hort. Vilm.-Andr. 'Celebrity Lilac'); 'Bonanza Yellow' French marigold (*Tagetes patula* L. ' Bonanza Yellow'); 'Royal Red' butterfly-bush (*Buddleia davidii* Franch. 'Royal Red'); 'Nellie R. Stevens' holly (*Ilex* x 'Nellie R. Stevens'); privet (*Ligustrum japonicum* Thunb.); and 'Mrs. G. G. Gerbing' azalea (*Rhododendron* x 'Mrs. G. G. Gerbing').

Significance to the Nursery Industry

Height control of bedding plants and development of good form of woody landscape plants during production are essential to obtaining a quality product. Primo (cimectacarb), a growth retardant labeled for warm- and cool-season turfgrasses, provided acceptable growth suppression in most species tested; however, phytotoxic symptoms developed on all bedding plant species and two of four woody landscape species making quality unacceptable. Based on these results, the use of Primo as an alternative to other chemical growth retardants in the production of herbaceous and woody landscape plants is not recommended. Additionally, concentrations of Primo applied to species in this study are similar to those recommended for turfgrasses; this raises the concern of potential injury to herbaceous and woody plants in the landscape from drift or overspray when Primo is applied to turfgrasses.

Introduction

Chemical growth retardants such as B-Nine (daminozide), Cycocel (chlormequat chloride), A-Rest (ancymidol), Bonzi (paclobutrazol), and Sumagic (uniconazole) are applied to bedding plants to promote compactness and uniformity and to extend marketability (6). Growth retardants may also improve transplant survival by maintaining favorable root to shoot ratios and reducing water use, hence increasing a plant's drought tolerance (10).

Mechanical pruning to control excessive vegetative growth and improve plant form is a major expense in the production and maintenance of woody landscape plants. Numerous compounds have been tested to retard woody plant growth, but most remain uneconomical or cause undesirable side effects (3, 4, 9). Currently registered chemical growth retardants for use in the production of woody landscape plants include

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Bonzi, Royal Slo-Gro (maleic hydrazide), and Atrimmec (dikegulac sodium). However, these materials are used infrequently, if at all by growers (personal communication with numerous nurserymen).

Primo (cimectacarb, Novartis Crop Protection, Greensboro, NC) is a growth retardant labeled for use on warm- and cool-season turfgrasses. Primo, a cyclohexadione, represents a relatively new class of plant growth regulators that inhibit the biosynthesis of gibberellic acid, resulting in a decrease in cellular elongation and internode length. Inhibition from Primo occurs much later in the gibberellin biosynthesis pathway than that induced by Cycocel and the triazole compounds Bonzi and Sumagic (1). There is limited literature on Primo effects on herbaceous and woody landscape plants (7, 8). The objective of this study was to determine the effectiveness of Primo in controlling shoot growth when applied as a foliar spray during greenhouse production of bedding plants and during container nursery production of woody landscape plants.

Materials and Methods

In the first experiment, uniform plants of 'Celebrity Lilac' petunia, 'Jazz Bronze' coleus, 'Goldcrest' cosmos, 'Accent Deep Pink' impatiens, 'Pinkie' periwinkle and 'Bonanza Yellow' French marigold in 32 cell flats of a peat moss and perlite growth medium (Pro-Mix BX, Premier Brands, Inc., New Rochelle, NY) were placed in a double polyethylene greenhouse in March 1990. Minimum day/night temperatures in the greenhouse were 21/16C (70/60F). Plants were fertilized weekly with 300 ppm N from 20N–4.3P–16.6K (20–10–20) Peter's Peatlite Special (Scott's Co., Marysville, OH).

The following treatments were applied on March 30, 1990, when petunia, coleus, cosmos, impatiens, periwinkle and marigold averaged 6.2, 5.3, 8.5, 4.7, 3.0, and 5.2 cm (2.4, 2.1, 3.3, 1.9, 1.2, and 2.0 in) in height, respectively: a single foliar spray of Primo at 0, 1, 10, 100, 500, or 1000 ppm ai. Treatments were applied in a volume of about 1.2 ml (0.04 oz)/plant using a hand-held sprayer to uniformly wet foliage and stems. Ambient temperature was 23.9C (75F) with 86% relative humidity at time of application. Treatments were arranged in a completely randomized design within species with 12 single-plant replications. Observations on plant appearance were made beginning three days after treatment and continued periodically until plant heights were measured six weeks after treatment (WAT). Data were subjected to analysis of variance, and regression analysis was used to determine significant linear and quadratic responses to Primo.

A second experiment was initiated in 1993 to evaluate the response of four woody landscape plants to Primo. Forty-nine uniform liners per species were potted in May 1993, in a pine bark and peat moss medium (3:1 by vol) amended with 8.3 kg/m^3 (14 lb/yd^3) Osmocote 17N–3P–10K (17–7–12), 3.6 kg/m^3 (6 lb/yd^3) dolomitic limestone, 1.2 kg/m^3 (2 lb/yd^3) gypsum, and 0.9 kg/cm^3(1.5 lb/yd^3) Micromax micronutrient fertilizer. Plant species and container sizes included *Ilex* x 'Nellie R. Stevens' (holly), *Rhododendron* x 'Mrs. G.G. Gerbing' (azalea), and *Ligustrum japonicum* (privet) in 7.6 liter (#2) containers, and *Buddleia davidii* 'Royal Red' (butterfly-bush) in 11.4 liter (#3) containers. Plants were placed outdoors in full sun and irrigated daily with overhead impact sprinklers. On June 28, 1993, single foliar sprays of Primo at 0, 500, 1000, 1500, 2000, 2500 and 3000 ppm were applied in a volume of 204 ml/m^2 (2 qt/100 ft^2) to holly, azalea and privet. Environmental conditions at time of application were 31.1C (88F) and 74% relative humidity. Butterfly-bush was pruned for uniformity at this time, and the same treatments were applied one week later when new growth was 5 to 10 cm (2 to 4 in) long and no flowers were present. Temperature and relative humidity at treatment were 32.8C (91F) and 68%, respectively. Treatments were completely randomized within species with seven single-plant replications. Observations were made on all species two, four, and ten WAT (one, three, and nine WAT for butterfly-bush). On July 28, 1996, four WAT (three WAT for butterfly-bush), a growth index [(height + width at the widest point + width 90° to the widest point) / 3] and foliar color rating (1 = white; 2 = yellow; 3 = light green; 4 = medium green; 5 = dark green) were determined for all species with the exception of the color rating for azalea. Lengths of the three longest shoots per plant were also measured for holly. On September 2, 1993, growth index was determined for all species. The same statistical analysis used in the first experiment was used in the second experiment.

Results and Discussion

Experiment 1. Within three days of treatment, foliage of all species sprayed with 100, 500, or 1000 ppm Primo appeared bleached. Symptoms were relatively minor on plants treated with 100 ppm but severe on those treated with the two highest concentrations. Bleaching was primarily on the newer foliage and was concentrated near leaf tips and margins. At the termination of the experiment, six WAT, bleached foliage was still evident on plants of petunia, coleus, impatiens, and marigold treated with the two highest concentrations of Primo. Flowers were present on petunia, impatiens, and periwinkle when treated; these flowers were also bleached by 100, 500, and 1000 ppm Primo and subsequent flowers that formed during the study opened bleached. Flowers that formed on marigold and cosmos opened without any abnormal symptoms while coleus did not flower. Bleaching of red-purple (cyanic) flowers but not yellow flowers from foliar application of Primo has been reported in potted chrysanthemum, and the authors speculated that the chemical disrupted anthocyanin synthesis (7). This speculation may explain why flower color of cosmos and marigold were unaffected by Primo application.

Table 1. Heights (cm) of four bedding plants sprayed with Primo, May 14, 1990 (6 WAT[z]).

Primo rate (ppm)	'Accent Deep Pink' impatiens	'Celebrity Lilac' petunia	'Gold-crest' cosmos	'Jazz Bronze' coleus
0	17.3[y]	33.0	32.5	22.3
1	14.4	37.3	36.1	23.8
10	17.4	36.3	35.2	23.1
100	15.3	31.5	30.9	27.3
500	13.2	17.3	22.3	24.2
1000	13.5	11.8	22.9	18.0
Significance[x]	L**	Q***	Q***	Q**

[z]WAT = weeks after treatment.

[y]Means of 12 single-plant replications.

[x]Regression response linear (L) or quadratic (Q) at $P \leq 0.01$ (**) or 0.001 (***).

Table 2. Effects of single foliar sprays of Primo on foliar color of *Buddleia davidii* 'Royal Red' and shoot length of *Ilex* x 'Nellie R. Stevens', Experiment 2.

Primo rate (ppm)	Butterfly-bush (*Buddleia davidii* 'Royal Red') Foliar color rating[z]	Holly (*Ilex* x Nellie R.Stevens') Shoot length[y] (cm)
0	4.0[x]	4.0
500	3.5	3.8
1000	3.5	2.8
1500	3.2	1.5
2000	3.1	1.5
2500	3.1	1.1
3000	3.0	1.3
Significance[w]	L***Q**	L***

[z]Foliar color rating where 1 = white, 2 = yellow, 3 = light green, 4 = medium green, and 5 = dark green; plants rated three weeks after treatment (WAT).

[y]Shoot length: Average mean shoot lengths of the three longest shoots per plant measured four WAT.

[x]Means of seven single-plant replications.

[w]Regression response linear (L) or quadratic (Q) at $P \leq 0.05$ (*), 0.01 (**), or 0.001 (***).

Heights of impatiens, petunia, cosmos, and coleus were affected by Primo application (Table 1) , while heights of marigold and periwinkle were not (data not shown). Heights of impatiens were suppressed linearly with increasing rates of Primo; plants treated with the highest rate were 22% shorter than controls. Heights of petunia and cosmos were suppressed quadratically with increasing Primo rates. Concentration ≤ 100 ppm had minimal effects on plant height, 5% or less, whereas at 1000 ppm heights of petunia and cosmos were 64% and 31%, respectively less than that of controls. Primo had a quadratic effect on coleus height; at ≤ 10 ppm height was similar to that of controls, whereas at 100 and 1000 ppm heights were 22% greater and 19% less, respectively, than that of the controls. The study was terminated six WAT because treatments had either made plants unmarketable or were ineffective in controlling shoot growth.

Experiment 2. At two and four WAT, new growth of azalea treated with Primo was distorted and chlorotic to bronze in color. Symptoms occured on all plants treated with Primo but increased in severity with increasing rate. At 10 WAT, new growth was healthy and vigorous in appearance; however, there was still evidence of bronzed older foliage present at two and four WAT. Bronzing was slight with 500 ppm, moderate with 1000 and 1500 ppm, and moderate to severe with 2000, 2500, and 3000 ppm Primo treated plants.

New growth of butterfly-bush was reduced in size and chlorotic to bleached in appearance at one WAT. Symptoms were present on all plants treated with Primo rates but were progressively more severe at higher rates. At three WAT, foliage of all treated plants were lighter green than that of control plants. Bleached leaf tips were present on plants receiving ≥ 1500 ppm Primo. Differences among treatments were reflected in the foliar color rating (Table 2) in which chlorosis increased as Primo rate increased. Flowering began about three WAT. Flowers on control plants were a normal deep purple color, while those of plants treated with 500 ppm Primo were a pale lavender color, and those of plants treated with ≥ 1000 ppm were bleached white. At 10 WAT, foliage of all plants appeared normal. Flowers of controls and plants treated with 500 ppm Primo were deep purple while those receiving higher rates were progressively lighter in color. No abnormal symptoms were present on holly or privet at any of the observational dates, and foliar color ratings made four WAT were not significant (data not shown).

Growth indices of azalea, butterfly-bush, and holly decreased quadratically and linearly four and 10 WAT, respectively, with increasing Primo rate (Table 3). Relative to control plants, growth suppression of azalea with 3000 ppm Primo was similar at both 4 and 10 WAT, 23% and 24%, respectively, as was that of holly, 29% and 32%, indicating prolonged activity of Primo. Shoot length of holly also decreased linearly with increasing Primo rate at four WAT; shoots of plants receiving 3000 ppm were 68% shorter than those of controls (Table 2). With butterfly-bush, growth index of plants receiving 3000 ppm Primo was 30% lower than that of controls three WAT. However, by nine WAT, differences in growth index decreased to 22%, indicating a dissipation of growth suppression. Growth index of privet decreased quadratically with increasing Primo rate four WAT; growth index of plants treated with 3000 ppm Primo was 10% lower than controls. At 10 WAT, growth index of privet

Table 3. Effects of single foliar sprays of Primo on growth indices[z] of four woody landscape plants, Experiment 2.

Primo rate (ppm)	Azalea (*Rhododendron* x 'G.G. Gerbing')		Butterfly-bush (*Buddleia davidii* 'Royal Red')		Holly (*Ilex* x 'Nellie R. Stevens')		Privet (*Ligustrum japonicum*)
	4 WAT[y]	10 WAT	3 WAT	9 WAT	4 WAT	10 WAT	4 WAT
0	27.7[x]	44.9	60.3	78.6	33.7	46.7	33.7
500	22.0	41.3	62.0	94.3	29.3	44.6	33.0
1000	25.5	42.1	59.1	81.8	28.1	41.0	30.2
1500	23.8	38.5	55.5	71.6	24.7	34.2	27.8
2000	18.9	33.2	55.0	84.1	25.5	36.7	29.8
2500	21.3	37.0	51.0	71.5	24.7	34.7	30.0
3000	21.3	33.9	42.2	61.3	23.8	31.8	30.4
Significance[w]	L***Q*	L***	L***Q*	L***	L***Q*	L***	L*Q*

[z]Growth index = (height + width at the widest point + width 90° to the widest point) ÷ 3, in cm.

[y]WAT = weeks after treatment.

[x]Means of seven single-plant replications.

[w]Regression response linear (L) or quadratic (Q) at $P \leq 0.05$ (*) or 0.001 (***).

Fig 1. Untreated *Ligustrum japonicum* (left) and plants treated with a foliar spray of 3000 ppm Primo, 10 weeks after treatment.

was not affected by treatment (data not shown), indicating that treated plants grew more than controls between four and 10 WAT. This was evident upon observation. At four WAT, treated plants were compact, but by 10 WAT shoots of treated plants had elongated excessively (Fig. 1). Appearance was similar to that of plants treated with gibberillic acid (GA). Primo inhibits GA biosynthesis and thus cell elongation; however, cell division continues during growth inhibition. Rapid shoot elongation often occurs when GA biosynthesis resumes. Accelerated growth of retardant-treated plants has been observed in other studies after growth suppression effects have dissipated (2,5) and may relate to the accumulation of large reserves of carbohydrates during the period of growth inhibition. These large reserves stimulate rapid growth as effects of a growth retardant lessens (2).

Findings of these two experiments indicate that Primo was effective at suppressing shoot growth of several herbaceous and woody landscape plants. However, at rates necessary for shoot control, phytotoxicity was common to foliage, flowers, or both of most species. Results also suggest that herbaceous or woody landscape plants may be injured by Primo application to turf due to overspray or drift. The recommended rate of Primo for turf application is 0.08–0.5 ml/m^2 (0.25–1.5 oz of product/1000 ft^2) in a volume of 20–102 ml/m^2 (0.5–2.5 gal/1000 ft^2). At these recommended rates, Primo would be applied at up to 2810 ppm, much higher than rates that caused injury to both herbaceous and woody landscape species in these experiments.

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