Growth and Water Status of Pruned and Unpruned Woody Landscape Plants Treated with Sumagic (Uniconazole), Cutless (Flurprimidol), or Atrimmec (Dikegulac)[1]

Jeffrey G. Norcini[2]
University of Florida-IFAS
Agricultural Research and Education Center
Rural Route 4, Box 4092
Monticello, FL 32344-9302

Abstract

Efficacy of Cutless (flurprimidol), Sumagic (uniconazole), and Atrimmec (dikegulac) as affected by application date after pruning was investigated with *Pyracantha* × 'Teton', *Ligustrum* × *vicaryi*, and *Euonymus fortunei* var. coloratus. Cutless (flurprimidol) applied to the medium surface, or foliar sprays of Sumagic (uniconazole) or Atrimmec (dikegulac) were applied 1, 2, 3 or 7 days after pruning (DAP) and to unpruned plants in spring 1989. Height and width were recorded weekly into November, 1989. The effect of these plant growth regulators (PGRs) on short-term plant water relations was measured at 2, 3, 18, 22, or 24 days on unpruned plants and plants treated 2 DAP. Growth rate of *Pyracantha* was reduced for 6 to 7 weeks if Sumagic (uniconazole) was applied 2 DAP or less, or to unpruned plants; otherwise growth rate was reduced 4 to 5 weeks. Sumagic (uniconazole) reduced *Pyracantha* growth rate more than Atrimmec (dikegulac); however, Atrimmec-treated plants had a more normal growth habit by the end of the experiment. Atrimmec (dikegulac) also suppressed *Ligustrum* growth without detrimentally affecting plant appearance. Cutless (flurprimidol) was the only PGR that effectively inhibited growth of *Euonymus*; however, this treatment excessively dwarfed *Pyracantha* and *Ligustrum*. The influence of Atrimmec (dikegulac) and Cutless (flurprimidol) on leaf area varied with the species, and pruning had no effect. Short-term effects of Sumagic (uniconazole), Cutless (flurprimidol), and Atrimmec (dikegulac) on transpiration and stomatal conductance to water vapor were species dependent, with some species exhibiting partial stomatal closure. Improvement of plant water status (stem water potential and relative leaf water content) occurred in some cases.

Index words: chemical pruning agent, growth retardant, plant water status, stomatal conductance, transpiration

Species used in this study: vicaryi privet (*Ligustrum* × *ovalifolium* 'Aureo-marginata' Hassk. × *Ligustrum vulgare* L.); wintercreeper euonymus (*Euonymus fortunei* var. coloratus [Rehd.] Rehd.); Teton pyracantha ([*Pyracantha* coccinea × Pyracantha fortuneana (Maxim.) Li] × Pyracantha rogersiana [A.B. Jacks] Bean 'Flava').

Growth regulators used in this study: Atrimmec (dikegulac), 2,3:4,6 bis-o-(1-methylethylidene)-o-l-xylo-2-hexulofuranosonic acid; Cutless (flurprimidol), α-(1-methylethyl)-α-[4-(trifluoromethoxy)phenyl]-5-pyrimidinemethanol; Sumagic (uniconazole), (E)-(p-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)-1-penten-3-ol.

Significance to the Nursery Industry

Temporary suppression of *Euonymus*, *Pyracantha*, and *Ligustrum* growth was achieved with some PGR treatments without affecting final plant size or appearance. However, length of control was dependent upon species and PGR. As it was suggested previously (8), the use of PGRs may have a place in nursery production schemes. Growth of crops that are at saleable size and are "containerized" (e.g., fabric, plastic, balled-and-burlapped) could be held in check temporarily so as to maintain the quality of the plant until a future shipping date.

Cutless (flurprimidol) applied to the medium surface at 10 mg ai per plant appears to be a very desirable practice for *Euonymus fortunei* var. coloratus production. Plants treated with Cutless (flurprimidol) were more aesthetically appealing because they were more densely foliated and had slightly larger leaves.

The retarding effect of Sumagic (uniconazole) on height of *Pyracantha* species might prove helpful when dealing with hedges but would not be practical for reduction of pruning during production if the growth habit is normally upright, such as with *Pyracantha* × 'Teton'.

Reduction of water stress is a potential use for these PGRs, especially Atrimmec (dikegulac). Atrimmec (dikegulac) caused the most consistent improvements in plant water status and is registered for use on nursery crops. However, additional research needs to conducted because of the variability among species in dikegulac's effects on plant water relations.

Introduction

The plant growth regulators (PGRs) Cutless (flurprimidol) and Sumagic (uniconazole) have shown promise for reducing pruning frequency of woody plants in nurseries and landscapes. Both PGRs control vegetative growth of several woody species, including *Pyracantha* (7, 8) and *Ligustrum* (3, 7, 8, 12).

Effective utilization of these PGRs is strongly influenced by time of application with respect to pruning date. Sumagic (uniconazole) most effectively reduced growth rate of *Pyracantha* and *Ligustrum* the first 2 to 3 weeks after application if applied 1 day after pruning (DAP) compared to 10 DAP (8). The response of *Photinia* × *fraseri* to Cutless (flurprimidol) was also related to pruning date (6).

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[2]Assistant Professor.

Besides controlling vegetative growth of woody plants in nursery or landscape situations, PGRs can reduce water consumption. Growth retardants cause a long-term decline in water use through reduced growth rate and changes in leaf morphology. Leaves of PGR-treated plants are frequently smaller (3, 5, 12) thereby reducing total leaf area, and consequently reducing whole-plant transpiration (2, 9, 13, 17). However, there is evidence that growth retardants reduce transpiration through a decrease in stomatal conductance (1, 14, 16).

The objectives of this study were to examine the effect of pruning date on growth inhibition induced by Sumagic (uniconazole) and Cutless (flurprimidol) and to determine the effect of these PGRs on short-term plant water status. Atrimmec (dikegulac), a PGR labelled for woody landscape plants, was included in the study for comparison.

Materials and Methods

Liners of *Euonymus fortunei* var. coloratus, *Ligustrum* × *vicaryi*, and *Pyracantha* × 'Teton' were potted in 3.8 l (1 gal) containers with a medium of pine bark:Canadian sphagnum peat:sand (5:1:1 by vol). One cubic meter (1.3 yd^3) of medium was amended with 2.97 kg (6.55 lb) superphosphate, 0.89 kg (1.96 lb) Micromax (12S-0.1B-0.5Cu-12Fe-2.5Mn-0.05Mo-12Zn), and 5.9 kg (13.0 lb) Osmocote 18N-2.6P-1.0K (18-6-12). *Euonymus* and *Pyracantha* were potted in March, placed under 30% shade for 2 weeks, and then moved to full sun for the remainder of the experiment. *Ligustrum* were potted in April and grown under 30% shade for the whole experiment. All plants were watered by overhead irrigation. A top dressing of Osmocote 18N:2.6P:1.0K (18-6-12) was applied every 3 months starting at the time of transplanting. Plants were pruned 1, 2, 3, or 7 days before PGR treatment. Pruning served to achieve relatively uniform plant size and shape. *Euonymus* were pruned to two main stems per pot and so that all stems were within the pot perimeter. Pruned *Euonymus* were about 16 cm (6.3 in) tall and 15 cm (6.0 in) wide while unpruned plants were about 26 cm (10.2 in) tall and 24 cm (9.4 in) wide. Pruned *Pyracantha* were about 11 cm (4.3 in) tall and 9 cm (3.5 in) wide while unpruned plants were about 14 cm (5.5 in) tall and 13 cm (5.1 in) wide. *Ligustrum* were pruned to two to three stems per pot. Pruned *Ligustrum* were about 32 cm (12.6 in) tall and 16 cm (6.3 in) wide while unpruned plants were about 33 cm (13 in) tall and 22 cm (8.7 in) wide. On April 14, 1989 (May 10 for *Ligustrum*), plants were treated either with a spray (to wet) of 4000 ppm Atrimmec (dikegulac) or 100 ppm Sumagic 10 WDG (uniconazole), or top-dressed with 10 mg ai Cutless 0.33G (flurprimidol). Unpruned plants were treated similarly. Environmental conditions were as follows on April 14 and May 10, respectively: air temperature—18.3 and 22.2°C (65 and 72°F); soil temperature—20 and 21.1°C (68 and 70°F); soil moisture—near field capacity on both dates; relative humidity—52 and 90%; sky—cloudy on both dates; time of application—0900 to 1000 and 0830 to 0930 HR. There were six replications per treatment in a completely randomized design within each species. Width in two directions, the widest point (W1) and perpendicular to the widest point (W2), and height were recorded weekly through November 9, 1989. In mid-October, six recently expanded fully mature leaves were selected at random from each plant for leaf area determination.

Plants not used in the above experiment were used for determining the effect of these PGRs on short-term water status. These plants were grown and treated the same as before except for the pruning treatment. The PGRs were applied 2 days after pruning (DAP) or to unpruned plants. There were five replications per treatment in a randomized complete block design within each species. Stomatal conductance to water vapor (gs) and transpiration rate (E) were recorded between 1000 and 1300 HR 3, 18, and 24 days after treatment (DAT) (2 and 22 DAT for *Ligustrum*) using a LICOR Model LI-1600 Steady State Porometer. Fully expanded leaves that had developed before PGR treatment were used for gas exchange measurements. Measurements 24 DAT (*Euonymus* and *Pyracantha* only) were recorded 64 hr after the plants had last been irrigated to evaluate the effects of these PGRs on water stress. Stem water potential (ψ_x) was recorded during the same time and dates (except 2 DAT) using a pressure chamber apparatus (11). Also measured (except 2 and 3 DAT) was relative leaf water content (RLWC), defined as

$$\text{RLWC} = \frac{\text{initial fresh weight} - \text{dry weight}}{\text{turgid weight} - \text{dry weight}} \times 100$$

where turgid weight was the leaf fresh weight after 24 hr in the dark at near 100% relative humidity with the leaf petioles immersed in water. On July 13, leaf area was determined for 10 fully expanded recently matured leaves developed after treatment.

Data were analyzed by general linear model (GLM) procedures (10). Relative leaf water content was analyzed after square root transformation; however, untransformed data are reported.

Results and Discussion

Atrimmec (dikegulac) at 4000 ppm caused minor chlorosis of *Euonymus* and *Pyracantha* leaves that had not fully expanded starting about 2 weeks after application and lasting for up to 2 weeks. Neither Cutless (flurprimidol) or Sumagic (uniconazole) caused any foliar phytotoxicity, although all three PGRs affected leaf size in some cases (Table 1).

Table 1. Effect of growth regulators on leaf area of *Euonymus fortunei* var. coloratus, *Ligustrum* × *vicaryi*, and *Pyracantha* × 'Teton'. *Euonymus* and *Pyracantha* were treated on April 14, 1989, and *Ligustrum* on May 10. Leaves were harvested in mid-July and mid-October.

	Leaf area (cm)[z]					
	Euonymus		*Ligustrum*		*Pyracantha*	
Treatment[y]	July	Oct.	July	Oct.	July	Oct.
Untreated	4.9	5.2	5.4	7.1	0.8	0.9
Dikegulac	5.2	5.6	1.6	6.8	0.7	0.9
Flurprimidol	7.0	6.8	2.5	4.6	1.2	1.6
Uniconazole	5.5	5.4	4.1	7.3	1.2	0.9
LSD 5%	0.7	0.4	0.9	0.4	0.2	0.1

[z]July and October values are the means of 10 and 6 fully expanded leaves developed after treatment application, respectively.

[y]Only growth regulator effects are presented as both pruning (pruned vs. unpruned, and pruning date) and interactive effects were nonsignificant.

Visible suppression of height and width increases of all three species was not noted until 8 to 14 DAT, which concurs with previous reports (7, 8). The degree of vegetative growth control varied by species and PGR (Table 2), with pruning (pruned vs. unpruned, and pruning date) generally exerting little influence on PGR activity.

Cutless (flurprimidol) at 10 mg ai per plant applied as a top dress reduced growth of all three species the most, however it caused extreme dwarfing of *Pyracantha* and *Ligustrum*. However, *Euonymus* treated with Cutless (flurprimidol) were about 25% smaller in width (Table 2), more densely foliated, and had leaves that were about 30 to 40% larger than untreated plants (Table 1), resulting in plants that were more aesthetically desirable compared to plants from other treatments.

Atrimmec (dikegulac), labelled for nursery crop production and landscape maintenance, generally was more effective than foliar-applied Sumagic (uniconazole) at 100 ppm. Atrimmec (dikegulac) at 4000 ppm inhibited growth of *Euonymus* for 3 weeks after treatment (WAT) whereas Sumagic (uniconazole) was ineffective (results not shown), although neither PGR inhibited long-term growth (Table 2). Conversely, Johnson and Lumis (5) reported that *Euonymus fortunei* 'Colorata' treated with 4000 ppm dikegulac (applied about 2 months after pruning) were excessively compact and had much reduced leaf size. Atrimmec (dikegulac) had no effect on *Euonymus* leaf size in our experiment (Table 1). The discrepancy in efficacy of Atrimmec (dikegulac) may have been related to environmental conditions. Johnson and Lumis (5) conducted their experiment under a relatively cool Canadian summer climate while our experimental conditions were subtropical.

Sumagic (uniconazole) also did not control growth of *Ligustrum* whereas Atrimmec (dikegulac) reduced total height and width increases (about 37% and 21%, respectively) without detrimentally affecting plant appearance. The lack of sensitivity of *Ligustrum* × *vicaryi* to Sumagic's (uniconazole) growth retarding effects seems to be an exception within the genus. Growth of *Ligustrum sinense* (8) and *Ligustrum lucidum* (8) were retarded by foliar applied Sumagic (uniconazole) at 100 ppm or less. Sumagic (uniconazole) applied to the medium inhibited growth of *Ligustrum* × *ibolium* (7) and *Ligustrum japonicum* 'Texanum' (13). Also, Hield (3) reported that paclobutrazol, a triazole similar to Sumagic (uniconazole), effectively retarded growth of established field-grown *Ligustrum japonicum*. Sumagic (uniconazole) may have been more effective on all species if an adjuvant had been added to the spray mixture to improve uptake through the stem. Stem-absorbed Sumagic (uniconazole) is translocated to the growing points via the xylem, whereas Sumagic (uniconazole) absorbed by the leaves remains there (4).

Sumagic (uniconazole) suppressed growth of *Pyracantha* slightly more than Atrimmec (dikegulac) (Table 2), although Atrimmec-treated plants had a normal growth habit. *Pyracantha* × 'Teton' is an upright cultivar and Sumagic (uniconazole) retarded height more than width. Short-term activity of Sumagic (uniconazole) was influenced by pruning. Sumagic (uniconazole) reduced growth rate for 6 to 7 WAT if applied to unpruned plants or within 2 DAP but only 4 to 5 WAT if applied 3 or 7 DAP. Similarly, short-term growth inhibition of *Pyracantha koidzumii* 'Wonderberry' by Sumagic (uniconazole) was greatest if applied 1 DAP as opposed to 10 DAP (8).

Pruning promoted total increases in height and width of *Pyracantha*. However, these increases were negated by application of Sumagic (uniconazole) (68.5 vs 51.1 cm for control and uniconazole, respectively; Prob. $> |T| = 0.0045$) and width (72.2 vs. 62.2 cm for control and uniconazole, respectively; Prob. $> |T| = 0.0039$). Atrimmec (dikegulac) similarly retarded the pruning-enhanced increases in total height (68.5 vs. 59.6 cm for control and dikegulac, respectively; Prob. $> |T| = 0.0188$) and width (72.2 vs. 61.7 cm for control and dikegulac, respectively; Prob. $> |T| = 0.0032$). Pruning also stimulated increases in total height of *Euonymus* (10.2 vs. 26.1 cm for unpruned vs. pruned, respectively), but no PGR could negate this effect.

Short-term effects of these PGRs on midday water status generally were species dependent (Tables 3, 4). Atrimmec (dikegulac) and Cutless (flurprimidol) consistently improved short-term midday water status 18 or 22 DAT, although the enhanced water status of Cutless-treated *Ligustrum* and *Pyracantha* might not occur at rates that do not cause such excessive dwarfing. Only Atrimmec (dikegulac) improved the midday water status of *Euonymus* and *Pyracantha* subjected to drought stress (2.5 days without irrigation) as evidenced by the least negative ψ_x's compared to other treatments (Table 3). The improved water status was probably related to the reduced growth rate that occurred during the first few weeks after treatment.

Reductions in gs and E, however, did not seem related to PGR-induced growth inhibition. Cutless (flurprimidol)

Table 2. Effect of growth regulators on increase in height and width of *Pyracantha* × 'Teton', *Euonymus fortunei* var. coloratus, and *Ligustrum* × *vicaryi* from April 14 (May 10 for *Ligustrum*) to November 9, 1989. *Pyracantha* and *Euonymus* were treated on April 14; *Ligustrum* was treated on May 10.

Treatment	*Pyracantha*[z] Height (cm)	*Pyracantha*[z] Width[x] (cm)	*Euonymus*[y] Height (cm)	*Euonymus*[y] Width (cm)	*Ligustrum*[z] Height (cm)	*Ligustrum*[z] Width (cm)
Untreated	67.3	70.3	21.9	87.9	49.0	56.7
Dikegulac	59.5	61.2	21.2	79.6	30.7	44.9
Flurprimidol	3.0	5.8	24.0	66.2	7.2	24.6
Uniconazole	52.2	63.4	24.6	91.7	44.5	52.3
LSD 5%	5.2	4.6	NS	7.0	6.0	3.8

[z]Pruning (pruned vs. unpruned, and pruning date) and interactive effects were nonsignificant.

[y]Pruning (pruned vs. unpruned) significantly affected height; total height increase for pruned and unpruned plants was 26.1 and 10.2 cm, respectively (LSD 5% = 4.6). Pruning date and interactive effects were nonsignificant.

[x]Width = (W1 + W2)/2, where W1 = width at the widest point and W2 = width perpendicular to W1.

reduced E of pruned *Euonymus* 3 DAT (Table 3), i.e., before any growth inhibition was observed. However, 18 DAT, when Atrimmec (dikegulac) and Cutless (flurprimidol) reduced growth rate, gs and E were not lower in growth-inhibited plants, although ψ_x improved. This observation is consistent with a previous report of a flurprimidol-induced increase in ψ_x of forsythia in which E was unaffected (15). Also, no PGRs affected E and gs of *Pyracantha* (results not shown), even though all PGRs reduced the short-term growth rate.

Declines in gs or E did not appear related to changes in leaf anatomy or morphology as gs and E were measured on leaves that had fully matured before PGR treatment. Leaf area (Table 2) probably had little to no influence on short-term midday water status since only a very small proportion of the canopy would have developed during the 22 to 24 days after treatment. Partial stomatal closure of Sumagic-treated *Ligustrum* may have been mediated by a brief rise in ABA levels. Decreased gs of bean plants treated with triadimefon, a triazole similar to uniconazole, was related to a rise in ABA levels (1). The manner in which Atrimmec (dikegulac) affected stomates is unknown.

(*Ed. note*: This paper reports the results of research only, and does not imply registration of a pesticide under amended FIFRA. Before using any of the products mentioned in this research paper, be certain of their registration by appropriate state and/or federal authorities.)

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Table 3. Effect of growth regulators on transpiration rate (E), stomatal conductance to water vapor (gs), stem water potential (ψ_x), and relative leaf water content of pruned and unpruned *Euonymus fortunei* var. coloratus and *Pyracantha* × 'Teton'. Plants were pruned 2 days before treatment on April 14, 1989. Measurements were recorded between 1000 and 1300 HR on leaves that were present before treatment.

	April 17				May 2							May 8 (after 64 hr without irrigation)[z]		
	Euonymus[y]				*Euonymus*[y]					*Pyracantha*[z]		*Euonymus*		*Pyracantha*
	E ($mmol \cdot m^{-2} \cdot s^{-1}$)		gs ($mmol \cdot m^{-2} \cdot s^{-1}$)		E ($mmol \cdot m^{-2} \cdot s^{-1}$)		gs ($mmol \cdot m^{-2} \cdot s^{-1}$)					gs		
Treatment	Unpruned	Pruned	Unpruned	Pruned	Unpruned	Pruned	Unpruned	Pruned	ψ_x (MPa)	ψ_x (MPa)	RLWC (%)	($mmol \cdot m^{-2} \cdot s^{-1}$)	ψ_x (MPa)	ψ_x (MPa)
Untreated	4.16	5.56	173	238	3.54	4.19	172	246	−1.09	−1.12	86.9	259	−1.30	−1.11
Dikegulac	4.02	5.66	173	244	3.51	4.33	213	295	−0.97	−0.86	89.5	317	−0.96	−0.91
Flurprimidol	5.17	4.19	230	175	4.24	4.92	249	299	−0.96	−0.92	90.6	232	−1.22	−1.02
Uniconazole	4.82	4.44	219	184	4.47	4.96	278	309	−1.08	−0.96	90.2	253	−1.31	−1.14
LSD 5%	1.83	1.31	91	68	1.33	1.09	84	65	0.11	0.14	2.2	59	0.12	0.14
Significance[x]														
PGR	NS		NS		NS		*		*	**	*	*	***	**
PRN	NS		NS		*		*		NS	NS	NS	NS	NS	NS
PGR × PRN	*		*		NS		NS		NS	NS	NS	NS	NS	NS

[z]Pruning (pruned vs. unpruned, and pruning date) and interactive effects were nonsignificant.

[y]t-tests comparing pruned vs. unpruned plants within a treatment were nonsignificant on April 17 and May 2 except for dikegulac-treated plants on April 17.

[x]NS, **, *Nonsignificant, or significant at the 5% or 1% level, respectively.

Table 4. Effect of growth regulators on transpiration rate (E), stomatal conductance to water vapor (gs), stem water potential (ψ_x), and relative leaf water content of pruned and unpruned *Ligustrum* × *vicaryi*. Plants were pruned 2 days before treatment on May 10, 1989. Measurements were recorded between 1000 and 1300 HR on leaves that were present before treatment.

	May 12					June 1[z]			
	E ($mmol \cdot m^{-2} \cdot s^{-1}$)		gs ($mmol \cdot m^{-2} \cdot s^{-1}$)		ψ_x	E	gs	ψ_x	RLWC
Treatment	Unpruned	Pruned[y]	Unpruned	Pruned[y]	(MPa)	($mmol \cdot m^{-2} \cdot s^{-1}$)	($mmol \cdot m^{-2} \cdot s^{-1}$)	(MPa)	(%)
Untreated	2.96	3.91	120	161	−0.88	8.67	446	−1.31	90.2
Dikegulac	2.91	2.82	118	114	−0.94	5.03	234	−1.17	96.4
Flurprimidol	2.60	4.31	106	175	−0.91	9.56	451	−1.16	93.2
Uniconazole	2.43	2.83	97	108	−0.92	8.71	442	−1.23	92.9
LSD 5%	1.19	0.98	49	38	0.13	1.34	72	0.10	2.4
Significance[x]									
PGR	NS		*		NS	**	***	*	***
PRN	**		*		NS	NS	NS	NS	NS
PGR × PRN	NS		NS		NS	NS	NS	NS	NS

[z]Pruning (pruned vs. unpruned, and pruning date) and interactive effects were nonsignificant.

[y]t-tests comparing pruned and unpruned plants within a treatment were nonsignificant except for flurprimidol-treated plants on May 12.

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