Flurprimidol Performance on Ornamental Species in Relation to Trimming Time and Method of Application

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Abstract. The plant growth regulator flurprimidol (Cutless G) is registered for use on ornamental plants to reduce internode elongation and reduce trimming frequency. It has been hypothesized that timing of the trimming event can be related to the efficacy of the flurprimidol treatment. Granular flurprimidol was applied to well-established plants at a standard rate of 22.5 g/a.i. (15 lbs product)/1000 ft² on 23 Apr. 2012 and 1 May 2013. Two common Florida landscaping species, *Viburnum odoratissimum* and *V. suspensum*, were selected to be trimmed at different times to investigate flurprimidol efficacy by measuring plant regrowth, biomass, and visual appearance. The five trimming treatments occurred at 7 days before (flurprimidol) application (DBA), 0 DBA, 7 days after application (DAA), 14 DAA, and 21 DAA. No significant differences were observed in trimming times for flurprimidol-treated *V. odoratissimum* or *V. suspensum*. *V. odoratissimum* shoot regrowth was significantly reduced in flurprimidol-treated plants compared with the untreated control (UTC). The insufficient growth regulation observed in both *Viburnum* species is likely the result of species tolerance. Two flurprimidol application methods, granular and drench, were evaluated against an UTC on two landscaping species, *Elaeagnus pungens* and *Loropetalum chinense*. This experiment was to determine if a granular or drench application would influence the performance of flurprimidol. Shoot growth of *E. pungens* was reduced 4.3% and 13.9% by the granular and drench applications, respectively, but was not significantly different from one another or the UTC. The granular application reduced biomass (25.1%) but was not significantly different from the drench (16.9%). *L. chinense* shoot regrowth was decreased 39.5% and 38.2% by the granular and drench treatments, respectively. Plant biomass was significantly reduced in both treatments compared with the UTC (17.0% by granular and 13.9% by drench), but the biomass and visual assessments between the application methods were not significantly different. Species sensitivity was found to have a substantial influence on the efficacy of a flurprimidol application.

The upkeep of commercial landscapes is a major industry throughout the United States accounting for more than \$50 billion in 2007, the largest sector of the green industry (Hodges et al., 2011). Landscapers are required to maintain high-quality landscaping year-round, but this becomes more difficult in climates that allow for a year-round growing season. Hedges must be trimmed numerous times to sustain the appearance desired by property owners. However, with each trimming event, landscapers must allocate time and resources, which contribute to additional operating costs (i.e., labor, equipment wear, cleanup). Landscaping companies have the option of applying plant growth regulators (PGRs) to decrease the number of trimmings required per year. After application, shoot internode

length is reduced and hedges display a more compact and uniform appearance depending on species sensitivity and environmental conditions.

Plant growth regulators are synthetic compounds commonly used on ornamental, greenhouse species to produce a uniform and compact appearance (Banko and Stefani, 1995; Krug et al., 2005). Gibberellin [gibberellic acid (GA)] biosynthesis inhibition is the most common mechanism of action used today because it has the least potential for phytotoxicity (Graebe, 1987; Rademacher, 2000). Although PGRs are widely accepted in the greenhouse market, there has been limited adoption of this technology with landscaping companies. This is mainly the result of cost and inconsistencies often observed with GA inhibitors on large landscaping species (Keever and Gilliam, 1994).

Flurprimidol (0.33%) [alpha-(1-methylethyl)-alpha-(4-(trifluoromethoxyphenyl)-5-pyrimidinemethanol)] is a PGR commercially available for use in landscaping, nurseries, and greenhouses.

Sold as a granule formulation (Cutless G; SePRO Corp., Carmel, IN), irrigation is required to facilitate the movement of flurprimidol into the root zone of the plant where it is absorbed and translocated through the xylem along with plant water uptake (Sterrett and Tworowski, 1987). Several studies have shown that flurprimidol has performed as well or better when compared with other landscaping PGRs (Banko and Stefani, 1995; Keever and Gilliam, 1994; Krug et al., 2005; Norcini, 1991).

With each PGR application, there is an accompanying trimming event to shape the hedge to its desired appearance. However, inconsistencies occur when unregulated shoots emerge giving the hedge an undesirable and irregular profile. Currently, there are no recommendations on when to trim hedges relative to the PGR application date. Although flurprimidol has proven to reduce shoot internode length and biomass, there are still inconsistencies in overall plant regulation and the effects of trimming time on flurprimidol performance are still unknown. It has been hypothesized that the inconsistent performance in flurprimidol is attributable, in part, to the timing of trimming and/or application technique. If trimming occurs too soon after flurprimidol application, regrowth may occur before the xylem mobile compound can reach the apical buds. Conversely, if trimming is delayed too long, the removal of buds containing flurprimidol may result, leaving an insufficient concentration in the plant for growth regulation.

Trimming (the removal of apical/terminal buds) has been shown to stimulate water uptake and cause the redistribution of carbohydrate reserves to mend injured tissue, promoting new growth (Heyden and Stock, 1996). Because flurprimidol is a xylem mobile compound, the idea is that trimming would increase water uptake and simultaneously increase the uptake of flurprimidol from the plant root zone. This could improve growth regulation by making flurprimidol available at the time of water uptake, enabling the initial surge of flurprimidol capable of regulating GA biosynthesis throughout the entire plant. This could potentially reduce the number of unregulated shoots while providing a sustained even appearance for several months.

Flurprimidol granules are commonly broadcast over the designated landscape bed with a modified leaf blower, making the application rate potentially variable because inconsistent placement of the granules is likely. It is possible that the inconsistent plant response to flurprimidol is the result of the difficulty of getting a critical concentration into the root zone to adequately regulate plant growth (Hooey, 1994). To achieve more consistent results, a more consistent application method may be needed. There is evidence that suggests flurprimidol drenches could potentially increase overall plant regulation in larger plant species (Redding et al., 1994). A drench application could quickly concentrate flurprimidol in the root zone

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compared with the slower release from a granular application. It would also reduce the loss of product resulting from off-target placement and concentrate the flurprimidol at the base of the intended plant. Therefore, the objectives of this study are to evaluate the effects of trimming time on flurprimidol performance and investigate a drench application method for flurprimidol to improve overall growth regulation.

Materials and Methods

Expt. 1: *Viburnum* trimming time and flurprimidol performance. Established *Viburnum odoratissimum* and *V. suspensum* hedges were selected for this experiment on the campus of the University of Florida in Gainesville, FL. Hedges were divided into 3.1 m × 1.5-m plots, three plants per plot, in a split-plot, complete randomized block design where flurprimidol was the whole plot factor and trimming time was the split. As a result of inadequate hedge length at any given location, three replications were blocked in space at multiple sites at the University of Florida, Gainesville campus. In both years we selected consistent hedges for each species, *V. odoratissimum* and *V. suspensum*. Weather data were collected from the Florida Automated Weather Network (FAWN) web site supported by the University of Florida.

Flurprimidol applications, in the form of Cutless G, were made 23 Apr. 2012 and 1 May 2013 at a rate of 0 or 22.5 g/9.3 m² (which corresponds to 15 lb Cutless G per 1000 ft²). Applications were made using a handheld rotary granular spreader with granules directed under the foliage at the base of the plant. Calibration was performed using multiple 0.093-m² (1 ft²) calibration trays. Trimming treatments were designed around the flurprimidol application date to evaluate the effect of trimming timing on growth regulation. Five trimming dates were evaluated to investigate the interaction between trimming time and flurprimidol application. Trimming time treatments were 7 DBA, 0 DBA, 7 DAA, 14 DAA, and 21 DAA. Because flurprimidol is a root-absorbed chemical, hedges were divided into flurprimidol treated and UTC sections. This was to prevent treatment overlap and produce a more consistent plant response across replications. Trimming treatments were applied to the flurprimidol-treated and untreated sections to compare the flurprimidol performance against a control.

Flurprimidol performance was evaluated by measuring shoot regrowth length, plant biomass, and visual assessment. Nine plant shoots per plot were tagged to monitor shoot regrowth throughout the summer and shoots were not tagged until active growth was observed at a given bud. Plant biomass was harvested, per plot, at 15 to 17 weeks after application each year and dried at 50 °C for 1 week and dry weights (g) were recorded. Visual assessments were also used to evaluate flurprimidol performance across the entire plot. This assessment was a quality rating based on a 0 to 10 scale with 0 equaling

a poor, uneven appearance and 10 equaling a perfect aesthetic appearance. We designated a quality rating of 3 to indicate when a hedge would need to be trimmed. The purpose of the visual assessment was to provide a quality rating for the entire plot because only nine shoots, out of an estimated 1000, could be tagged for measurement. Data were collected every 2 weeks after the final trimming treatment and continued until normal plant growth returned, 4 to 5 months after the flurprimidol application. Using a split-plot design, collected data were analyzed using analysis of variance (ANOVA) to determine the presence of main effects and interactions and means were separated using Fisher's least significant difference (LSD) at a 0.05 significance level.

Expt. 2: Application method for flurprimidol. Two common landscaping species were selected to evaluate the application method for flurprimidol: *Elaeagnus pungens* (Silverthorn *elaegnus*) in Gainesville, FL, and *Loropetalum chinense* in Apopka, FL, for 2012 and 2013. Flurprimidol was applied at 22.5 g/a.i. (15 lbs product)/1000 ft² for both species. Plots included four to five plants and plot size was roughly 13.9 m² (150 ft²). Three plants were selected as data plants and the others were used as barrier plants to prevent treatment overlap.

The first treatment applied flurprimidol according to the label's recommendations. This included applying the granules with a rotary granular spreader and directing them under the dripline of the plant followed by 1.3 cm of irrigation. The second treatment consisted of a drench method by dissolving an equivalent amount of flurprimidol in water (6 L) and applying it as a drench 30 to 45 cm from the base of each plant. The determined amount of product required for each plot was divided into two 3-L bottles of water and shaken vigorously until the granules completely dissolved. One bottle was applied to each side of the hedge, resulting in a volume of 40 L per 92.9 m² (1000 ft²). This method was designed to concentrate flurprimidol in a small area, which should increase plant uptake and translocation efficiency. UTC plots were used to divide application types and prevent overlapping in flurprimidol application methods. We were not able to measure the dimensions of the intended root zones so one to two barrier plants were used as buffers between the plots.

Shoot regrowth length, plant biomass, and a visual quality rating were evaluated

as described previously. Data were collected every 2 weeks after the initial trimming and continued until normal plant growth returned. Using a split-plot design, collected data were analyzed using ANOVA and means were then separated with Fisher's LSD means at a 0.05 significance level in SAS (SAS Institute Inc., 2011).

Results

Expt. 1: *Viburnum* trimming time and flurprimidol performance. It was determined that the main effect of trimming time, and all associated interactions, was not significant for shoot regrowth, biomass, or visual assessment for either *Viburnum* species. However, the main effects of year and flurprimidol application were significant; therefore, data were presented as flurprimidol-treated hedges compared with the UTC hedges. Although data collection occurred every 2 weeks, the regrowth and biomass data presented are 15 weeks after treatment (WAT) for *V. odoratissimum* and 18 WAT for *V. suspensum*.

For *V. odoratissimum*, shoot regrowth was responsive to flurprimidol because significant differences were observed for 2012 and 2013 (Table 1). Biomass of flurprimidol-treated *V. odoratissimum* was significantly different from the UTC in 2012, but it was not in 2013 (Table 1). Visual assessments of *V. odoratissimum* hedge quality were also collected. This was conducted as a qualitative measure of overall hedge appearance. Because it would be impossible to measure all shoots within the hedge, the visual assessment provided a means of documenting regrowth on a plot-by-plot basis. Again it was observed that trimming timing had no significant impact on the visual quality of *V. odoratissimum* (data not shown).

As previously stated, trimming time has no significant effect on the regrowth, biomass, or visual evaluation of *V. suspensum*. A treatment-by-year interaction was observed for shoot regrowth of *V. suspensum* and those data are shown separately by year. Flurprimidol had no impact on the shoot regrowth of *V. suspensum*, because no significant differences were observed in 2012 or 2013 (Table 1). No treatment-by-year interaction was observed for *V. suspensum* biomass measurements; therefore, data were pooled across years. The biomass of flurprimidol-treated hedges was not significantly different from the untreated control (Table 1). Visual assessments were used to measure the overall

Table 1. Shoot regrowth and biomass measurements of flurprimidol-treated hedges.

Species	Treatment	Avg shoot regrowth (cm)		Avg biomass (g)	
		2012	2013	2012	2013
<i>Viburnum odoratissimum</i>	Flurprimidol	41.5 b	143.7 b	812.3 b	1184.2 a
	Untreated	69.6 a	169.0 a	1055.7 a	1383.8 a
<i>Viburnum suspensum</i>	Flurprimidol	32.8 a	71.6 a	387.9 b	672.9 a
	Untreated	36.3 a	70.6 a	530.0 a	625.6 a

Note: Shoot regrowth measurements were collected every 2 weeks. Plant biomass was collected once normal growth resumed: 15 weeks after treatment for *V. odoratissimum* and 18 weeks after treatment for *V. suspensum*. Letters indicate a statistical difference between the treatment means (n = 60, Fisher's protected least significant difference, $P \leq 0.05$).

aesthetic appearance of the hedges and again no differences among visual ratings were observed for *V. suspensum* (data not shown).

Expt. 2: Application method for flurprimidol. Shoot growth of *E. pungens* was reduced 4.3% and 13.9% by the granular and drenches applications (Fig. 1), respectively, but was not significantly different from one another or the UTC. Biomass collected from both application methods was compared with the same UTC plots as a percent reduction. The granular application reduced biomass (25.1%) but was not significantly different from the drench (16.9%) (Fig. 2). Visual ratings determined that the drench method provided a significant difference at 15 WAT in aesthetic appearance and overall growth regulation compared with the UTC but was not significantly different from the granular treatment (Table 2). The vigorous growth habit of *E. pungens*, or species sensitivity, may explain the lack of significant differences in biomass.

The impact of flurprimidol on *L. chinense* was more pronounced than that observed in *E. pungens*. *L. chinense* regrowth was significantly reduced by both application methods compared with the untreated control (Fig. 3). Shoot regrowth was decreased 39.5% and 38.2% by the granular and drench treatments, respectively. Plant biomass was significantly reduced in both treatments compared with the UTC (17.0% by granular and 13.9% by drench), but biomass between the application methods was not significantly different (Fig. 4). By visual assessment, the drench method was significantly different from the UTC at 15 WAT, but no differences in visual ratings were observed between flurprimidol application methods. Both the granular and drench applications of flurprimidol provided a rating of 8 or more for the 15-week observation period (Table 2).

Discussion

Previous reports have documented that flurprimidol is an effective PGR used to control the growth of woody plants (Norcini, 1991; Steffens, 1988; Sterrett and Tworowski, 1987). It is widely known that PGR applications come with a certain amount of variability because several factors (i.e., rainfall/irrigation, environmental conditions, etc.) can contribute to carbon allocation and plant growth (Gaussoin et al., 1997). One factor known to affect plant growth is the stimulation of carbohydrates reserves through plant trimming (Heyden and Stock, 1996). Because of the variability associated with PGRs, trimming time was investigated to see if a relationship was present between trimming date and flurprimidol application date. This was to determine if altering when plants are trimmed would decrease the variability associated with flurprimidol performance.

The lack of differences observed between trimming treatments for *V. odoratissimum* and *V. suspensum* was not expected. Moreover, there is no documentation in the literature or on the Cutless G label (Anonymous,

2008) that would indicate a lack of growth regulation within these two species. As mentioned previously, the flurprimidol-treated and untreated hedges were separated in space, as blocks, to avoid overlap in roots between one plot and the next. Although the shoot regrowth of flurprimidol-treated *V. odoratissimum* hedges was reduced, the visual quality ratings were not different from the untreated. The emergence of unregulated shoots on flurprimidol-treated plants still occurred, affecting the overall visual rating of the hedge. It was simply not practical to tag each shoot on every plant, which is why a visual rating was included. For *V. suspensum*,

the untreated plots exhibited surprisingly slow growth after trimming and the reason for the lack of growth in the untreated is not known. The untreated plants were in the same location as the treated hedges; therefore, fertility, rainfall, etc., should have been identical.

The reason for the biomass differences between years is unclear, but shoot regrowth and biomass increased for both *Viburnum* species in 2013, whereas rainfall was lower for the time period, 2012 (97.0 cm) and 2013 (85.3 cm) (FAWN Database, 2012–13). This is misleading because we received only 5.7 cm of rain in the first 5 weeks of the

Fig. 1. Shoot regrowth of *Elaeagnus pungens* treated by a granular or drench flurprimidol application compared with an untreated control [15 weeks after treatment (WAT)] (2012–13). Letters indicate a significant difference at $P \leq 0.05$ level using Fisher's protected least significant difference. Error bars represent the SEM for each treatment ($n = 30$).

Fig. 2. Biomass of *Elaeagnus pungens* treated by a granular or drench flurprimidol application compared with an untreated control [15 weeks after treatment (WAT)] (2012–13). Letters indicate a significant difference at $P \leq 0.05$ level using Fisher's protected least significant difference. Error bars represent the SEM for each treatment ($n = 30$).

Table 2. Visual assessment rating to evaluate overall growth regulation in *E. pungens* and *L. chinense*.

Weeks after treatment	Visual quality rating					
	<i>E. pungens</i>			<i>L. chinense</i>		
	Granular	Drench	Control	Granular	Drench	Control
9	8.0 a	8.7 a	7.3 a	9.0 a	9.0 a	9.0 a
11	5.0 a	6.0 a	4.3 a	9.0 a	9.0 a	8.3 a
13	4.3 a	5.3 a	2.7 b	8.7 a	8.7 a	7.0 b
15	3.0 ab	4.7 a	2.3 b	8.7 a	8.7 a	6.3 b

Note: Bimonthly visual assessments were measured on a 0 to 10 scale with 10 representing the highest aesthetic value and 3 represents when trimming would occur. Means within a row, within a given species, followed by different letters are significantly different (Fisher's protected least significant difference, $P \leq 0.05$ level, $n = 15$).

Fig. 3. Shoot regrowth of *Loropetalum chinense* treated with a granular or drench flurprimidol application compared with an untreated control [17 weeks after treatment (WAT)] (2012–13). Letters indicate a significant difference at $P \leq 0.05$ level using Fisher's protected least significant difference. Error bars represent SEM for each treatment ($n = 30$).

Fig. 4. Biomass of *Loropetalum chinense* treated by a granular or drench flurprimidol application compared with an untreated control [17 weeks after treatment (WAT)] (2012–13). Letters indicate a significant difference at $P \leq 0.05$ level using Fisher's protected least significant difference. Error bars represent SEM for each treatment ($n = 30$).

experiments in 2012 (FAWN Database, 2012–13). The lack of early rainfall in 2012 could have slowed the growth of the *Viburnums* compared with the more consistent rainfall observed in 2013. An additional reason for lack of differences was the growth pattern exhibited by these plants. It was common for one shoot to measure 5 cm in length, whereas the next shoot measured 40 cm. This level of variability within a treatment made statistical comparisons difficult.

The lack of differences in this trial is most likely because *V. odoratissimum* and *V. suspensum* were chosen as our species of interest. In general, landscape managers plant species that are hardy and reliable. This generally translates into plants with rapid growth, which is likely why flurprimidol did not provide sufficient growth regulation at the applied rate. Flurprimidol is preferred by many ground managers as a result of the uncommon occurrence of “overregulation” or phytotoxicity (Sterrett and Tworowski, 1987). However, this may also mean that flurprimidol will struggle to manage the growth of highly aggressive plant species. In conclusion, it is likely that any effect of trimming timing was overshadowed by the

inability of flurprimidol to effectively manage the growth of *V. odoratissimum* and *V. suspensum*. Future research should focus on the efficacy of flurprimidol and the interaction trimming timing provided that species with a history of known flurprimidol performance are chosen.

Flurprimidol reduced shoot regrowth and biomass in both *E. pungens* and *L. chinense*. However, it was determined that application method (granular or drench) had little impact on the efficacy of flurprimidol. We hypothesized that the granule formulation would delay the growth regulation effects of flurprimidol by its slow-release design. Therefore, our thinking that the drench application would better facilitate flurprimidol movement into the root zone more efficiently did not result. It is again questioned if species sensitivity is what primarily impacts the efficacy and consistency of flurprimidol performance. For example, we selected two species with different growing habits to evaluate the application methods. *E. pungens* is a robust, fast-growing species that requires many more trimmings per year compared with *L. chinense*, a woody, slow-growing shrub. In this example, *L. chinense* was

adequately regulated by flurprimidol, whereas *E. pungens* was inconsistent. It is possible that flurprimidol alone will not sufficiently regulate certain plant species because of sensitivity or size. It is unclear how certain plants will respond to a PGR application because a variety of factors influence this response. Plant vigor, age, size, and species all need to be considered before PGR applications are made.

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