Weed Control

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Comparison of Glyphosate and Clopyralid for Mugwort (*Artemisia vulgaris*) Control in Field-Grown Nursery Crops

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Index Words: *Artemisia vulgaris*, chrysanthemum weed, clopyralid, glyphosate, mugwort

Nature of the Work: Mugwort, *Artemisia vulgaris L.*, is a rhizomatous perennial weed common in field grown nursery crops, landscape plantings, and turfgrass. The primary means of introduction into landscapes is in the root balls of contaminated nursery crops (4). From these introductions, rhizomes spread to adjacent plantings and turf. Once introduced, mugwort is very difficult to control; it is spread by cultivation, tolerates mowing and is not controlled by standard preemergence herbicide programs. Additionally, postemergence herbicides have not provided adequate control. Ahrens (1) reported mugwort control with asulam (Asulox) and glyphosate (Roundup), but Asulox is no longer available and the control obtained with Roundup was temporary. Gouin (3) controlled mugwort with July, August and September applications of glyphosate but June applications were not as effective. Despite the frequent use of Roundup in nursery crops, mugwort persists. Recently, Bradley and Hagood (2) reported up to 95% control of mugwort with a single application of clopyralid (Lontrel). The objective of this study was to compare single and multiple applications, and application timing of Roundup-Pro and Lontrel for their efficacy on established mugwort and safety on field grown nursery crops.

Two experiments were conducted, one in 1998-1999, the second in 2000. Each year the herbicides and application rates were: Lontrel (clopyralid) at 0.25 lb ai/A and Roundup-Pro (glyphosate) at 2 lb ai/A. Herbicides were applied with a CO_2 pressurized backpack sprayer calibrated to deliver 30 gallons per acre. In 1998, herbicides were applied singly in May or August, and sequentially in May plus August as directed applications in a two-year old planting of Callery pear (*Pyrus calleryana*). In May mugwort was 6 to 24 inches tall; in August mugwort plants were up to five feet tall and flowering. Since single applications in August to five-foot tall weeds are impractical, this treatment was dropped from the 2000 test. In the 2000 test, herbicides were applied singly in May to three-inch tall weeds (early-post (EPO)), EPO and again four weeks later, or EPO and again in August. In 2000 herbicides were applied as directed applications to two-year old 'Green Giant' arborvitae (*Thuja* *plicata* 'Green Giant'), contacting the lower 12 inches of the foliage. Weed control was visually evaluated on a percent scale where 0 = no control (equal to the untreated plots) and 100 = complete control. Plots were evaluated periodically through the first season and again the following spring.

Results and Discussion: Evaluated in the spring of 1999, the August 1998 application of Lontrel provided no mugwort control whereas the spring treatment provided 32% control. Two applications (May plus August) of Lontrel, provided about 50% control, which was equivalent to one application of Roundup-Pro in either May or August. Two applications of Roundup-Pro provided over 90% mugwort control. Similar results were observed in 2000, where two applications of Lontrel, regardless of the application interval, provided about 60% control. These results differ from the observations of Bailey and Hagood (2) who reported up to 95% control with a single application and did not increase in control with multiple treatments. As in the first test, mugwort control with two applications of Roundup-Pro was greater than 90%, regardless of the application interval.

'Green Giant' arborvitae sustained slight injury from directed applications of Roundup-Pro in May and June. However, the injury was limited to contacted foliage. No injury was observed from Lontrel applications. No injury to two-year old Callery pear were observed from directed applications of either herbicide.

Significance to the Industry: Mugwort continues to be a difficult-to-control weed of field nursery crops and landscape plantings. This research suggests that two applications, spring and summer, of Roundup-Pro can provide greater than 90% control; however, care must be taken to avoid contact with the foliage of desirable plants. Where Roundup-Pro cannot be used, multiple applications of Lontrel will provide some suppression of mugwort with less potential for damage on conifers.

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Effects of Herbicides and Application Timing on Rooting of Azalea and Japanese Holly Cuttings

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Index Words: flumioxazin, oxadiazon, oxadiazon + oxyfluorfen, preemergence, prodiamine, propagation

Nature of the Work: Currently, no preemergence herbicides are labeled for use on unrooted cuttings and few herbicides are labeled for use on liners. Consequently, growers rely on handweeding and sanitation to deter weed growth in propagation facilities. There is great concern among growers on the safety of herbicides used during the rooting process and the residual effects of these herbicides on liner growth (1). Limited research has been done on evaluating herbicidal safety and activity during propagation and root initiation (4). Warren et al. (5) reported that Pennant (metolachlor) applied preemergence and Poast (sethoxydim) applied postemergence caused no detectable damage on seven species of deciduous tree seedlings. Although, Ronstar (oxadiazon), Devrinol (napropamide), Surflan (oryzalin), and Ornamental Herbicide 2 (OH-2) (oxyfluorfen + pendimethalin) applied preemergence injured one or more species tested. Several researchers have reported that Surflan and other oryzalin-based herbicides suppressed root growth on cuttings of selected woody plants, while Ronstar did not (2, 4). Oryzalin is in the dinitroanaline herbicide family, and its mode of action is through root inhibition. In contrast, Pennant and Ronstar are generally considered to be “shoot” inhibitors. Other non-root inhibiting preemergence herbicides labeled for (or being tested for use in) woody nursery crops include oxyfluorfen (an ingredient in several granular herbicides including OH2, Rout, Regal O-O) and flumioxazin (Broadstar). In this experiment our objective was to evaluate the effects of three non-root-inhibiting preemergence herbicides compared to a dinitroanaline herbicide on rooting of woody nursery crop cuttings.

The experiment was conducted at Greenleaf Nursery in Tarboro, NC. Three species were vegetatively propagated under shade cloth and placed under intermittent mist until fully rooted. Flats were hand-weeded to avoid confounding effects of differential weed control. Plant species were azalea (*Rhododendron X* ‘Girard Rose’), hetzi holly (*Ilex crenata* var. Hetzii), and compact Japanese holly (*Ilex crenata* var. Compacta). Cuttings were stuck on August 1, eight cuttings of each species were placed, one cutting per cell, in a 24 cell flat. Herbicides were applied at sticking, 5-weeks after sticking (newly formed roots were approximately 1cm long) and at 8 weeks (roots had reached the edges of the cells).

Preemergence herbicides used were Ronstar 2G at 3 lb ai/A, Regal O-O 3G oxadiazon + oxyfluorfen) at 3 lb ai/A, Regalkade 0.5G (prodiamine) at 1 lb ai/A, and Broadstar 0.17G at 0.25 lb ai/A. Regalkade 0.5G is a dinitroanaline herbicide and a known root inhibitor. Root quality was visually evaluated 4 months after initiation on a scale of 0 to 5, with 5 being a fully formed root ball and 0 being a dead plant. The experiment design was a randomized complete block design with four replicates. Data were subjected to analysis of variance and means were separated using a protected LSD test at the 5% level.

Results and Discussion: Neither Ronstar, Regal O-O, nor Broadstar reduced azalea or Japanese holly root quality regardless of the date of application (data not shown). Our results with Ronstar concurred with those previously reported by Thetford et al. (4) and Langmaid (3). However it should be noted that Langmaid reported injury on *Nandina domestica* from Ronstar applications. When applied at sticking, Regalkade G significantly reduced azalea and holly rooting. Azalea cuttings were more severely affected than holly cuttings. When applied to azalea cuttings five-weeks after sticking, root quality was significantly reduced, but applications eight weeks after sticking resulted in no effect on root quality.

Significance to the Industry: This experiment showed that there is a potential for non-root-inhibiting herbicides to be used in propagation. It appears that Ronstar, Regal O-O, and Broadstar may be applied at the time of sticking for preemergence control of weeds during propagation of woody liners but further research is needed. Root inhibitors, such as Regalkade G, should not be used until cuttings are fully rooted.

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Table 1. Preemergence herbicide injury on azalea, Hetzi holly, and compact Japanese holly cuttings.

				Root Quality Rating *		
Herbicide	**Active Ingredient**	**Dose (lb ai/A)**	**Application Timing ****	**Azalea**	**Hetzi Holly**	**'Compacta' Holly**
Regalkade G	prodiamine	1	At Sticking	1.8 c	2.2 b	3.0 b
Regalkade G	prodiamine	1	5-weeks after	3.3 b	3.6 ab	3.8 ab
Regalkade G	prodiamine	1	8-weeks after	3.8 ab	3.6 ab	4.0 ab
Untreated				4.7 a	4.3 a	4.6 a

* Root quality rating scale: 0 to 5; with 5 being a fully formed root ball and 0 being a dead plant

** Herbicide treatments applied at sticking; 5-weeks after sticking (newly formed roots were ~ 1cm long); 8-weeks after sticking (roots had reached the edges of the cells). Means within a column followed by the same letter are not significantly different at the 5% level.

Preemergence Weed Control in Container Ornamentals using Flumioxazin

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Index Words: flumioxazin, crabgrass, *Digitaria sanguinalis*, longstalked phyllanthus, *Phyllanthus tennulus*, bittercress, *Cardamine hirsuta*, eclipta, *Eclipta prostrata*, doveweed, *Murdannia nudiflora*, spirea, *Spirea* X 'Goldmound', daylily, *Hemerocallis* X 'Stella de Oro'

Nature of Work: Flumioxazin is a preemergence and postemergence herbicide with activity similar to oxyfluorfen (Goal) that recently has been labeled for broadleaf weed control in soybeans. We have previously reported that in a 0.17% ai granular formulation, flumioxazin controls many nursery weeds and is safe on many woody ornamentals (1). In that test, flumioxazin applied at 0.17 to 0.25 lb ai/A controlled several common broadleaf weeds but did not control crabgrass (*Digitaria sanguinalis* (L.) Scop) or eclipta (*Eclipta prostrata* L.). This study was designed to confirm the results of the first trial and to evaluate combinations of flumioxazin with pendimethalin for enhanced weed control.

In April, 2000, nine ornamental species were potted into 3-gallon containers and placed on a gravel pad with overhead irrigation. Pots were seeded with seven weed species (a single weed species per pot). The ornamental species were 'Nellie R. Stevens' holly (*Ilex* X 'Nellie R. Stevens'), daylily (*Hemerocallis* X 'Stella de Oro'), azalea (*Rhododendron* X 'Delaware Valley White'), wax myrtle (*Myrica cerifera*), heavenly bamboo (*Nandina domestica*), arborvitae (*Thuja occidentalis* 'Emerald'), 'Goldmound' spirea (*Spiraea* X 'Goldmound'), 'Chindo' viburnum (*Viburnum awabuki* 'Chindo'), and 'Green Luster' holly (*Ilex crenata* 'Green Luster'). The weed species were hairy bittercress (*Cardamine hirsuta* L.), doveweed (*Murdannia nudiflora* (L.) Brenan), spotted spurge (*Euphorbia maculata* L.), longstalked phyllanthus (*Phyllanthus tennelus*), and American burnweed (*Erechtites hieraciifolium* L.). Plants were arranged in a randomized complete block design with four replicates and three pots of each species per plot. After seeding the weeds, herbicide treatments were applied on 4/6/00. Treatments were flumioxazin alone at 0.25, 0.38 and 0.5 lb ai/A and in combinations with pendimethalin (Pendulum 2G). The doses of flumioxazin + pendimethalin in combination were 0.25 + 1.0, 0.25 + 2.0, 0.25 + 3.0, and 0.5 + 2.0 lb ai/A, respectively. For comparison, Scotts Ornamental Herbicide 2 (2% oxyfluorfen + 1% pendimethalin) at 3 lb ai/A was included. Pots were hand weeded and treatments were reapplied on June 14, 2000. Weed control and nursery crop injury were visually evaluated periodically throughout the season until termination of the study in mid-September.

Results and Discussion: Flumioxazin was safe on all ornamental species except spirea and daylily. From the first application, injury to spirea from flumioxazin alone was similar for all doses but plants treated with lower doses recovered after about 6 weeks. However, following the second application, damage was more severe and plants did not recover before the end of the experiment. Damage to daylily was more severe at higher doses. Injury to daylily was similar to that caused by Scotts OH2, and consisted of contact "burning" of the foliage. New growth that formed after treatment was not affected but the damaged foliage persisted throughout the season. The resulting plants would not have been saleable. Adding Pendulum did not increase herbicide damage. Other woody ornamental species tested were not injured by flumioxazin.

American burnweed, bittercress, doveweed, and phyllanthus were controlled by all rates of flumioxazin. As in our previous study (1) eclipta and crabgrass were not well controlled, but increasing the dose of flumioxazin improved control of both species. Eclipta control 6 weeks after treatment was 67%, 89% and 90% with flumioxazin at 0.25, 0.38 and 0.5 lb ai/A, respectively; crabgrass control was 63%, 85% and 88%, respectively. The levels of eclipta control were slightly better than that provided by Scotts OH2 (55 to 65%), but OH2 provided nearly complete control of crabgrass at most rating dates. Pendulum did not control eclipta applied alone and did not improve eclipta control when combined with flumioxazin. Pendimethalin at 3 lb ai/A provided 90% crabgrass control 6 weeks after treatment, and significantly enhanced crabgrass control with flumioxazin applied at the low dose but not at the higher doses.

Significance to the Industry: Flumioxazin is a preemergence herbicide that controls many hard-to-control broadleaf weeds in woody nursery crops. When applied at between 0.25 and 0.38 lb ai/A, weed control will be comparable to that observed with the industry-standard, Scotts OH2, with the exception of crabgrass which is not as well controlled by flumioxazin. However, flumioxazin controlled doveweed better than currently labeled herbicides. As demonstrated by the injury on spirea and weakness on crabgrass and eclipta, more research is needed with flumioxazin to define the spectrum of weeds controlled and tolerant ornamental species.

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Evaluation of Weed Control in Three Container Grown Ornamentals to Flumioxazin

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Index Words: Dianthus, *Dianthus alpinus*, Variegated liriope, *Liriope muscari,* Spirea, Spirea x bumalda 'Anthony Waterer', Large crabgrass, *Digitaria sanguinalis* (L.) Scop., Tall morningglory, *Ipomoea purpurea* (L.) Roth), Flumioxazin, Weed control.

Nature of Work: To test the tolerance of three container grown ornamentals, dianthus (*Dianthus alpinus*), variegated liriope (*Liriope muscari* 'Variegata'), spirea (*Spirea* x *Bumalda* 'Anthony Waterer') to flumioxazin, as well as to test the efficacy of flumioxazin on large crabgrass (*Digitaria sanguinalis* (L.) Scop.) and tall morningglory (*Ipomoea purpurea* (L.) Roth).

Two formulations of flumioxazin (V-53482), granular and liquid, as well as a mixture of flumioxazin and pendimethalin (Pendulum) were compared to a standard herbicide treatment XL 2G (oryzalin 1% and benefin 1%). The treatment list is as follows:

Treatment #	*Trade Name*	*lb ai/A*
1	V-53482	0.17
2	V-53482	0.34
3	V-53482	0.51
4	V-53482	0.34
	Pendulum	2
5	V-53482	0.51
	Pendulum	2
6	V-53482	0.17
7	XL	3
8	Check	

The three ornamental crops, dianthus, liriope, and spirea, were received as liners and potted in one-gallon containers and allowed to establish for four weeks. The media used was Metro-Mix 510. The containers were overseeded with 1 tsp. of a 50:50 mix (by volume) of large crabgrass and tall morningglory. In addition, 1 tsp. / pot of (14-14-14) Osmocote fertilizer was applied at the time of seeding. Granular treatments 1-5 and 7, weighed out prior to the test, were applied to the pots by hand. The sixth treatment, a water dispersible granular (WDG), was applied with a CO_2 backpack sprayer calibated to deliver 30 GPA (8003 flat fan tips).

The test was designed as a Randomized Complete Block with four replications. For homogenous rating, 3 pots of each species were included in each treatment. The test was performed on a weed mat, and irrigated daily (1 inch / day) with overhead sprinklers.

The first herbicide application was made on June 29, 2000 and ratings were taken at 1, 2, 4, and 8 weeks after treatment (WAT). A second identical herbicide application was made on August 24, 2000 and ratings were taken at 2 and 4 WAT. Injury ratings were taken on a 0-10 scale and were averaged between the three pots of each species. Our rating scale for injury was as follows:

Numerical value	*Injury symptoms*
0	No injury
1-3	Slight discoloration in the foliage
4-6	Some yellowing, necrotic foliage
7-9	Severe yellowing, much of the foliage is necrotic or dead. Little live foliage
10	Dead plant

Weed control ratings were averaged over all nine pots in each treatment. Weed control ratings were done on a 0-100 scale, and were as follows:

Numerical value	*Injury symptoms*
0-10	No apparent response
10-40	Slight control or injury, chlorosis, discoloration
40-60	Poor control, numbers reduced, injured
60-80	Fair control, numbers reduced, suppression in size or discolored
80-90	Good weed control, numbers reduced significantly, severe phytotoxicity or necrosis
90-100	Excellent weed control, few remaining weed plants

All data was analyzed by analysis of variance (ANOVA), and means were subjected to Fisher's Least Significant Difference (LSD) with ($P = 0.05$).

Results and Discussion: The only herbicide formulation that caused any phytotoxicity throughout the test was the sprayable formulation (Treatment #6) of flumioxazin (0.17 lb lb ai/A). An injury rating of 1 was given to the liriope up to 4 WAT (Table 1). The worst injury to spirea (7), was recorded at 1 and 2 WAT, but declined to 4.3 by 4 WAT (Table 2). Injury ratings of dianthus peaked at 4 (2 WAT), but had diminished to less than 1 at 8 WAT (Table 3). Injury rating trends were similar after the second herbicide application was applied (Table 1, 2, 3).

The best weed control throughout the experiment was found with the sprayable formulation of flumioxazin (0.17 lb ai/A) for both large crabgrass (95% at 8 WAT) and tall morningglory species (99.5 at 8 WAT) (Table 4 and 5). Similar weed control was seen with both combination treatments of flumioxazin (0.51 or 0.34 lb ai/A) / pendimethalin (2.0 lb ai/A). Control ratings of both weeds were greater than 87 % at 8 WAT for both treatments. The poorest weed control was seen with the low rate of the granular flumioxazin (0.17 lb ai/A). Control ratings for morningglory were 80 % at 8 WAT, but crabgrass control had declined to 50 % by 8 WAT. With XL, control of morningglory and crabgrass was greater than 77.5 at 8 WAT.

At 8 WAT, the middle rate of the granular application of flumioxazin (0.34 lb ai/A) provided fair weed control of tall morningglory (87.5 %) and crabgrass (66.3 %). The high rate of the granular application of flumioxazin (0.51 lb ai/A) provided good control of both tall morningglory (97.5 %) and crabgrass (95.3 %) by 8 WAT.

Ratings of weed control and crop damage were also taken at 2 and 4 WAT from the second herbicide application. A killing frost occurred after the 4 WAT rating and no further ratings were taken. After the sequential application the spirea did exhibit phytotoxicity at 2 WAT (7.8 with treatment 6) and 4 WAT (1.8 with treatment 6)(Table 2). At 2 WAT, liriope exhibited an injury rating of 1.0 with treatment 6 (Table 1). No injury was noted with any of the other herbicide treatments.

Despite the second herbicide application, weed control declined for most herbicide treatment. At 4 WAT, morningglory control with the granular applications of flumioxazin alone were no greater than 72.5 % (Table 4). Morningglory control with both granular applications of flumioxazin / pendimethalin were greater than 92.5%. The XL treatment only provided 62.5% control of morningglory at 4 WAT. As for the crabgrass, only the high rate of flumioxazin (alone and in combination with pendimethalin), and the spray application of flumioxazin provided adequate control (> 79.5 %) (Table 5). Control of crabgrass was poor (52.5 %) with the XL treatment.

Significance to Industry: It appeared that the liquid application of flumioxazin and the higher rate of granular flumioxazin in combination with pendimethalin provided excellent long term control of crabgrass and tall morningglory. Combinations with other herbicides such as isoxaben, dithiopyr, or a dinitroaniline may increase and broaden the spectrum of weed control of the granular formulations of flumioxazin. Although the liquid formulation of flumioxazin provided excellent control of the weed species tested, injury to the dianthus and spirea cultivars studied was significant, and would not be accepted by the industry. However, little published information is available on the safety of flumioxazin to ornamental species. Timing of application or the addition of a safener to the sprayable formulation may help increase safety to ornamentals.

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Table 1. Injury to variegated liriope (*Liriope muscari*) by flumioxazin.[a]

LIRIOPE INJURY

		FIRST TREATMENT				*SEQUENTIAL TREATMENT*	
Treatments #	*Treatment Name*	*1 WAT*	*2 WAT*	*4 WAT*	*8 WAT*	*2 WAT*	*4 WAT*
1	V-53482	0.0 b	0.0 a	0.0 b	0.0 a	0.0 b	0.0 a
2	V-53482	0.0 b	0.0 a	0.0 b	0.0 a	0.0 b	0.0 a
3	V-53482	0.0 b	0.0 a	0.0 b	0.0 a	0.0 b	0.0 a
4	V-53482	0.0 b	0.0 a	0.0 b	0.0 a	0.0 b	0.0 a
4	Pendulum						
5	V-53482	0.0 b	0.0 a	0.0 b	0.0 a	0.0 b	0.0 a
5	Pendulum						
6	V-53482	1.0 a	0.3 a	1.0 a	0.0 a	1.0 a	0.0 a
7	XL	0.0 b	0.0 a	0.0 b	0.0 a	0.0 b	0.0 a
8	Check	0.0 b	0.0 a	0.0 b	0.0 a	0.0 b	0.0 a
LSD		0.0	0.26	0.0	0.0 a	0.0	0.0
Standard Deviation		0.0	0.18	0.0	0.0 a	0.0	0.0

[a] Means within a column followed by the same letter are not different according to Fisher's Protected LSD test at P=0.05.

Table 2. Injury to Spirea (Spirea x bumalda 'Anthony Waterer) by flumioxazin.[a]

SPIREA INJURY

Treatments #	Treatment Name	FIRST TREATMENT				SEQUENTIAL TREATMENT	
		1 WAT	*2 WAT*	*4 WAT*	*8 WAT*	*2 WAT*	*4 WAT*
1	V-53482	0.0 b	0.0 b	0.0 b	0.0 a	0.0 b	0.0 a
2	V-53482	0.0 b	0.0 b	0.0 b	0.0 a	0.0 b	0.0 a
3	V-53482	0.0 b	0.0 b	0.0 b	0.0 a	0.0 b	0.0 a
4	V-53482	0.0 b	0.0 b	0.0 b	0.0 a	0.0 b	0.0 a
4	Pendulum						
5	V-53482	0.0 b	0.0 b	0.0 b	0.0 a	0.0 b	0.0 a
5	Pendulum						
6	V-53482	7.0 a	7.5 a	4.3 a	0.0 a	7.8 a	1.8 a
7	XL	0.0 b	0.0 b	0.0 b	0.0 a	0.0 b	0.0 a
8	Check	0.0 b	0.0 b	0.0 b	0.0 a	0.0 b	0.0 a
LSD		0.0	0.30	0.50	0.0 a	0.26	0.26
Standard Deviation		0.0	0.20	0.34	0.0 a	0.18	0.18

[a] Means within a column followed by the same letter are not different according to Fisher's Protected LSD test at P=0.05.

Table 3. Injury to Dianthus *(Dianthus alpinus*) by flumioxazin.[a]

DIANTHUS INJURY

Treatments #	Treatment Name	FIRST TREATMENT				SEQUENTIAL TREATMENT	
		1 WAT	*2 WAT*	*4 WAT*	*8 WAT*	*2 WAT*	*4 WAT*
1	V-53482	0.0 b	0.0 a	0.0 b	0.0 a	0.0 a	0.0 a
2	V-53482	0.0 b	0.0 a	0.0 b	0.0 a	0.0 a	0.0 a
3	V-53482	0.0 b	0.0 a	0.0 b	0.0 a	0.0 a	0.0 a
4	V-53482	0.0 b	0.0 a	0.0 b	0.0 a	0.0 a	0.0 a
4	Pendulum						
5	V-53482	0.0 b	0.0 a	0.0 b	0.0 a	0.0 a	0.0 a
5	Pendulum						
6	V-53482	3.0 a	4.0 a	0.8 a	0.0 a	0.0 a	0.0 a
7	XL	0.0 b	0.0 a	0.0 b	0.0 a	0.0 a	0.0 a
8	Check	0.0 b	0.0 a	0.0 b	0.0 a	0.0 a	0.0 a
LSD		0.0	0.42	0.26	0.0 a	0.0	0.0
Standard Deviation		0.0	0.29	0.18	0.0 a	0.0	0.0

[a] Means within a column followed by the same letter are not different according to Fisher's Protected LSD test at P=0.05.

Table 4. Control of Tall morningglory (*Ipomoea purpurea* (L.) Roth) by flumioxazin.[a]

MORNINGGLORY CONTROL

		FIRST TREATMENT			SEQUENTIAL TREATMENT	
Treatments #	Treatment Name	2 WAT	4 WAT	8 WAT	2 WAT	4 WAT
1	V-53482	96.0 ab	83.5 b	80.0 ab	87.0 a	72.5 a
2	V-53482	92.0 bc	94.5 a	87.5 ab	80.0 a	65.0 a
3	V-53482	99.3 a	99.3 a	97.5 a	97.5 a	71.3 a
4	V-53482	99.3 a	98.8 a	97.8 a	90.0 a	92.5 a
4	Pendulum					
5	V-53482	99.5 a	99.8 a	99.5 a	98.8 a	95.0 a
5	Pendulum					
6	V-53482	100.0 a	100.0 a	99.5 a	100.0 a	100.0 a
7	XL	88.8 c	91.8 ab	77.5 b	77.5 a	62.5 a
8	Check	0.0 d	0.0 c	0.0 c	0.0 b	0.0 b
LSD		4.22	9.05	13.62	18.40	45.35
Standard Deviation		2.87	6.15	9.26	12.51	30.83

[a] Means within a column followed by the same letter are not different according to Fisher's Protected LSD test at P=0.05.

Table 5. Control of Large crabgrass (*Digitaria sanguinalis* (L.) Scop) by flumioxazin.[a]

CRABGRASS CONTROL

		FIRST TREATMENT			SEQUENTIAL TREATMENT	
Treatments #	Treatment Name	2 WAT	4 WAT	8 WAT	2 WAT	4 WAT
1	V-53482	96.5 ab	90.0 b	50.0 c	80.0 a	25.0 bc
2	V-53482	97.8 ab	96.0 a	66.3 b	87.5 a	25.0 bc
3	V-53482	100.0 a	99.0 a	95.3 a	97.5 a	79.5 a
4	V-53482	100.0 a	96.5 a	87.0 a	95.0 a	65.0 ab
4	Pendulum					
5	V-53482	99.5 a	98.8 a	94.5 a	100.0 a	87.0 a
5	Pendulum					
6	V-53482	100.0 a	100.0 a	96.5 a	100.0 a	95.0 a
7	XL	95.3 b	95.3 a	92.0 a	92.5 a	52.5 ab
8	Check	0.0 c	0.0 c	0.0 d	0.0 b	0.0 c
LSD		2.42	4.09	13.34	12.90	36.80
Standard Deviation		1.64	2.78	9.07	8.77	25.02

[a] Means within a column followed by the same letter are not different according to Fisher's Protected LSD test at P=0.05.

Oxalis Weed Species Reduce Growth of *Echinacea purpurea* 'White Swan' Liners

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Index Words: *Oxalis stricta, O. corniculata*, *Echinacea purpurea* 'Bravado', weed competition, herbaceous perennial, container-grown, liner

Nature of Work: There are many different species of oxalis with *Oxalis stricta* (yellow woodsorrel), *O. corniculata* (creeping woodsorrel), and *O. dillenii* ssp. *dillenii* (woodsorrel) being the most commonly found in ornamental nurseries. Typically these weeds follow an annual cool season life cycle, however they can be a perennial nuisance in hoop houses and greenhouses where the environmental conditions are more moderate. Removal of mature weeds and control of seedling emergence are required for effective control. Understanding the reproductive strategies of this weed is an important aspect of control.

O. corniculata and *O. dillenii* ssp. *dillenii* are both creeping and stoloniferous, with many stolons originating from a single taproot and lacking underground rhizomes. The stolons have numerous nodes that readily root, which in turn produce new plants at the nodes. *O. corniculata* has leaves that are mostly purple tinged while *O. dillenii* ssp. *dillenii* has leaves that may vary from light green to brownish in color. *O. stricta* is an upright species with several branches originating from the base of the plant, lacks a taproot and spreads vegetatively by underground rhizomes. All three oxalis species reproduce primarily from seed production. At maturity, the pods expel seed for several feet in all directions to ensure adequate seed distribution in your nursery.

Eliminating seedling emergence is essential to a successful oxalis control program. Ideally, if the mature weeds are removed prior to seed distribution then the reproduction cycle can be broken. This is important because *Oxalis* species are particularly troublesome weeds in container production in the Southeast that compete with ornamental plants for essential nutrients and moisture. A research project conducted at the Nursery Research and Service Center at Tennessee Technological University illustrates this competition effect.

Echinacea purpurea 'White Swan' plugs were transplanted into 1801 cell packs using Promix BX media. *Oxalis stricta* and *Oxalis dillenii* seedlings were selected from a greenhouse population and transplanted with the *Echinacea* plugs. Treatment densities were 1 weed seedling or 3 weed seedlings of either *Oxalis* species per cell. A weed free control was included. Each treatment was replicated 12 times and allowed to grow for 60 days. At 60 DAT data collected included dry weight and leaf area for the *Echinacea purpurea* 'White Swan'. All data were analyzed using analysis of variance (ANOVA) and, if significantly different, by mean separation (LSD), P=0.05.

Results and Discussion: Both species of *Oxalis* inhibited growth of *Echinacea purpurea* 'White Swan'. Reductions in dry weight and leaf area were similar for both of the *O. dillenii* treatment densities and the single *O. stricta* density (Table 1). However, the three *O. stricta* treatment densities resulted in the greatest growth reduction of 88% (dry weight) and 77% (leaf area) (Table 1). These differences are related to the growth habit of the weed species used. The *Oxalis stricta* not only competed with the *Echinacea purpurea* 'White Swan' for water and nutrients, but due to it's upright growth habit also was in direct competition for light.

Significance to the Industry: This study highlights the importance of controlling weed populations that will compete with your ornamental crops. Control your weeds and you will produce a healthy, vigorous and more importantly, a very salable crop.

Table 1. Dry weight and leaf area of *Echinacea purpurea* 'White Swan' grown with two *Oxalis* species at three weed population densities.

Weed Population	Dry Weight (g)	Leaf Area (cm^2)
1 *Oxalis dillenii*	0.75 b[z]	109.24 b
3 *Oxalis dillenii*	0.71 b	109.29 b
1 *Oxalis stricta*	0.57 b	94.37 b
3 *Oxalis stricta*	0.22 c	52.03 c
Weed-free Control	1.78 a	218.63 a

[z]Mean separation by Least Significant Difference (LSD), P=0.05.

Rabbits as Weed Vectors and Vegetative Dispersal Agents

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Index Words: *Sylvilagus floridanus*, Eastern Cottontail, nimblewill, hawthorn

Nature of Work: Gravity, wind, soil erosion, and water all play a role in the dispersal of seeds. Seeds may also be transported by active or passive action of humans and animals. Seeds may become attached to the carrier's clothing, fur, or hair or caught in mud and carried to a new location. Seeds may also be ingested, either as a direct food source or in consequence to the consumption of plant tissues surrounding the seeds.

Evidence that viable seeds have survived the digestive processes of grazers has been shown for elephants, rhinoceros, horses, sheep, pronghorn antelope, grizzly bears, and emus (1). Viable seeds have also been recovered from rabbit feces (4, 5, 7, 9, 10). Observations of rabbit seed dispersal have demonstrated the potential to disperse herbaceous plant species, including weeds, within their range (5, 7, 8, 10). Rabbits around semiarid vernal pools in California dispersed 18 herbaceous plant species in their pellets. Of the 18, 10 were native to the vernal pools and most were considered weeds (10). Malo and Suarez (5) found that 52 Mediterranean plant species were dispersed in wild rabbit feces. More, wild rabbits dispersed as many as 500 seeds in a 24-hour period. The wild rabbit (*Oryctolagus cuniculus* L.) can produce 120 to 520 pellets during a 24-hour period (4). A separate experiment found that jackrabbit pellets contained an average of 2.5 prickly pear cactus seeds (9). Taken together, rabbits may potentially excrete numerous viable seeds every 24 hours.

Regardless, the number of viable seeds present in rabbit pellets is expected to vary with the amount of time that seeds spend in the rabbit digestive tract. It takes approximately 10-72 hours for cottontails to ingest and excrete their food (10). Rabbits are also coprophagous. They produce both hard pellets and soft dung. Immediately after excretion, rabbits will eat the soft pellets, allowing further absorption of slowly processed nutrients, while also providing the rabbits with protein and B vitamins (6).

Native eastern cottontail rabbits (*Sylvilagus floridanus* L.) are the most widely distributed rabbit in North America. Eastern cottontails prefer brushy habitats, overgrown fields, forest edges: where there are a variety of plant species (2). *S. floridanus* are herbivorous, feeding on a variety of woody and herbaceous plants. In spring and summer, cottontails prefer herbaceous understory plants, including grasses and clover. In winter, rabbits switch to woody plants, including red maple and blackberry (2).

Eastern cottontail rabbits are abundant throughout the grounds of the University of Tennessee Institute of Agriculture (UTIA) campus. Within the campus, the ornamental nursery research facility and UT Trial Gardens are spread across 3 acres bordered by the Tennessee River. Various habitats are included within the property: a brushy, under-story woodland, Third Creek and the Tennessee River waterways, ornamental plantings that surround the gardens and greenhouses, and a heavily trafficked road, which borders one side of the gardens.

The objective of this study was to determine which seeds survive the rabbit digestive process, remaining viable in the feces. Identification of preferred food resources might lead to conclusions about the potential effect of eastern cottontail rabbits as seed dispersal agents in nursery production settings and in the landscape.

In a preliminary experiment, 200 excreted rabbit pellets were collected in January in the UTIA Nursery Compound. Pellets were placed in a Good Sense™ zipper seal bag (Webster Industries, Peabody, MA), transported back to the lab, and kept dry at room temperature. Pellets were subdivided into 24 dark brown and 24 light brown groups, broken apart and incorporated into ProMix BX® (Premier Brands, Stamford, CT) soilless mix, and were cultured in 12-cell plastic trays (Corning Glass Works, Corning, NY) with lids. Trays were maintained in a Percival Model I-35VL growth chamber (Percival Scientific, Boone, IA) under 16-light: 8-dark photoperiod at 25 ± 3°C (77 ± 5°F) and 85%± 5% relative humidity. Seed germination was recorded over a period of two weeks.

Based on preliminary results, fresh pellets were collected and subdivided into light brown, medium brown/gray, and dark brown/black treatments. In all, 756 pellets were cultured using a randomized complete block design of seven blocks with three replicates per treatment. Trays were maintained for four weeks as described for the preliminary experiment and cells were hand-watered as needed. Seedlings that emerged were removed from individual cells, potted in individual pots, and grown until a positive identification could be made.

Results and Discussion: Among the 756 pellets that we collected in February, only 2% produced seedlings. Further, the 15 seedlings that germinated represented only two species: nimblewill (*Muhlenbergia schreberi* (J.F. Gmel.)) and Washington hawthorn (*Crataegus phaenopyrum* (L.f.) Medik). Hawthorn fruit resemble rose hips in fruit size, seed number, and arrangements of seeds. Hawthorn fruit are a ready source of winter nutrition to a number of animals, including rabbits (2). Nimblewill is a weakly rooted grass that resembles bermudagrass in leaf shape and growth form. Nimblewill differs from bermudagrass in the position of its' leaf blades, which are held 90° from the stem.

Trends among pellet color-based treatments were not apparent. However, the presence of only 2 plant species in February-collected pellets suggests either that rabbits preferentially foraged for these food resources, or that only the seeds of these species were capable of surviving the digestive process. Similar to our findings with eastern cottontail, Pakeman and others (7) found that among seeds of 37 plant species dispersed in the UK by wild rabbits (*O. cuniculus)*, just four species comprised 87% of the germinating seeds. The authors hypothesized that wild rabbit food preferences included these species: stinging nettle (*Urtica dioica* L.), corn speedwell (*Veronica arvensis* L.), common pearlwort (*Sagina apetala* Ard.), and tansy ragwort (*Senecio jacobaea* L.). Documentation of pellet deposition rates during a one-year period also revealed higher numbers of pellets produced in the summer than the winter (7). Limited winter feeding counts may explain the low percentage of germinated seeds that were recovered from our samples.

The capacity of rabbits for rapid population growth can make them problematic in nursery production. While the forage and behavioral range of rabbits typically remains close to the warren, population management is a persistent challenge (3). Control recommendations have included gassing, snaring, poisoning, shooting, and cage trapping (3). These techniques require special equipment and training and are often unsuited for landscapes and nursery operations. Legal issues may also complicate control efforts. Natural predators, which include foxes, owls, snakes, and hawks, help maintain rabbit populations. Perhaps the most efficient population controls remain the dogs and cats associated with urban habitats.

Future research efforts focusing on pellets excreted in late spring and summer will increase our understanding of the food preferences of cottontail rabbits. In turn, this will provide insight into the role of rabbits as seed dispersal agents in the landscape and in nursery production systems.

Significance to Industry: Eastern cottontail rabbits can become destructive pests in nursery production systems. Injury to ornamental plants includes leaf, root, and bark feeding, stem and trunk girdling. Production may be disrupted when rabbits chew through drip irrigation tubing, knock down containers, and dig warrens and reproductive burrows in production fields. Evidence also exists that feeding rabbits disperse viable weedy and ornamental plant seeds throughout nursery production areas and landscapes while excreting partially digested fecal material. Because legal and effective control options are limited, research is warranted to find a practical rabbit repellent or feeding deterrent.

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Weed Control In Perennial Production Utilizing Self-felting Wool Pellets

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Index words: Wulpak, weed control, liners, perennials

Nature of Work: Economic pressure to produce quality perennial plants in the least amount of time involves an intensive use of water, fertilizers, and pesticides. Unfortunately, these practices also provide optimal conditions for weeds and the necessity for frequent applications of herbicides. In addition, concerns for the protection of water resources (3) dictate that techniques to reduce the use and movement of herbicides in runoff waters be adopted. However, herbicide use is not likely to decrease without demonstrated effective alternative strategies.

Wulpak, self-felting wool pellets (Wilbro, Inc., Norway, S.C.) show promise for potential use in weed management. They may control weeds alone or in combination with chemical herbicides. Many herbaceous perennials are sensitive to available herbicides (2, 4); thus wool pellets may provide weed suppression without causing a phytotoxic response. Wulpak may also bind herbicides to the layer of wool, reducing leaching into the root zone and herbicide contamination of runoff. Finally, previous research has shown that copper-treated fabric disks have suppressed weed growth in container-grown willow oaks (1), so use of Wulpak in combination with Spin Out (copper hydroxide) (Griffin LLC, Valdosta, Ga.) may provide weed suppression without the use of herbicides. Use of wool pellets may prove to be an environmentally friendly method to help control weeds. Therefore, our objective was to determine weed control efficacy of Wulpak alone and in conjunction with herbicides or Spinout.

The study was conducted at Walters Gardens, Zeeland, and consisted of four treatments applied to rooted liners of five species. Species studied were Siberian bugloss [*Brunnera macrophylla* (Adams) Johnst.], royal fern (*Osmunda regalis* L.), spotted deadnettle (*Lamium maculatum* L. ‘White Nancy’), butterfly bush (*Buddleia davidii* Franch.), and Oriental poppy (*Papavar orientale* L. ‘Carneum’). Total number of liners depended on size of pot used (400 liners (2.5 inch) for spotted deadnettle and Oriental poppy and 320 liners (3 inch) for Siberian bugloss, butterfly bush, and royal fern. Treatments included wool pellets (155 g/ft^2 of surface) alone, wool pellets treated with Spin Out, wool pellets treated with the herbicide Gallery 75 DF (isoxaben), and a control consisting of no treatment. To ensure a weed population, flats were exposed to hairy bittercress (*Cardamine hirsuta*), liverwort (*Marchantia polymorpha*), and yellow woodsorrel (*Oxalis* spp.) by placing flats of these weeds every three feet in the growing area.

Initial measurements of plant height were recorded on a subsample of five plants per rep when the study commenced 25 May. At this time, plants were evaluated with an overall visual rating (ranging from 0 to 5, with a higher number representing higher quality). Additional measurements of plant height, weed density per flat, visual rating, plant survival, and substrate moisture were recorded 29 June and 16 August when plants were harvested. Substrate moisture content was measured with a Theta Probe Soil Moisture Sensor ML2X (Delta-T Devices, Ltd., Cambridge, U.K.). At harvest, shoot and root dry weights were obtained and dry mass accumulation was calculated. Treatment effects were compared by analysis of variance (PROC GLM, SAS Institute, Cary, N.C.) and significant differences among treatments were separated by Tukey's Studentized Range (HSD) test.

Results and Discussion: Although, there were quantitative differences among species, there were no significant interactions between species and treatments for growth and shoot dry weight accumulation, therefore, these data were averaged over species. Plants in the Wulpak treatment resulted in the greatest shoot dry weight accumulation per plant (Table 1), whereas, the control (no Wulpak) resulted in the lowest increase in shoot growth. The increased growth under Wulpak could be due to the slow release of N as the wool breaks down.

All other parameters exhibited interactions, so these data are presented individually for each species (Table 2). General trends were the same, but there were some differences among species. Root dry weight accumulation was greatest for plants of Siberian bugloss, butterfly bush, and Oriental poppy when treated with Wukpak or Wulpak +SpinOut. Even so, these treatments were not significantly different when compared to the control. For spotted deadnettle, the Wulpak treatment resulted in the least increase in dry weight. The zero growth recorded for Oriental poppy in the Wulpak + Gallery treatment is due to the fact that the Gallery application killed all the plants. In contrast, Gallery did not have an adverse effect on spotted deadnettle.

Plant health as measured by visual rating was relatively the same except for plants treated with Gallery. The Wulpak treatment and the control were generally best. Visual rating provide an arbitrary assessment of potential negative effects of Wulpak or herbicide applications.

Regardless of species, the highest rate of plant survival occurred under control conditions. Wulpak and Wulpak + SpinOut treatment resulted in lower survival rates, but the differences were not always significant. Gallery was detrimental to all species and as stated previously, Gallery killed 100% of the Oriental poppies. There are two main reasons why Wulpak treatments resulted in higher plant mortality. First, plants of royal fern, Oriental poppy, and to some extent Siberian bugloss, were rather small when wool pellets were applied. Upon wetting, they swelled and smothered many of these small plants. If Wulpak was applied after the plants had more time to become established this problem could be at least partially solved. Second, the application of Wulpak significantly increased substrate moisture (0.346 vs. 0.287 volumetric moisture fraction). This can be a positive or negative influence on plant growth depending on the watering regime.

The best treatment for weed control was generally Wulpak + SpinOut. The combination of Wulpak and copper hydroxide inhibited weed establishment. The poorest treatment was either the control or Wulpak + Gallery. In the control treatment there was nothing added to inhibit weeds. High weed densities for the Wulpak + Gallery treatment can probably be attributed to either the ineffectiveness of the herbicide or the lessened plant competition resulting from a lower survival rate of the perennials. Weeds completely covered the flats of Oriental poppy where Gallery killed all poppies. Weeds also smothered the flats of royal fern, probably because of the small plant size.

Significance to Industry: The practice of utilizing wool pellets has potential as an alternative weed control strategy for liner production. Not only may the practice help suppress weeds, but it could reduce the need for herbicide applications, which in turn may limit potential crop damage, lessen exposure of nursery workers to chemicals, and result in less contamination to the environment. In the present study, the best treatment for weed control was generally Wulpak + SpinOut. In addition, the use of Wulpak and Wulpak + SpinOut increased shoot dry weight accumulation in all species tested and were often equal to or better than the control in regards to root dry weight accumulation. The negative result of Wulpak applications in any form was the general higher plant mortality when compared to the control. This could be a function of water management.

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Table 1. Effect of Wulpak treatment on plant height and shoot dry weight accumulation. Data averaged over species.

Treatment	Growth in height (cm)	Shoot dry weight accumulation per plant (g)
No Wulpak(Control)	26.9 a	1.62 b
Wulpak	30.4 a	2.25 a
Wulpak + Spinout	28.9 a	1.72 b
Wulpak + Gallery	28.0 a	1.94 ab

Mean separation among treatments by Tukey's Studentized Range (HSD) test, $P \leq 0.05$. Treatments with identical letters are not significantly different.

Table 2. Effect of Wulpak treatment on dry weight accumulation, plant visual rating, survival, and weed density of *Brunnera macrophylla*, *Buddleia davidii, Lamium maculatum* 'White Nancy', *Osmunda regalis*, and *Papavar orientale* 'Carneum'.

Treatment	Root dry weight accumulation per plant (g)	Visual rating	Plant survival (%)	Weed density per flat (%)
Brunnera				
No Wulpak	2.27 ab	4.50 a	93.8 a	8.0 ab
Wulpak	2.99 a	4.50 a	83.7 ab	2.0 b
Wulpak + Spinout	1.72 ab	3.87 b	92.5 a	1.0 b
Wulpak + Gallery	1.29 b	3.62 b	68.7 b	15.0 a
Buddleia				
No Wulpak	0.39 ab	4.50 a	100.0 a	67.5 a
Wulpak	0.68 a	4.50 a	87.5 a	16.2 bc
Wulpak + Spinout	0.63 a	4.50 a	95.0 a	3.7 c
Wulpak + Gallery	0.31 b	3.75 a	43.7 b	50.0 ab
Lamium				
No Wulpak	1.27 a	4.50 a	96.0 a	20.0 ab
Wulpak	0.35 c	3.87 a	61.0 b	38.7 a
Wulpak + Spinout	0.51 bc	4.25 a	74.0 ab	5.5 b
Wulpak + Gallery	0.89 ab	4.12 a	60.0 b	10.0 b
Osmunda				
No Wulpak	1.20 a	4.37 a	92.5 a	100.0 a
Wulpak	0.50 a	4.00 ab	12.5 b	100.0 a
Wulpak + Spinout	1.33 a	4.00 ab	65.0 a	100.0 a
Wulpak + Gallery	0.69 a	3.75 b	20.0 b	100.0 a
Papaver				
No Wulpak	0.71 ab	4.25 ab	71.0 a	20.0 b
Wulpak	0.79 a	4.37 a	46.2 b	21.2 b
Wulpak + Spinout	0.96 a	3.75 b	52.2 ab	5.5 c
Wulpak + Gallery	0 b	0 c	0 c	100.0 a

Mean separation among treatments by Tukey's Studentized Range (HSD) test, $P \leq 0.05$. Treatments with identical letters are not significantly different.

Using AlbaGro For *Marchantia* Control

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Index Words: liverworts, *Rhododendron* 'Cannon's Double,' meadowfoam, seed meal

Nature of Work: The predominant liverwort species infesting container grown plants in the Pacific Northwest is *Marchantia polymorpha*. *Marchantia* spreads by airborne spores, splashed gemmae, and fragmentation to rapidly infest moist surfaces having adequate concentrations of nitrogen and phosphorus. A variety of strategies are being studied to reduce *Marchantia* infestations (Svenson, 1997; Svenson et al., 1997), because available herbicides have limited effectiveness in many situations (Svenson, 1998).

Meadowfoam (*Limnanthes alba*) is a winter rotational field crop in Oregon. Meadowfoam oil is used as a substitute for whale and jojoba oil. After the oil is extracted from harvested meadowfoam seeds, the seed meal is left over as a waste product. Our initial investigations suggested that meadowfoam seed meal is useful for control of *Marchantia* infestations of container production systems (Svenson and Deuel, 2000), but the raw seed meal had several objectionable characteristics (not easily applied, odor, infested with grass seed). AlbaGro is a natural fertilizer product derived from meadowfoam seed meal and granular sulfate (Natural Plant Products, Salem, Oregon). AlbaGro provides 4% of N, P_2O_5, and K_20, 5% Ca, and 1.5% Mg. The objective of this study was to determine if AlbaGro was useful for control of *Marchantia* infesting container grown *Rhododendron*.

Rhododendron 'Cannon's Double' (2 $^1/_4$ -in liners) were potted into trade 1-gal pots filled with a 100% Douglas-fir bark substrate on 30 May 2000. The substrate was amended with 8 lbs. dolomitic limestone per cubic yard of substrate (pH was 6.6 two weeks after potting). After potting, plants were topped dressed with 12 grams of Nutricote 16-10-10 (1:3 by weight blend of type 40 and type 100). Thirty days after potting, all pots were inoculated with a *Marchantia* slurry composed of *Marchantia* gemmae and thallus blended with buttermilk and water (Svenson, 1998). Plants were grown in an unheated hoop structure covered with white poly-film (50% shade).

On 10 August, all pots were infested with *Marchantia*. Pots were treated with 1/4 cup or 1/2 cup of AlbaGro applied to the surface of the substrate, or left untreated. The percentage of the substrate surface covered with *Marchantia* was evaluated 15, 30 and 60 days after treatment. The experiment was a randomized complete block design, using three pots as subsamples within each of 5 blocks. Data was analyzed using SAS analysis of variance, with means separated using Duncan's Multiple Range Test.

Results and Discussion: AlbaGro provided excellent control of *Marchantia* at 15 and 30 days after treatment (Table 1), but the 1/4 -cup application rate provided less control by 60 days after treatment. There was no phytotoxicity to *Rhododendron* at the rates tested. Unlike unprocessed meadowfoam seed meal (Svenson and Deuel, 2000), AlbaGro was easily applied, did not have an objectionable odor, and was not infested with viable grass seed. As a pelleted product, AlbaGro can be uniformly applied using mechanical spreaders. This study was repeated in Fall of 2000, with similar results.

Significance to Industry: AlbaGro appears to be a useful product for *Marchantia* control, but this use must first be registered with U.S. EPA. AlbaGro provides a natural alternative product as part of an overall integrated approach for *Marchantia* control.

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Table 1. Influence of AlbaGro on the percentage of substrate surface covered by *Marchantia*.

	Application	**Days after application**		
Product	**Rate**	15	30	60
Untreated		60 a[1]	75 a	100 a
Meadowfoam	1/4 cup	0 b	0 b	40 b
Meadowfoam	1/2 cup	0 b	0 b	4 c

[1] Means in columns followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Composts and Shading Influence *Marchantia* Infestations In Container Grown Nursery Crops

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Index Words: liverwort, retractable roof systems, swine compost, dairy compost, *Pieris*, *Thuja*, *Vaccinium*.

Nature of Work: *Marchantia polymorpha* is the predominant liverwort species infesting container grown plants in the Pacific Northwest. *Marchantia* spreads by airborne spores, splashed gemmae, and fragmentation to rapidly infest moist substrate surfaces that have adequate concentrations of nitrogen and phosphorus. A variety of strategies are being studied to reduce *Marchantia* infestations (Svenson, 1997; Svenson et al., 1997; Svenson and Deuel, 2000), because available herbicides have limited effectiveness in many situations (Svenson, 1998). As part of an overall integrated management approach to *Marchantia* control, the objective of this study was to determine if composts added to the growing substrate or if the type of shading system used would influence *Marchantia* infestations of container grown nursery stock.

Potted liners of *Pieris japonica* 'Mountain Fire,' *Thuja occidentalis* 'Danica,' and *Vaccinium* 'Darrow' were potted into #1 (2.5 liter) nursery pots filled with 100% Douglas-fir bark, bark amended with 10% (by volume) swine compost, bark amended with 20% swine compost, bark amended with 10% dairy compost, or bark amended with 20% dairy compost. Composts were supplied by Bion Technologies (Denver, Colorado), and plants were potted on June 16, 2000. After potting, plants were top-dressed with 18 grams of Osmocote 18-6-12. Plants were placed in a split-plot treatment arrangement in a randomized complete block design. Three blocks containing three plants of each substrate treatment were randomly placed in three growing locations including: a retractable roof shading structure glazed with a woven white poly film (50% shading); a hoop structure covered with black saran shade cloth (30% shading); or in an uncovered growing area. The retractable roof structure was operated manually to provide shading from 11AM to 4 PM daily (roof retracted on cloudy days). All growing areas were gravel beds with overhead irrigation. Irrigation at all three sites was adjusted to supply 3/4 -in of rainfall daily (on average, application volumes varied based on available water pressure). The water source was well water, having an EC of 0.3 (millimhos/cm) and a pH of 7.2 (seasonal average). All plants were exposed to natural rainfall.

Thirty days after potting, all pots were innoculated with a *Marchantia* slurry composed of *Marchantia* gemmae and thallus blended with buttermilk and water (Svenson, 1998). On 25 September, the percentage of the substrate surface covered with *Marchantia* was recorded. Data were analyzed for significant response to substrate treatment, growing location, and plant taxa using SAS ANOVA, with mean separations using standard errors or Least Significant Difference for individual comparisons.

Results and Discussion: Plant taxa did not influence *Marchantia* infestation, so data were pooled within substrate treatments and growing locations. There were no interactions between substrate treatments and growing locations on *Marchantia* infestation, so response to substrate treatments and growing location were analyzed separately.

There was generally less *Marchantia* growing on the surface of substrates amended with 20% swine compost compared to all other substrates (Table 1). *Marchantia* is sensitive to heavy metals, especially zinc and copper. A high concentrations of zinc and copper in the 20% swine substrate (data not shown) may have helped inhibit the growth of *Marchantia* on the soil surface.

There was generally less *Marchantia* growing on the surface of substrates when plants were grown uncovered compared to plants under stationary or retractable shading (Table 2), and plants grown under retractable shading had less *Marchantia* compared to plants grown under stationary shading.

Significance to Industry: Selection of substrate components and type of shading system can influence the growth of *Marchantia* in container nursery stock. Hoop structures covered with shade cloth appear to encourage growth of *Marchantia* compared to retractable roof shading systems, or uncovered production areas. Some composts may be useful as top-dressings to help reduce *Marchantia* infestations of the substrate surface.

Acknowledgements: The authors thank Fall Creek Farm and Nursery, Monrovia Growers and Mitsch Nursery for support of this study.

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Table 1. Influence of compost amendment on percentage of substrate surface covered by *Marchantia polymorpha*.

Growing[1] substrate	**Surface Coverage (%)**
unamended bark	41.0 bc[2]
10% swine	54.5 a
20% swine	36.7 c
10% dairy	45.2 ab
20% dairy	47.7 ab

[1] all plants were potted in a Douglas-fir bark amended with compost; unamended bark = without compost.
[2] means within columns are not significantly different (5% significance level) using the LSD mean comparison test.

Table 2. Influence of growing location on percentage of substrate surface covered by *Marchantia polymorpha*.

Growing[1] location	**Surface Coverage (%)**
uncovered	5.9 c[2]
stationary shading	73.3 a
retractable shading	34.8 b

[1] uncovered = plants grown on an uncovered outdoor gravel bed; stationary shading = plants grown under a hoop structure covered with black shade cloth providing 30% shading; retractable shading = plants grown in a flat retractable roof structure providing 50% shading from woven white poly film whenever the film is extended over the crop.
[2] means within columns are not significantly different (5% significance level) using the LSD mean comparison test.

Preemergence Control of *Microstegium vimineum*

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Index Words: *Microstegium vimineum*, *Digitaria sanguinalis*, Japanese stiltgrass, large crabgrass

Nature of Work: *Microstegium vimineum* (microstegium, Japanese stiltgrass, bamboograss, or annual jewgrass) is a summer annual C_4 grass with a prostrate to erect, sprawling and freely branched growth habit, and spreading stems that root at the nodes. It was first reported in the US in 1919 near Knoxville, TN (2). Its current known distribution is mostly east of the Mississippi River including all of the southern states and north to New York (3). Unlike other C_4 species, it is very well adapted to shade. It can flourish without a significant growth reduction at 18% full sunlight, and at 5% full sunlight growth was only inhibited by 17% (4). In shady, moist environments microstegium forms monotypic stands under canopy cover, displacing native vegetation. It is ranked #1 on the USDA eastern region invasive plant list, the highest ranking for a non-native invasive weed. Since microstegium is very well adapted to disturbed, shady, and moist conditions, it occurs predominantly in areas such as stream banks, rights-of-way, and wetlands (1). From these areas, it has spread into and has been reported in low-maintenance turf and mulched landscape beds.

Very little research has been conducted investigating the control of microstegium. Two recommendations by the Virginia Native Plant Society are the use of Roundup (glyphosate) or mechanical control before seed set. These options may not be feasible due to proximity of desirable species, eliminating the practicality of Roundup, or due to lack of resources for mechanical control. To explore other control options, two outdoor container experiments were conducted to determine susceptibility of microstegium to preemergence herbicides commonly used for the control of large crabgrass (*Digitaria sanguinalis*), another C_4 annual grass.

In the first experiment, herbicide applications were made on 4/24/00 to 3-qt (2.8 L) containers. The second experiment utilized 3-gallon (11.4 L) containers and was treated on 6/28/00. The potting substrate was a bark:sand mix (7:1 v/v) amended with 10 lbs/yd^3 (3.5 kg/m^3) Wilbro (15-4-9) slow release fertilizer and 6 lbs/yd^3 (2.1 kg/m^3) pulverized dolomitic limestone. Weeds were surface seeded before herbicide application. Liquid herbicide applications were made using a CO_2 pressurized backpack sprayer calibrated to deliver 30 gallons per acre (280 L/ha).

Granular herbicides were applied with a handheld shaker jar using pre-weighed aliquots. Treatments included Barricade 65WG (prodiamine) at 0.75 lb ai/A (0.84 kg ai/ha), Devrinol 2G (napropamide) at 4 lb ai/A (4.48 kg ai/ha), Dimension 1E (dithiopyr) at 0.5 lb ai/A (0.56 kg ai/ha), Gallery 75DF (isoxaben) at 1 lb ai/A (1.12 kg ai/ha), Pendulum 3.3EC (pendimethalin) at 3 lb ai/A (3.36 kg ai/ha), Pennant 7.8EC (metolachlor) at 4 lb ai/A (4.48 kg ai/ha), Preen 1.47G (trifluralin) at 4 lb ai/A (4.48 kg ai/ha), Ronstar 2G (oxadiazon) at 4 lb ai/A (4.48 kg ai/ha), Snapshot 2.5G (isoxaben + trifluralin) at 5 lb ai/A (5.6 kg ai/ha), Surflan 4AS (oryzalin) at 3 lb ai/A (3.36 kg ai/ha), Team Pro 0.86G (trifluralin + benefin) at 3 lb ai/A (3.36 kg ai/ha), and XL 2G (benefin + oryzalin) at 4 lb ai/A (4.48 kg ai/ha).

Each experiment was conducted in a randomized complete block design with four replicates and three pots of each species per experimental unit. Percent control was visually assessed compared to a non-treated control every two weeks starting when plants were large enough to evaluate until 8 weeks after treatment (8 WAT). Data were subjected to analysis of variance and means were separated using Fisher's protected LSD at the 5% level.

Results and Discussion: No treatment by experiment interaction was observed for microstegium; therefore, the data for the two experiments were pooled (Table 1). In contrast, large crabgrass had a significant treatment by experiment interaction; as a result, data from each experiment are presented separately (Table 1). In general, herbicides provided as good or better control of microstegium than large crabgrass, with the exception of Pennant which controlled large crabgrass but not microstegium. Excellent control of microstegium was achieved with Barricade, Surflan, XL, Pendulum, Dimension, Preen, Snapshot and Ronstar. Team Pro, Pennant and Devrinol provided only moderate suppression of microstegium. Gallery did not control microstegium or large crabgrass.

In the second experiment many of the herbicides had lost their effectiveness on large crabgrass by 8 WAT, thus accounting for the large treatment by experiment interaction at this timing. However, 4 WAT many of the herbicides provided similar control of large crabgrass as 8 WAT in the first experiment (Table 1). This may be due to the fact that the second experiment was conducted later in the growing season where higher temperatures, increased plant growth, and heavier but less frequent rainfall occur. Since the first experiment was conducted earlier in the season, plants were not large enough to evaluate at 4 WAT and therefore direct comparisons cannot be made.

Significance to Industry: Microstegium can be controlled with preemergence herbicides currently labeled for use in landscape plantings. Furthermore, with the exception of Pennant, those herbicides labeled for preemergence crabgrass control are equally or more effective for microstegium control.

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Table 1. Comparison of preemergence herbicide efficacy on microstegium and large crabgrass.

Herbicide	Microstegium control (%) 8 WAT[a] Pooled over 2 experiments	Large crabgrass control (%) 8 WAT[a] Experiment 1	Large crabgrass control (%) 4 WAT[a] Experiment 2	Large crabgrass control (%) 8 WAT[a] Experiment 2
Barricade	99	100	100	100
Surflan	99	91	73	39
XL	98	84	88	73
Pendulum	98	99	98	86
Dimension	98	96	95	86
Preen	93	96	99	86
Snapshot	93	98	99	83
Ronstar	87	75	83	45
Team Pro	77	90	73	20
Devrinol	59	58	78	40
Pennant	39	87	89	59
Gallery	4	0	13	3
LSD (p=0.05)	14.8	16.9	13.4	25.6

[a] WAT = weeks after treatment

Evaluation of Biodac as a Herbicide Carrier

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Index Words: Oryzalin, Biodac, Herbicide Carrier

Nature of Work: The container nursery industry currently uses broadcast applications of spray or granular herbicide for preemergent weed control. This application method causes a significant amount of non-target loss. Growers make an average of three applications per year with losses of up to 80% per application (2). These losses vary depending on application equipment, container spacing and crop canopy (6). Material lost with current weed control practices represents a significant unproductive cost to the grower as well as potential contributors to surface and ground water contamination. Other techniques have been evaluated to reduce chemical losses in container production, including herbicide coated fertilizers (4), geotextile disks (1), and slow release herbicide tablets (3). The objective of this research is to evaluate new herbicide carriers and formulation techniques to determine their potential for use as an extended delivery herbicide. Such a product if effective would be applied directly to each container once yearly at potting or in the field providing adequate control of weeds with no adverse effects to the plants. The goal of this formulation would be to eliminate non-target losses associated with current application techniques, which will improve nursery runoff water quality.

The commercially available cellulose complex carrier Biodac® (GranTek Inc., Granger, Indiana 46530) was chosen for laboratory evaluation. Three Biodac® grades were used: Biodac 16/30 mesh (B-1), 12/20 mesh (B-2) and 20/50 mesh (B-3). B-1, B-2 and B-3 were formulated with oryzalin to an active ingredient concentration of approximately 9.4%. Biodac®-oryzalin formulations were placed into 4.1 oz. (125 ml) pear shaped separatory funnels and 3ml of water were added daily to simulate irrigation events. The water was allowed to remain in the funnels for 30 minutes before leaching. Leachates were collected and analyzed for oryzalin concentration. A second experiment was conducted to determine the efficacy of the Biodac®-oryzalin formulations in a nursery setting. B-1, B-2 and B-3 were applied to 5” containers filled with a typical pinebark growing media at rates of 4, 8, 12, 16, 20, 24 and 28 lbs ai/A. Other treatments included Surflan® at 2 and 4 lb ai/A, Rout® at 2, 4 and 8 lb ai/A and an untreated control. Pots were over seeded with crabgrass (*Digitaria sanguinalis*) and placed under overhead irrigation. Weeds were harvested and pots reseeded with crabgrass every thirty days throughout the experiment.

Results and Discussion: Lab experiments showed that after 10 days of leaching B-1 and B-2 had the highest release rate having released an average of 0.24% of the oryzalin per event followed by 0.19% for B-3 (Figure 1). During leaching events 11-20, B-1 and B-2 also released the most, leaching an average of 0.11% per event followed by 0.09% for B-3. During leaching events 21-30 all three carriers leached an average of 0.9% per event. Cumulative oryzalin released was 4.6, 4.5 and 3.7% for the B-1, B-2 and B-3 carriers respectively.

Nursery efficacy tests showed a significant linear or quadratic rate response on weed dry weight for all formulations at 90 days after treatment (DAT) (Table 1). Contrast analysis revealed no differences in weed dry weight between any Biodac® formulation (Table 1). There was also no difference between B-1 and Surflan or Rout. Weed dry weights were lower for all herbicide formulations when compared to the untreated control at 90 and 120 DAT.

Significance to the Industry: Results of these experiments indicate that Biodac may have potential as extended delivery carriers of oryzalin and perhaps other pre-emergent active herbicides. In comparison Keese et al. (5), reported that the release of oryzalin from the granular formulation Rout® was comparatively rapid with cumulative loss after 21 simulated irrigation events of 71.3%.

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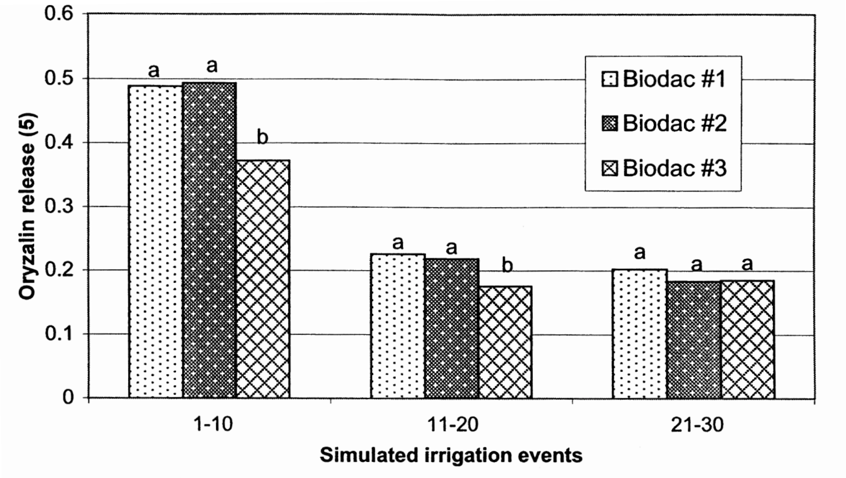

Figure 1. Average daily herbicide release for simulated irrigation events 1-10, 11-20 and 21-30 (n=4).

Table 1. Effects of extended delivery herbicide formulations on crabgrass control.

Herbicide	Rate (lbs ai/A)	Crabgrass dry weight (grams) 90 DAT[z]	120 DAT
Biodac 1	4	0.03	0.6
Biodac 1	8	0.006	0.37
Biodac 1	12	0.004	0.27
Biodac 1	16	0.001	0.49
Biodac 1	20	0.001	0.17
Biodac 1	24	0.001	0.36
Biodac 1	28	0	0.12
		L***[y]	Q**
Biodac 2	4	0.013	0.6
Biodac 2	8	0.002	0.3
Biodac 2	12	0.006	0.21
Biodac 2	16	0.088	0.85
Biodac 2	20	0.014	0.7
Biodac 2	24	0.001	0.18
Biodac 2	28	0	0.21
		Q**	Q**
Biodac 3	4	0.48	0.77
Biodac 3	8	0	1.5
Biodac 3	12	0.002	0.35
Biodac 3	16	0.002	0.034
Biodac 3	20	0	0.64
Biodac 3	24	0.003	0.35
Biodac 3	28	0	0.18
		L**	Q**
Rout	2	0.21	0.161
Rout	4	0	0.037
Rout	8	0	0.004
		L***	L***
Surflan	2	0.01	0.12
Surflan	4	0.002	0.05
Control		1.24	1.23

Contrast: Biodac 1 vs. Biodac 2 Biodac 1 vs. Biodac 3 Biodac 2 vs. Biodac 3 Biodac 1 vs Rout Biodac 1 vs Surflan Biodac 1 vs. Cont

(0.006 vs. 0.018) NS’	(0.34 vs. 0.44) NS
(0.006 vs. 0.069) NS	(0.34 vs. 0.54) NS
(0.0 18 vs. 0.069) NS	(0.44 vs. 0.54) NS
(0.006 vs. 0.069) NS	(0.34 vs. 0.067) NS
(0.006 vs. 0.006) NS	(0.34 vs. 0.082) NS
(0. 006 vs. 1. 15) ***	(0.34 vs. 1.23) ***

[z]Days after treatment.
[y]L or Q represents linear or quadric responses within a herbicide, *, ** and *** represents significance as alpha = 0.05, 0.01 and 0.001.
[x]Contrast means in parenthesis followed by significance.

Evaluation of a Year Long Weed Control Program for Container Grown Ornamentals

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Index Words: Crape Myrtle, Gallery 75 DF, Magnolia, Regal O-O, RegalStar G, Ronstar 50 WP, Snapshot 2.5 TG

Nature of Work: Weed control is a continual problem with the production of container grown ornamentals. There are many effective herbicides and herbicide combinations available for broad spectrum weed control (2). The objective of this study was to evaluate two different herbicide- based weed control programs over a two year period: Regal O-O followed by RegalStar G and Gallery 75DF tank mixed with Ronstar 50WP followed by Snapshot 2.5 TG (Table 1) (1, 2). Regal O-O is a combination of Goal and Ronstar while RegalStar G is a combination of Ronstar and Factor. This weed control system used non-dinitroanaline (DNA) combinations of herbicides in the late fall and late winter for broadleaf weed control followed with DNA and non-DNA combination herbicides throughout the growing season for broadleaf and grassy weed control (1, 2, 3).

Research was conducted at Gainous Shade Trees, Inc. in Cairo, GA. On February 8, 1999 and February 9, 2000, #7 black plastic containers filled with milled pine bark, peat moss, and river sand (70: 20: 10 by volume) and amended with micronutrients and dolomtic limestone were planted with *Lagerstroemia indica* x *fauriei* 'Tuscarora' (1999) and *Magnolia grandiflora* 'Mgtig' (2000), respectively. All plants were hand weeded. Each container was topdressed with 135 gram (4.8 oz) of 360 day Nutricote 17-6-8. The following herbicide combinations (Table 1) were applied on February 15, and October 15, 1999 and 2000: Regal 0-0 or Gallery 75 DF tank mixed with Ronstar 50 WP. On April 15, June 15, and August 16, 1999 and 2000 the following herbicide combinations were applied: RegalStar G (following Regal O-O) and Snapshot 2.5 TG (following Gallery + Ronstar). Granular herbicides were broadcast over the containers using pre- weighed samples and a hand-held shaker jar. The tank mixed herbicides were applied using a Solo backpack sprayer. Plants were arranged using a completely randomized block design with four replications each having five samples per replication.

Visual ratings for percent surface weed coverage (1 = 0% surface weed coverage; 2 = less than 26%; 3 = 26 to 50%; 4 = 51 to 75%; and 5 = 76 to 100%) were performed at 30 and 60 days after treatment (DAT). Weeds were harvested at 60 DAT for dry weights. Data was subjected to analysis of variance using SAS. The Waller-Duncan K-ratio t test was used for percent coverage and dry weed weight data.

Results and Discussion: In 1999 percent surface weed coverage varied among all treatments. The weed control program of Regal O-O followed by RegalStar G provided the best reduction of surface weed coverage in 1999. In 2000 there were no differences in surface weed coverage between the two herbicide programs. The two herbicide-based weed control programs decreased surface weed coverage during both years compared with the control program of no herbicides (Table 2).

In 1999 the weed control program of Regal O-O and RegalStar G reduced total weed dry weight by 80% compared with the control, while Gallery 75+ Ronstar/Snapshot 2.5 TG reduced weed dry weight by 44% compared with the control. In 2000 the weed control program of Regal O-O and RegalStar G reduced weed dry weight by 96% compared with the control, while Gallery 75+ Ronstar/Snapshot 2.5 TG reduced weed dry weight by 89% compared to the control. There were no differences in weed dry weight between the two herbicide programs for 1999 or 2000 (Table 3).

Weed species observed during 1999 were *Cardamine hirsuta* (Hairy Bittercress), *Eupatorium capillifolium* (Dogfennel), *Mollugo verticillata* (Carpetweed), and *Digitaria spp*. (Crabgrass). Bittercress was present throughout this study from February 15, 1999 to February 15, 2000 because of the canopy coverage created by the crape myrtles. This canopy provided bittercress with an ideal microclimate to allow it to survive throughout the summer growing season. Weed species observed during 2000 were *Euphorbia maculata* (Spotted Spurge), *Cardamine hirsuta* (Hairy Bittercress), *Digitaria spp*. (Crabgrass), and *Oxalis stricta* (Yellow Woodsorrel). Spotted spurge requires light for germination. The openness of the magnolia canopy allowed light to penetrate down to the substrate surface thus allowing spotted spurge to germinate. In1999 there was no spotted spurge due to the limited amount of light reaching the substrate surface. Plant canopies had an influence on the different taxa of weed species seen during this two year study.

Significance to Industry: Weed pressure was not strong during both seasons. Results may be different under heavier weed pressures. Based on the results of this study Regal O-O followed by RegalStar G during the 1999 growing season provided the best weed control system for controlling a variety of nursery weeds when based on percent surface coverage. There was no one weed control system that provided an advantage during the 2000 growing season. By helping producers understand the many options they have for container weed control we can reduce labor costs associated with hand-weeding and/or repeat applications of herbicides that are not providing sufficient weed control.

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Table 1. Trade and common names of herbicides used in this study.

Trade name	Common name	Percent active ingredients	Pounds per acre
Gallery 75 DF	isoxaben	75	1.0
Regal O-O	Oxyfluorfen + Oxadiazon	2.0 1.0	100
RegalStar G	Oxadiazon + Prodiamine	1.0 .2	200
Ronstar 50 WP	Oxadiazon	50	6.0
Snapshot 2.5 TG	Trifluralin + isoxaben	2.0 .5	150

Table 2. Influence of herbicidal treatments on percent surface weed coverage.

Treatments	Weed surface coverage rating	
	1999*	2000**
Regal O-O RegalStar G	1.25c	1.05b
Gallery 75 DF + Ronstar 50 WP Snapshot 2.5 TG	1.65b	1.14b
Control	2.17a	1.84a

Means with the same letter are not significantly different.
*P ≤ 0.0001, **P ≤ 0.05

Table 3. Weed dry weight.

Treatments	Weed dry wt. in grams.	
	1999*	2000**
Regal O-O RegalStar G	.56b	.48b
Gallery 75 DF + Ronstar 50 WP Snapshot 2.5 TG	1.55b	1.41b
Control	2.79a	13.03a

Means with the same letter are not significantly different.
*P ≤ 0.0002, **P≤ 0.05