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Response of Five Woody Landscape Plants to Primo and Pruning[1]

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Abstract

The use of Primo (trinexapac-ethyl) was investigated as an alternative to pruning of container-grown woody ornamental species. A foliar spray of 469, 938, or 1407 ppm (0.5, 1.0 or 1.5 oz/gal) was applied to pruned plants. A nontreated control (water) and an industry control [Atrimmec (dikegulac-sodium)] were also included for comparison. Monthly mechanical pruning or no pruning treatments were imposed during the production period. Monthly pruning alone reduced the height of euonymus, forsythia, Chinese privet, waxleaf privet, and azalea. Efficacy of plant growth regulator treatments differed among the five species. Primo was not effective in suppressing the height or trimming dry weight of forsythia, Chinese privet, or waxleaf privet and provided only a transient suppression of euonymus and azalea.

Index words: chemical pruning agent, growth retardant, growth regulation.

Species used in this study: Formosa azalea [*Rhododendron indica* (L.) Sweet 'Formosa']; forsythia (*Forsythia* x *intermedia*); Manhattan euonymus (*Euonymus kiautschovicus* Loes. 'Manhattan'); Variegated Chinese privet (*Ligustrum sinense* Lour. 'Variegatum'); Variegated waxleaf privet (*Ligustrum lucidum* Ait. f. 'Variegatus').

Growth regulators used in this study: Atrimmec (dikegulac-sodium), sodium salt of 2,3:4,6 bis-O-(1-methylethylidene)-*a*-L-xylo-2-hexufuranosonic acid; Primo (trinexapac-ethyl), 4-(cyclopropyl-α-hydroxy-methylene)-3,5-dioxocyclohexanecarboxylic acid ethyl ester.

Significance to the Nursery Industry

Foliar application of Primo at 469, 938, or 1407 ppm (0.5, 1.0 or 1.5 oz/gal) did not result in acceptable growth reduction of forsythia, Chinese privet, or waxleaf privet and provided only a transient suppression of euonymus and azalea. Two of the five species tested actually exhibited an increase in plant height following treatment with Primo. While the landscape management industry may not benefit from Primo applications, a transient suppression of plant height followed by a resurgence of plant height without altering overall dry weight production may benefit the woody plant liner (transplant) industry. Short-term chemical pruning such as expressed by the two species in this study, may provide a greater degree of scheduling flexibility than mechanical pruning. Further work is needed to investigate the potential of this product for use in the nursery production industry.

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Introduction

There is continued interest in plant growth regulator (PGR) use on woody landscape plants to reduce vegetative growth. Landscape management firms and power companies continue to utilize PGRs as a cost-effective means of controlling woody plant growth in landscapes and near power lines. The turfgrass industry utilizes PGRs as a cost-effective means of controlling turfgrass growth in landscape situations (13). The nursery production industry may benefit from cost-effective plant growth regulators as well.

PGRs labeled for use on woody landscape plants include Atrimmec (dikegulac-sodium), Royal Slo-Gro (maleic hydrazide), Embark (mefluidide), Sumagic (uniconazole) and Bonzi (paclobutrazol). While these products are effective for regulating growth of woody landscape species, phytotoxicity symptoms can occur at the recommended rates (2, 5, 7,

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11, 12, 14). For landscape management firms, this phytotoxicity is not acceptable.

The triazole compound Primo (trinexapac-ethyl; Novartis Crop Protection Inc., Greensboro, NC), is a PGR that was introduced to the U.S. trufgrass market in 1991 (13). Primo effectively retards clipping production and canopy height of turfgrass without causing a marked decrease in turf quality (1, 3, 4, 6). Similar to the triazole PGRs uniconazole and paclobutrazol, Primo, reduces cell elongation by interfering with the production of gibberellins (13). The purpose of this study was to evaluate Primo as an alternative to pruning on fast-growing woody landscape ornamentals.

Materials and Methods

Fifty uniform liners each of euonymus, forsythia, waxleaf privet, Chinese privet, and azalea were potted at Flowerwood Nursery in Loxely, AL, in 11.4 liter (#3) containers May 16,1997. The potting substrate consisted of aged pinebark and sand (19:1 by vol) amended with 1.8 kg/m^3 (3 lbs/yd^3) calcitic lime, 1.8 kg/m^3 (3 lbs/yd^3) dolomitic lime, 3.6 kg/m^3 (6 lbs/yd^3) 13N–2.58P–4.98K (Graco 13–6–6) + micronutrients and 1.9 kg/m^3 (3.2 lbs/yd^3) Talstar (Whitmire Micro-Gen Research Laboratories, Inc., St. Louis, MO). A top dressing (54 g) of 17N–2.15P–9.13K (Polyon 10–12 month17–5–11, Pursell Technologies, Inc. Sylacauga, AL), was applied May 23, 1997. Plants were grown in full sun with overhead irrigation.

For each species, plants were arranged in a split plot design with 5 blocks. Mechanical pruning treatments were allocated to main plots within each block and plant growth regulator treatments were allocated to sub-plots within each main plot of every block. All plants of each species were mechanically pruned to a consistent height above the rim of the pot for shaping on May 17, 1997. Pruning heights were 13 cm (5 in) for euonymus, waxleaf privet, Chinese privet, and azalea and 15 cm (6 in) for forsythia. Primo was applied as a foliar spray (to drip) at 0.5×, 1.0× and 1.5× the label rate or 0, 469, 938, or 1407 ppm (0, 0.5, 1.0, or 1.5 oz/gal). Plants serving as an industry PGR control received a foliar spray (to drip) of Atrimmec at the recommended label rates of 2890 ppm (2.0 oz/gal) for euonymus and forsythia and 1445 ppm (1.0 oz/gal) for waxleaf privet, Chinese privet, and azalea. PGRs were applied to dry foliage with a pressurized handheld sprayer at noon following the daily irrigation cycle. Plants received their normally scheduled overhead irrigation the following day. After PGR application, plants were pruned June 16, 1997 [31 days after treatment (DAT)], July 23, 1997 (68 DAT), and September 10–11, 1997 (117–118 DAT).

Plants were evaluated for phytotoxic response 7, 14, 21, and 28 DAT using a visual rating scale where 1 = no injury, 2 = slight chlorosis, 3 = moderate chlorosis, 4 = severe chlorosis, 5 = defoliation or stem die-back and 6 = dead plant. Plant height and width (2 perpendicular measurements) were recorded just prior to each pruning and these measurements used to calculate a growth index (GI = [height + (mean of 2 widths)] / 2). Trimming dry weight was determined by collecting all trimmings and drying in a forced air oven at 70C (158F) for 24 hours prior to weighing. All plants were mechanically pruned to the aforementioned heights 117–118 DAT. General Linear Models procedures were used to test for significant responses between the main effects of pruning and PGR. Orthogonal polynomial contrasts were used to partition main effects sums of squares for PGR treatment comparisons. PGR comparisons include tap water control vs. Primo (938 ppm), industry control (Atrimmec) vs. Primo (938 ppm), and linear regression of three rates of Primo.

Table 1. Effects of monthly pruning on the height and trimming dry weight[z] of euonymus, forsythia, waxleaf privet, Chinese privet and azalea following treatment with Primo.

Species	Pruned	Not pruned	Significance[y]
	Height (cm) 68 DAT		
Euonymus	34.2[x]	30.5	*
Forsythia	66.4	76.6	*
Waxleaf privet	26.0	37.4	**
Chinese privet	21.6	37.9	***
Azalea	29.8	29.6	NS
	Height (cm) 118 DAT		
Euonymus	38.6	64.4	***
Forsythia	90.9	55.9	***
Waxleaf privet	25.2	50.8	***
Chinese privet	25.1	46.4	***
Azalea	25.8	45.5	***
	Trimming dry weight (g) 118 DAT		
Euonymus	31.0	51.5	***
Forsythia	58.0	88.3	***
Waxleaf privet	53.5	96.7	***
Chinese privet	4.7	28.5	***
Azalea	39.1	41.4	NS

[z]DAT = Days after treatment. Plant growth regulators applied May 17 ,1997, mechanical pruning June 16 (31 DAT), July 23 (68 DAT) and September 11 (118 DAT). Atrimmec (dikegulac-sodium) applied at1445 ppm (privet and azalea) or 2890 ppm (euonymus and forsythia); Primo (trinexapac-ethyl) applied at 469, 938, or 1407 ppm.

[y]NS, *, **, *** Nonsignificant or significant at the 5%, 1%, or 0.1% levels, respectively.

[x]n = 25.

Results and Discussion

Pruning. Monthly pruning alone was successful in suppressing the height of all species in this test (Table 1). Height of euonymus, forsythia, Chinese privet, and waxleaf privet was reduced 68 and 118 DAT for plants receiving monthly pruning. Monthly pruning also reduced the height of azalea but this suppression was not evident until 118 DAT. For euonymus, forsythia, Chinese privet, and waxleaf privet, cumulative trimming dry weight from plants pruned on a monthly interval was less than the trimming dry weight removed from non-pruned plants at 118 DAT. Monthly pruning did not suppress trimming dry weight of azalea compared to non pruned plants. These data demonstrate that monthly pruning resulted in a reduction of height and a suppression of cumulative trimming dry weight removed from euonymus, forsythia, Chinese privet, and waxleaf privet.

Plant growth regulation. Efficacy of plant growth regulator treatments differed among the five woody ornamental species (Tables 2–5). Regardless of pruning treatment, the recommended rate of Primo (938 ppm) was not effective in suppressing the height or trimming dry weight of azalea, forsythia, waxleaf privet, or Chinese privet. However, a suppression of height and growth index for euonymus and a reduction in growth indices for azalea were evident at 31 DAT. In this study, Primo did not prove to be an alternative to pruning for these landscape species.

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Table 2. Effects of Primo on the height of euonymus, forsythia, waxleaf privet, Chinese privet and azalea 31 days after treatment.

PGR treatment	Concn. (ppm)[z]	Height (cm)				
		Euonymus	Forsythia	Waxleaf privet	Chinese privet	Azalea
Tap water control	—	21.5[x]	39.6	21.0	23.4	20.4
Atrimmec	Label[y]	17.7	21.4	20.3	11.1	19.6
Primo	469	18.7	42.4	26.3	26.7	20.0
Primo	938	15.9	37.8	30.1	26.3	18.7
Primo	1407	15.6	42.5	25.8	28.4	15.9
Contrast (probability)						
Water vs. Primo (983 ppm)		0.0040	0.5800	0.0005	0.0630	0.2987
Atrimmec vs. Primo (983 ppm)		0.5200	0.0001	0.0143	0.0001	0.9716
Primo linear		0.0900	0.9700	0.8320	0.2680	0.0159

[z]Plant growth regulators (PGR) applied May 17 ,1997, mechanical pruning June 16 (31 DAT); Primo (trinexapac-ethyl) applied at 469, 983, or 1407 ppm.
[y]Label rate = Atrimmec (dikegulac-sodium) applied at 1445 ppm (privet and azalea) or 2890 ppm (euonymus and forsythia).
[x]n = 10.

Phytotoxicity. No phytotoxicity was noted on euonymus, forsythia, Chinese privet or waxleaf privet following Primo application. Phytotoxicity (foliar chlorosis and bronzing on new, expanding leaves) was noted on azalea following application of Primo at 938 and 1407 ppm (Table 6). However, no phytotoxicity was noted on azalea after 14 DAT. Keever and Olive (8) described similar phytotoxicity symptoms on azalea (*Rhododendron* x ' G. G. Gerbing') 2 and 4 weeks after treatment of Primo at 300 to 5000 ppm. In subsequent research, Keever and Olive (9) reported no such symptoms for gumpo azalea (*Rhododendron eriocarpum*) and suggested the occurrence or severity of phytotoxicity to Primo may be species or cultivar specific.

Primo resulted in less phytotoxicity to woody ornamental species than Atrimmec. Application of Atrimmec commonly results in a slight foliar chlorosis (11) and this was noted 7 and 14 DAT on new, expanding leaves of azalea, and Chinese privet (Table 6). Foliar chlorosis was no longer visible on azalea after 14 DAT. Foliar chlorosis of Chinese privet remained through 28 DAT and several plants also exhibited leaf drop at that time. By 31 DAT, four Chinese privet (2 pruned, 2 non pruned) died as a result of Atrimmec application, while the growth of remaining plants appeared normal. Foliar chlorosis was also present on forsythia 7, 14, and 21 DAT with a consistent rating of 2 which differed significantly ($p = 0.0001$) from the rating of 1 for the tap water controls and all rates of Primo.

Growth suppression. Primo (938 ppm) was effective for providing growth suppression of euonymus 31 DAT but plant height and growth index values did not differ from Atrimmec (Tables 2 and 3). By 68 DAT height suppression was no longer evident and cumulative trimming dry weight did not differ from the controls.

No suppression of height or growth indices of forsythia was evident with Primo 31 DAT and by 68 DAT, plants treated with Primo were actually taller than forsythia receiving only water (Table 4). Atrimmec did suppress height and growth indices of forsythia compared to Primo (938 ppm) 31 DAT but this suppression was no longer evident 68 DAT.

Growth of waxleaf privet was not suppressed with Primo at 31 DAT compared to the tap water controls (Tables 2 and 3). Height and growth indices were increased 31 DAT with the application of Primo (938 ppm) compared to tap water and Atrimmec controls (Table 4). By 68 DAT, growth of pruned waxleaf privet treated with Primo no longer exceed the controls while growth of non pruned waxleaf privet continued to exceed the growth of the controls. By 118 DAT

Table 3. Effects of Primo on the growth index[z] of euonymus, forsythia, waxleaf privet, Chinese privet and azalea 31 days after treatment.

PGR treatment[y]	Concn. (ppm)	Growth index (cm)				
		Euonymus	Forsythia	Waxleaf privet	Chinese privet	Azalea
Tap water control	—	27.2[w]	50.0	39.1	30.9	39.8
Atrimmec	Label[x]	21.8	25.4	41.5	11.9	34.7
Primo	469	23.2	53.1	49.9	35.6	36.2
Primo	938	18.9	46.6	58.1	35.1	31.6
Primo	1407	18.8	54.2	48.6	37.7	31.1
Contrast (probability)						
Water vs. Primo (983 ppm)		0.0017	0.4115	0.0001	0.0470	0.0007
Atrimmec vs. Primo (983 ppm)		0.5300	0.0001	0.0327	0.0001	0.5805
Primo linear		0.0800	0.7872	0.7100	0.3200	0.0094

[z]Growth index = [(height + mean of 2 widths) / 2].
[y]Plant growth regulators (PGR) applied May 17 ,1997, mechanical pruning June 16 (31 DAT); Primo (trinexapac-ethyl) applied at 469, 983, or 1407 ppm.
[x]Label rate = Atrimmec (dikegulac-sodium) applied at 1445 ppm (privet and azalea) or 2890 ppm (euonymus and forsythia)
[w]n = 10.

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Table 4. Effects of monthly pruning on the height of forsythia, waxleaf privet and Chinese privet 68 days after treatment with Primo.

PGR treatment[z]	Concn. (ppm)	Forsythia	Waxleaf privet		Chinese privet	
			Pruned	Not pruned	Pruned	Not pruned
Tap water control	—	62.1[x]	24.8	30.8	23.6	36.2
Atrimmec	Label[y]	69.3	24.2	34.2	17.0	16.8
Primo	469	67.6	25.0	32.4	21.8	44.4
Primo	938	78.0	28.2	49.6	24.0	43.0
Primo	1407	80.6	27.6	39.8	21.6	49.0
Significance[x]						
Pruning		*	**		***	
PGR		*	***		**	
Pruning x PGR		ns	*		***	
Contrast (probability)						
Water vs. Primo (938 ppm)		0.0231	0.2100	0.0002	0.8500	0.1030
Atrimmec vs. Primo (938 ppm)		0.8900	0.3300	0.1000	0.0020	0.0001
Primo Linear		0.5980	0.3400	0.0800	0.9200	0.2600

[z]DAT = Days after treatment. Plant growth regulators (PGR) applied May 17, 1997, mechanical pruning June 16 (31 DAT), July 23 (68 DAT) and September 11 (118 DAT). Primo (trinexapac-ethyl) applied at 469, 983, or 1407 ppm.

[y]Label rate = Atrimmec (dikegulac-sodium) applied at 1445 ppm (privet) or 2890 ppm (forsythia).

[x]n = 10 (forsythia) or n = 5 (privet).

[w]ns, *, **, *** Nonsignificant or significant at the 5%, 1%, or 0.1% levels, respectively.

height and trimming dry weight for plants treated with Primo did not differ from controls regardless of mechanical pruning treatment.

Growth of Chinese privet was suppressed with Atrimmec throughout the test period (Tables 2–5). However, severe chlorosis and necrosis resulted by 118 DAT. Chinese privet exhibited an increase in plant height and growth indices 31 DAT following application of Primo (Tables 2 and 3). This increased growth was no longer evident 68 DAT (Table 4). By 118 DAT, height and cumulative trimming dry weight was similar among the Primo and tap water treatments (Table 5).

Primo was effective in suppressing growth indices of azalea 31 DAT compared to the tap water control (Table 3) and height and growth indices of azalea decreased as the rate of Primo increased (Table 2). Following initial pruning (31 DAT), height suppression was no longer evident for azalea, but by 118 DAT height of plants treated with Primo increased compared to height of non treated plants (Table 5). This increased height suggests a resurgence of shoot growth for Primo treated plants between 31 and 118 DAT.

Results of this study suggest that a reduction in plant height and trimming dry weight can be achieved with a maintenance program consisting of monthly pruning. Monthly pruning

Table 5. Effects of monthly pruning on the height and trimming dry weight of Chinese privet and height of azalea 118 days after treatment with Primo.

PGR treatment[z]	Concn. (ppm)	Chinese privet			Azalea
			Trimming dry weight (g)		
		Height (cm)	Cumulative[y]	118 DAT	Height (cm)
Tap water control	—	37.0[x]	4.7	38.6	33.9
Atrimmec	1445	23.1	2.7	5.1	32.9
Primo	469	39.5	4.7	41.3	35.9
Primo	938	39.6	6.7	29.8	37.8
Primo	1407	39.7	4.5	28.2	37.7
Significance[w]					
Pruning		***	***		***
PGR		**	***		*
Pruning × PGR		ns	**		ns
Contrast (probability)					
Water vs. Primo (938 ppm)		0.4800	0.1490	0.2410	0.0376
Atrimmec vs. Primo (938 ppm)		0.0001	0.0207	0.0002	0.0671
Primo Linear		0.9500	0.9200	0.0900	0.3242

[z]DAT = Days after treatment. Plant growth regulators (PGR) applied May 17 ,1997, mechanical pruning June 16 (31 DAT), July 23 (68 DAT) and September 11 (118 DAT). Atrimmec (dikegulac-sodium) applied at 1445 ppm; Primo (trinexapac-ethyl) applied at 469, 938, or 1407 ppm.

[y]Cumulative = Sum of trimming dry weight from 31, 68, and 118 DAT.

[x]n = 10 (height) or n = 5 (dry weight).

[w]ns, *, **, *** Nonsignificant or significant at the 5%, 1%, or 0.1% levels, respectively.

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Table 6. Phytotoxicity ratings[z] for Chinese privet and azalea 7 and 14 days after treatment (DAT) with Primo.

PGR treatment[y]	Concn. (ppm)	Chinese privet		Azalea	
		7 DAT	14 DAT	7 DAT	14 DAT
Tap water control	—	1.0[x]	1.0	1.0	1.0
Atrimmec	1445	1.6	1.7	1.8	1.8
Primo	469	1.0	1.0	1.7	1.7
Primo	938	1.0	1.0	2.0	1.7
Primo	1407	1.5	1.0	2.8	2.1
Contrast (probability)					
Water vs. Primo (938 ppm)		1.0000	1.0000	0.0001	0.0006
Atrimmec vs. Primo (938 ppm)		0.0005	0.0001	0.1026	0.0078
Primo linear		0.0082	1.0000	0.0001	0.0363

[z]Phytotoxicity rating scale: 1 = no injury, 2 = slight chlorosis, 3 = moderate chlorosis, 4 = severe chlorosis, 5 = defoliation or stem die-back and 6 = dead plant.

[y]Plant growth regulators (PGR) applied May 17, 1997; Atrimmec (dikegulac-sodium) applied at 1445 ppm; Primo (trinexapac-ethyl) applied at 469, 938, or 1407 ppm.

[x]n = 10.

was more effective for height, growth indices, and trimming dry weight reduction than PGR application. While PGRs such as uniconazole (10) and flurprimidol (7) have been shown to reduce trimming weight of privet (*Ligustrum* sp.), no such response for privet was noted in this study. Forsythia, waxleaf privet and azalea actually exhibited an increase in plant height following treatment with Primo. A similar acceleration of growth was reported by Keever and Olive (8) for privet (*Ligustrum japonicum*) between four and 10 weeks after treatment with Primo at rates ranging from 500 ppm to 3,000 ppm. These authors (8) attributed the accelerated growth of privet to utilization of carbohydrate reserves that accumulate during the period of growth inhibition. A resurgence of plant growth following application of Primo would not be desirable in a landscape situation, hence, this product would not be recommended as an alternative to mechanical pruning regardless of the initial level of suppression achieved.

While the landscape management industry may not benefit from the growth resurgence demonstrated by the four species herein, this plant response may have a practical application within the nursery production industry. An initial, transient suppression of plant height followed by a resurgence of plant height without altering overall dry weight production may benefit the woody plant liner (transplant) industry. Application of Primo to woody ornamental liners may allow for a reduction in the labor intensive practice of repeated mechanical pruning. Short-term chemical pruning such as expressed by the species in this study, may provide a greater degree of scheduling flexibility than mechanical pruning. Chemical pruning would also allow for retention of a greater proportion of liner shoot growth prior to transplanting thereby allowing for earlier sales following transplant. A transient foliar phytotoxicity, if present, would not be a concern in such a production scheme since the end user would not see this effect by the time plants reach market size.

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