Table 5. Effects of calcium carbonate on growth and quality of gardenia and Japanese Holly.

Species	Rate[z] (kg/m³)	Fresh top wt. (g)	Visual[y] Grade	Branch Count	Fresh root wt. (g)
Gardenia	0	56.52b	6.83b	84.13b	16.79c
	0.237	57.39b	7.13ab	83.90b	17.64bc
	0.475	69.92a	7.47a	93.10a	20.69a
	0.712	60.26ab	7.42a	91.31a	19.44ab
Japanese Holly	0	41.51a	5.94b	19.92a	19.61a
	0.237	42.10a	6.19ab	20.38a	20.13a
	0.475	43.21a	6.47a	21.53a	21.83a
	0.712	40.32a	5.82b	20.85a	20.14a

[z]Rate expressed as kg/m³ of calcium from calcium carbonate.

[y]For each species, means within columns followed by the same letter or letters are not significantly different at the 5% level as determined by Duncan's multiple range test.

and magnesium oxide and test those combinations against that water supply. These tests should be made for each major plant species being grown, as respsonse to $CaCO_3$ and MgO will vary.

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Sensitivity and Time of Application of Fusilade 2000 to Azaleas[1]

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Abstract

Application of Fusilade 2000 (fluazifop-P-butyl) (R-butyl ± 2-[4-[5- (trifluoromethyl)-2-pyridinyl] oxyl] phenoxy] propanoic acid) on September 3 reduced flowering of 'Hino-Crimson' azalea by 60% and 25% compared to those treated on August 1 and nontreated control plants. Off-Shoot-O (methyl esters of C6-C12 fatty acids) treated plants responded similarly. 'Hino-Crimson' azaleas treated with Fusilade 2000 on July 2 and August 1 had greater flower numbers the following spring than comparable plants treated with Off-Shoot-O. Only azaleas sensitive to Fusilade 2000 respond as such. Sensitive azalea cultivars tested include: 'Hino-Crimson,' 'Hinodegiri,' 'Sherwood Red,' 'Girard's Scarlet' and 'Girard's Rose.'

Index words: postemergence herbicides, phytotoxicity, weed control, ornamentals, growth regulator, chemical pinching

Introduction

Fusilade 4E has been shown to be injurious to several azalea cultivars (1, 2, 3, 4). This injury is characterized by death of terminal shoots, when Fusilade 4E is applied at the recommended rate for annual grass control. Recent work (3) has shown that phytotoxicity associated with application of 0.28 kg/ha ai of Fusilade 4E on 'Hino-Crimson' azalea resulted in activity similar to chemical pinching. Flowering the following spring was greater with the plants treated with Fusilade 4E compared to nontreated plants (3).

While Fusilade (4E and 2000) is injurious to several

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azalea cultivars, other azalea cultivars are not injured by Fusilade. Bing and Macksel (1) evaluated 28 azalea cultivars and found only 2 ('Hino-Crimson' and 'Hinodegiri') to be definitely injured by Fusilade. 'Hershey Red' was listed as possibly sensitive to Fusilade in their test. Other azaleas cvs. sensitive to Fusilade are 'Rosebud' and 'Mother's Day' (4) and Hexe (2). While a large number of azaleas have been evaluated, it appears that only red flowering azaleas are sensitive to Fusilade.

The objectives of these studies were to screen red flowering azalea cultivars for sensitivity to Fusilade 2000, and to determine how late in the year Fusilade 2000 could be applied over-the-top of sensitive and non-sensitive cultivars before flowering the following spring was suppressed.

Methods and Materials

Experiment 1. Uniform liners of 'Mrs. G.G. Gerbing' and 'Hino-Crimson' azaleas were potted into 3.8 liter (#1) containers in March of 1984, in a 100% pine bark medium amended on a m^3 (yd^3) basis with 3.6 kg (6 lb) dolomitic limestone, 1.2 kg (2 lb) gypsum, 0.9 kg (1.5 lb) Micromax (micronutrient), and 6.0 kg (10 lb) Osmocote 17N-3P-10K (17-7-12). Plants were grown under 47% shade outdoors. Treatments consisted of single applications of Fusilade 2000 (0.14 kg/ha) (0.125 lb/A) plus Ortho X-77 spreader (0.5% by vol) (Chevron Chemical Co., San Francisco, CA 94105), Ortho X-77 alone, and Off-Shoot-O; each was applied on 4 different dates (July 2, August 1, September 3 and October 1). Off-Shoot-O, a commercial chemical pruning agent, was applied (9% by volume) because the authors had observed that plant response to this compound was similar to Fusilade. Fusilade 2000 was applied in 140 l/ha of water. The experiment consisted of a factorial arrangement with 3 chemical treatments and 4 application dates within each cultivar. The statistical design was completely randomized with 4 replicates of 4 plants each. Plants were rated for phytotoxicity at monthly intervals beginning August 1 on a 1-10 scale where 1 = dead plant, 5 = dead terminals + leaf chlorosis + necrotic leaf spots, and 10 = normal plant. Flower buds were counted the following spring and growth indices measured.

Experiment 2. Fifteen liners each of 14 azalea cultivars were potted on April 12, 1985, in 3.8-liter containers in an amended medium similar to that used in Expt. 1. Plants were grown under 47% shade. Treatments were applied on July 23 and consisted of Fusilade 2000 at 0, 0.14 and 0.28 kg/ha applied in 140 l/ha. Each treatment contained Ortho X-77 spreader at a 1% (by vol) rate. Plants were rated for phytotoxicity 15 and 30 days after treatment (DAT) as described in Expt. 1. The statistical design was a randomized complete block with 5 single plant replications.

Results and Discussion

In Experiment 1, 'Mrs. G.G. Gerbing' azalea was not injured by any treatment. When applied on July 2 to 'Hino-Crimson,' Fusilade 2000 at 0.14 kg/ha ai resulted in a phytotoxicity rating of 6.3 (30 DAT); however, plants outgrew the injury and were comparable to the control within 60 days (Table 1). Later applications resulted in similar phytotoxicity, but recovery appeared slower. Fusilade 2000 plus X-77 resulted in greater phytotoxicity than did the 9% solution of Off-Shoot-O regardless of application date. Application of X-77 resulted in no plant injury at any time throughout the study. However, application of Fusilade 2000 to 'Hino-Crimson' azalea resulted in greater branching (data not shown) and flowering the following spring compared to application of Off-Shoot-O (Table 2). 'Mrs. G.G. Gerbing' was not visibly affected by Fusilade 2000 application, and had flower bud number the following spring that were similar to the non-treated plants with the exception of the August treatment data where they were greater.

With regard to flower bud number, a significant material x date interaction occurred. Inspection of the data reveals probable cause for the interaction. With Fusilade application, a decline in flower bud numbers occurred with each subsequent application, July-August-September-October (Table 2). Off-Shoot-O treated plants responded similarly to plants treated with Fusilade 2000, except that the 2 earlier dates (July-August) were similar as were the 2 latter dates (September-October). The Ortho X-77 and the control plants had similar flower bud numbers with all application dates.

Application of Fusilade 2000 and Off-Shoot-O in July and August resulted in greater flower bud numbers than the non-treated plants (Table 2), while September

Table 1. Effects of time of application of Fusilade 2000 and Off-Shoot-0 on phytotoxicity to 'Hino-Crimson' azaleas (Experiment 1).

	Application date/phytotoxicity days after treatment[z]										
	July 2			August 1			September 3			October 1	
Treatment	30	60	90	30	60	90	30	60	90	30	60
Fusilade 2000 (0.14 kg/ha) + Ortho X-77 (0.5%)	6.3c[y]	10.0a	10.0a	5.1c	6.7b	7.8b	5.7c	6.0b	6.0b	7.8b	8.0b
Ortho X-77 (0.5%)	10.0a	10.0a	10.0a	10.0a	10.0a	10.0a	10.0a	10.0a	10.0a	10.0a	10.0a
Off-Shoot-0 (9%)	8.0b	10.0a	10.0a	8.0b	10.0a	10.0a	8.0b	10.0a	10.0a	8.0b	8.0b
Nontreated	10.0a	10.0a	10.0a	10.0a	10.0a	10.0a	10.0a	10.0a	10.0a	10.0a	10.0a

[z]Plants were treated on a 1-10 scale where 1 = dead plant, 5 = dead terminals + leaf chlorosis + necrotic leaf spots, and 10 = normal plants.

[y]Mean separation within columns followed by the same letter or letters are not significantly different at the 5% level as determined by Duncan's multiple range test.

application decreased flower bud numbers of 'Hino-Crimson' azalea compared to non-treated plants. The intent of this work is not to promote Fusilade 2000 as a flowering stimulant. Rather, these data show that Fusilade 2000 can be safely applied as an over-the-top application on azaleas previously reported sensitive to Fusilade 2000 (1, 2). The limiting factor for safe application of Fusilade 2000 to azaleas is not the cultivar but the time of the year applied. From our data it appears that Fusilade 2000 can be safely applied on sensitive azaleas as late in the year as a grower would normally use a chemical pinching agent (Off-Shoot-O).

While growth indices were similar when comparing 'Hino-Crimson' azaleas treated with Fusilade 2000 and Off-Shoot-O, Fusilade 2000 treated plants were more compact (data not shown). Earlier application (July and August) caused greater height suppression. 'Mrs. G.G. Gerbing' plant height was not affected by any treatment.

In Experiment 2, 9 of the 14 red flowering azalea cultivars were not injured by the recommended rate of Fusilade 2000 (Table 3). Of the cultivars injured, there were 2 Kurume type azaleas, 'Hino-Crimson' and 'Hinodegiri,' 2 Girard azaleas, 'Scarlet' and 'Rose,' and 'Sherwood Red.' Previous work had demonstrated 'Hino-Crimson' and 'Hinodegiri' sensitivity to Fusilade 4E (1, 2, 3). Kuhns et al. (4) reported Girard's Rose to be unaffected by Fusilade 4E; however, in our test it was

Table 2. Material x date interaction effects of Fusilade 2000 and Off-Shoot-0 on flower bud number of 'Hino-Crimson' and 'Mrs. G.G. Gerbing' azaleas (Experiment 1).

Treatment	Application date/flower bud no./plant			
	July 2[z]	Aug. 1	Sept. 3	Oct. 1
		'Hino-crimson'		
Fusilade 2000 (0.14 kg/ha) + Ortho X-77 (0.5%)	70a A[y]	57a B	23b C	12b D
Ortho-X-77 (0.5%)	28c A	34b A	28a A	30a A
Off-Shoot-0 (9%)	34b A	41b A	17c B	6c C
Nontreated	31bc A	31b A	31a A	31a A
		'Mrs. G.G. Gerbing'		
Fusilade 2000 (0.14 kg/ha) + Ortho X-77 (0.5%)	18a A	21a A	14a A	15a A
Ortho-X-77 (0.5%)	17a A	17b A	17a A	18a A
Off-Shoot-0 (9%)	20a A	24a A	5b B	7b B
Nontreated	15a A	15b A	15a A	15a A

[z]Application dates in 1984; data collected Feb. 26, 1985.

[y]Mean separation within columns (small letters), and row (capital letters) followed by the same letter or letters are not significantly different at the 5% level as determined by Duncan's multiple range test.

Table 3. Sensitivity of red flowering azalea cultivars to Fusilade 2000 (Experiment 2).

Cultivar	Fusilade 2000 (kg/ha) 15 DAT			Fusilade 2000 (kg/ha) 30 DAT		
	0.14	0.28	Control	0.14	0.28	Control
Girard's Hot Shot	10.0a[z]	10.0a[y]	10.0a	10.0a	10.0a	10.0a
Girard's Scarlet	9.7a	7.3b	10.0a	9.0a	4.7b	9.8a
Girard's Rose	8.5b	6.0c	10.0a	8.9a	5.0b	9.6a
Sherwood Red	6.0b	6.0b	10.0a	6.0b	3.8c	10.0a
Hino-Crimson	9.3b	7.3c	10.0a	8.7b	6.8c	10.0a
Hinodegiri	6.9b	6.3c	10.0a	7.9b	6.8c	10.0a
Red Ruffle	10.0a	10.0a	10.0a	10.0a	9.6a	10.0a
Red Formosa	10.0a	10.0a	10.0a	10.0a	9.0b	10.0a
Vayk's Scarlet	10.0a	10.0a	10.0a	10.0a	9.8a	10.0a
Mother's Day	10.0a	10.0a	10.0a	10.0a	10.0a	10.0a
Trouper	10.0a	10.0a	10.0a	10.0a	10.0a	10.0a
Little John	10.0a	10.0a	10.0a	9.8a	7.8b	10.0a
Hershey Red	10.0a	10.0a	10.0a	10.0a	10.0a	10.0a

[z]Plants were rated on a 1-10 scale where 1 = dead plant, 5 = dead terminals + leaf chlorosis + leaf necrosis, and 10 = normal plant growth.

[y]Mean separation within columns (small letters), and row (capital letters) followed by the same letter or letters are not significantly different at the 5% level as determined by Duncan's multiple range test.

sensitive to Fusilade 2000. Conversely, 'Hershey Red' was earlier reported sensitive to Fusilade 4E (1), but was not affected by Fusilade 2000 in our test.

Increasing the rate of Fusilade 2000 to 0.28 kg/ha (2x) resulted in injury to 9 of the 14 cultivars 30 DAT. These data indicate that application beyond the recommended rate for annual grass control may result in injury ranging from tip burn to stem dieback and leaf necrosis.

Significance to the Nursery Industry

Fusilade 2000 stimulated flowering on sensitive azalea cultivars the following spring when applied prior to September in the Mobile, Alabama, area, with 'Hino-Crimson' azalea injury being similar to that from an application of Off-Shoot-O. From this work and other research (1, 2, 3, 4), sensitive cultivars appear to be red floweing azaleas only; other colored azaleas are not affected (injured/pruned) by Fusilade 2000. With these non-red azaleas, Fusilade 2000 may be applied safely at any time of the year. Among the red flowering azaleas tested, sensitive azaleas that should not be treated with Fusilade 2000 after September include 'Hino-Crimson,' 'Hinodegiri,' 'Sherwood Red,' Girard's Scarlet and Girard's Rose.

(*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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Effects of Three Herbicides on the Foliage of Kurume Azaleas[1]

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Abstract

A single foliar spray of Fusilade 2000 (fluazifop-butyl) [(±)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl] oxy] phenoxy] propanoic acid] or PP005 (fluazifop-p-butyl) [butyl (R)-2[4-[[5-(trifluoromethyl)-2-pyridinyl] oxy] phenoxy] propanoate] at 0.50 or 1.0 kg/ha (0.45 or 0.89 lb/A) caused extensive foliar damage and reduced growth of 'Hinocrimson' azaleas but not 'Hershey Red.' Poast (sethoxydim) [2-[1-(ethoxyimino)butyl]-5-[2-ethylthio)-propyl]-3-hydroxy-2-cyclohexen-1-one] at 1 kg/ha (0.89 lb/A) or less did not injure 'Hinocrimson' or 'Hershey Red' azaleas. Scanning electron microscopy observations and photographs of the upper leaf surface of the untreated control plants of both azalea varieties revealed that the epidermal cells were uniformly turgid and covered with smooth epicuticular wax. The leaf epidermal cells of 'Hinocrimson' azalea treated with Fusilade 2000 or PP005 at rates of 0.25 kg/ha (0.22 lb/A) or more were flaccid, the epicuticular wax was damaged, and the stomatal configurations were altered to produce cells with an ovoid pointed appearance. When 'Hinocrimson' foliage treated with Fusilade 2000 or PP005 was examined with energy dispersive X-ray analysis (EDX), a potassium (K) peak which was over 3 times higher than that of the untreated control plants was observed. No increase in potassium peak size was observed following EDX analysis with any 'Hershey Red' foliage samples.

Index words: Poast, Fusilade 2000, PP005, herbicide, grass weeds, scanning electron microscope (SEM), energy dispersive X-ray analysis (EDX)

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Introduction

Weeds must be controlled effectively in azaleas for maximum growth in the field (5, 14), containers (6, 10, 17, 24), or the landscape (8, 16, 22). Handweeding is expensive and damage (2) to both foliage and root systems is a common problem under all landscape crop growing regimes (7, 13, 14, 16, 19, 25).

Recently a number of postemergence herbicides used