Weed Control

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Postemergent Control of Purple Nutsedge (Cyperus rotundus L.)

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Index Words: purple nutsedge, Cyperus *rotundus* L., Image, imazaquin, Manage, halosulfuron, Gramoxone Extra, paraquat, Roundup-Pro, glyphosate, Finale, glufosinate

Nature of Work: Purple nutsedge (Cyperus *rotundus* L.) is considered to be one of the world's worst weeds. It is a rhizomatous perennial sedge that reproduces primarily by tubers produced in chains on the rhizomes. Currently, there are no preemergence herbicides that control purple nutsedge in field nursery stock or landscape beds. The study was conducted to compare the effectiveness of several posternergence herbicides on purple nutsedge.

A field uniformly populated with purple nutsedge was divided into 10' x 20' plots that were treated early post (EPO), early post and 6 weeks later (EPO + 6) or late post (LPO), which was the same time as the second treatment date in the EPO + 6 treatment. The treatments were Image (imazaquin) EPO at 0.38 and 0.5 lb ai/ A, Image EPO + 6 at 0.38 and 0.5 lb ai/A, Image LPO at 0.5 lb ai/A, Manage (halosulfuron) EPO at 0.031, 0.042 and 0.062 lb ai/A, Manage EPO + 6 at 0.031, 0.042 and 0.062 lb ai/A, Manage LPO at 0.062 lb ai/A, Roundup-Pro (glyphosate) EPO + 6 at I and 2 lb ai/A, Roundup-Pro LPO at 2 lb aVA, Finale (glufosinate) EPO + 6 at 1 and 1.5 lb ai/A, Finale LPO at 1.5 lb ai/A, Gramoxone (paraquat) Extra EPO + 6 at 0.5 lb ai/A and Gramoxone Extra LPO at 0.5 lb ai/A. The first application was 6/16/99 and was followed by rain approximately 20 minutes after the last treatment was applied. Ratings were taken at 2 week intervals until the second treatment date 8/3/99. Again ratings were taken at 2 week intervals until interrupted by flooding caused by Hurricane Floyd. The final rating for 1999 was taken 11/1/99 and the final rating before terminating the study was taken 5/16/00.

Results and Discussion: Gramoxone gave excellent burn-down following both applications , but considerable regrowth had occurred by 4 weeks after treatment (WAT). The rain that followed the first application reduced the activity of Roundup-Pro and Finale (Table 2). Manage also was slow acting and did not provide acceptable levels of control until after the second application date (Table 1). It is possible that Manage efficacy was also reduced by the rains following the first applications.

Other treatments did not appear to have been adversely affected by the rain. Image was slow acting, but by 4WAIT the control for both rates was in the excellent range where it remained through the second application date.

Single EPO applications of Image and Manage did not provide season-long control (Table 1). When two applications were made there was no advantage to increasing the application rate over the lowest rate tested for each. Late season applications of Image and Manage did not provide control equal to the EPO + 6 treatments. In contrast, LPO applications of Roundup-Pro and Finale (Table 1) provided equal control to the EPO + 6 treatments (perhaps related to the reduced activity from rain following the first treatments).

In September ratings the following provided excellent purple nutsedge control:
- Two applications of Image - No rate response
- Two applications of Manage - No rate response
- EPO + 6 or LPO applications of Roundup-Pro
- EPO + 6 or LPO applications of Finale

In November ratings the only treatments maintaining excellent control of purple nutsedge were RoundupPro and Finale (Table 2), which were providing equivalent control. Significant regrowth had occurred in the Image and Manage plots (Table 1). Single EPO applications of Image or Manage and all Gramoxone treatments were providing no nutsedge control. Late-post Image and Manage treatments were providing fair and poor control, respectively.

In May 2000, the only treatments rated excellent in controlling purple nutsedge were the Roundup-Pro and Finale, suggesting that even late-post applications had significantly reduced tuber formation or viability. Roundup uniformly provided slightly greater control than Finale (Table 2).

Significance to the Industry: Purple nutsedge has had no effective control system to date, but it appears after one iteration of these treatments Roundup and Finale are the only treatments that provide long-term control through the reduction of subsequent infestations. Two applications of Image and Manage showed potential during the year in which the treatments were applied, though their effect did not carry over into the following year. It may be necessary to apply Image and Manage 3 times during the year to gain adequate control.

Table 1

Purple Nutsedge Control with Image and Manage

Treatment	Rate lb ai/A	Treatment Time	1WAT	4WAT	6WAT	8WAIT	10WAIT	19WAIT	5/16/2000
Image	0.38	EPO	2.25	9.23	9.10	7.13	5.13	0	0.88
	0.50	EPO	2.50	9.00	9.57	8.38	6.75	0.75	1.63
	0.38	EPO + 6				9.38	9.50	4.25	5.00
	0.50	EPO + 6				9.70	9.80	5.13	5.75
	0.50	LPO				3.63	7.38	7.63	0.25
Manage	0.031	EPO	2.50	3.25	2.50	1.50	0.50	0	0.75
	0.062	EPO	3.25	6.63	3.75	1.75	1.13	0.75	0.75
	0.031	EPO + 6				6.25	9.25	4.88	4.13
	0.062	EPO + 6				6.88	9.50	6.13	4.38
	0.062	LPO				3.88	8.50	4.25	0
LSD 0.05			0.67	1.25	1.28	1.28	1.05	1.28	1.66

Data for EPO and EPO + 6 are very similar, no need to have both on chart.

Table 2

Purple Nutsedge Control with Gramoxone Extra, Roundup and Finale

Treatment	Rate lb ai/A	Treatment Time	1WAT	4WAT	6WAT	8WAIT	10 WAIT	19WAIT	5/16/2000
Gramoxone	0.50	EPO + 6	9.00	2.25	2.25	7.25	4.38	0.75	0.63
	0.50	LPO				7.88	2.50	0.50	0
Roundup	1.00	EPO + 6	0	1.13	0.75				
	2.00	EPO + 6	0	1.75	1.50	9.50	9.70	9.80	9.48
	2.00	LPO				7.63	9.80	9.80	9.77
Finale	1.00	EPO + 6	5.50	0.63	1.25				
	1.50	EPO + 6	4.50	1.25	0.75	9.90	9.80	9.80	9.13
	1.50	LPO				9.90	9.70	9.48	7.88
LSD 0.05			0.67	1.25	1.28	1.28	1.05	1.28	1.66

Purple Nutsedge Control in Liriope and Daylily as Affected by Adjuvant Selection

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Index Words: Halosulfuron, Surfactant, Sulfonylurea Herbicide, Herbicide Tolerance, *Cyperus rotundus* L.

Nature of Work: Purple nutsedge is among the most common weeds found in southern nursery crops (Dowler, 1994) and, along with yellow nutsedge, is considered to be one of the most difficult weeds to control in container-grown plant materials (Gilliam et al., 1990). It is limited in distribution to the warmer parts of the southern United States where the average mid-winter air temperatures seldom drop below –2.2°C (28°F) (Bendixen and Nandihalli, 1987). Purple nutsedge produces viable seed (nutlets) from mid to late-summer which germinate early in the following spring. Within a few weeks of seedling emergence tubers begin to form and continue to produce additional tubers in “chains” along the rhizome until frost (Hauser, 1962; Stoller & Sweet, 1987). The principle method for spread and reproduction, therefore, is by underground rhizomes and tubers. Most tubers produced in a season sprout the following spring (Barry et al., 1992). A single parental tuber is capable of producing up to 99 basal bulbs and tubers within 90 days (Rao, 1968). In nurseries, nutsedge may be spread by division of stock plants; seed may be dispersed as stock is moved around the nursery; or may be introduced in poorly maintained and contaminated bark media, where composting has not been allowed to reach temperatures above 160°F, which will kill the tubers (Wilson, 1997).

Regular irrigation levels and warmer than ambient temperatures which are associated with gravel or landscape fabric substrates of nurseries allow purple nutsedge to compete effectively with container-grown crops. Thorough eradication of established nutsedge is accomplished only by costly manual labor. To address this, Manage® (halosulfuron) was developed for nutsedge control in turfgrass and agronomic crops and shows promise for nutsedge control in nursery crops (Bachman et al., 1995; Hurt and Vencill, 1993; Vencill et al., 1995; McDaniel et al., 1999). Halosulfuron is actively translocated to the underground vascular system of nutsedge rhizomes (Khan & Molin, 1997). Translocation is imperative because the nutsedge vascular system may stay intact long after aerial shoots have been removed (Hauser, 1962). Wills and Briscoe (1970) reported that an herbicide applied to the leaf surface must penetrate the waxy upper surface, or move through the stomata or the thinly cutinized cells of the lower leaf surface, in order to reach the vascular system. Used with a postemergence herbicide like Manage®, adjuvant type and concentration can influence retention of spray solutions, enhance entry into foliage and increase the herbicide's efficacy on target weed species. Adjuvants can also elicit phytotoxicity among desirable ornamental species. These concerns prompted a comparison of non-ionic, paraffin-based crop oil, soybean oil, sunflower oil, and organosilicone surfactants in combination with Manage®, which was applied at reduced rates. Experimental criteria included: a) the efficiency of purple nutsedge control and b) an evaluation of growth and phytotoxicity to two container-grown ornamental species.

Green Liriope (*Liriope muscari* (Decne.) Bailey 'Big Blue') 3.8 liter (4 quart, #1) containers and daylily (*Hemerocallis* L. 'Stella d'Oro') were potted in 11.4 liter (3 gallon) containers filled with soilless media. Media consisted of ground pine bark:ProMix BX® peat-based growing mix (4:1 v/v) amended with 4.2 kg/m^3 (7.0 lb/yd^3) of dolomitic lime, 1.2 kg/m^3 (2 lb/yd^3) of triple superphosphate 0N-20.2P-0K (0-46-0), 1.4 kg/m^3 (2.3 lb/yd^3) of gypsum, and 0.9 kg/m^3 (1.5 lb/yd^3) of Micromax®. Purple nutsedge tubers (5 sprouted tubers/container) were transplanted to each plant species in May, 1999. Following nutsedge inoculation, liriope were topdressed with Osmocote® 14N-6.2P-11.6K (14-14-14) at 5 g (0.18 oz)/container and daylily at 20g (0.72 oz)/container. An initial supplement fertilization of Peters® General Purpose soluble fertilizer 20N-8.8P-16.6K (20-20-20) at 100 mg/liter N (100 ppm) was made weekly for 3 weeks to establish nutsedge.

Herbicide treatments consisted of Manage® herbicide (halosulfuron) at 18 g ai/ha (0.26 oz/A) or 27 g ai/ha (0.38 oz/A), one-half (1/2x) and three-fourths (3/4x) of the lowest rate (31 g ai/ha (0.5 oz/A)) recommended for spot-treatment control of nutsedge. Herbicides were combined with the following surfactants: 0.25% (v/v) X-77® (non-ionic), 1.0% (v/v) Scoil® (methylated soybean seed oil), 1.0% (v/v) Sun-It II® (methylated sun-flower seed oil), 1.0% (v/v) Action "99" ® (non-ionic organosilicone), and 1.0% (v/v) Agri-Dex® (paraffin crop oil concentrate). The purple nutsedge control received only water, with neither herbicide nor surfactants. The herbicide control consisted of Manage® at each rate, independent of surfactants. Untreated plants received only water and were kept weed-free by hand cultivation. Treatments were applied when nutsedge was at a height of 10-15 cm (4-6 in), 5 weeks after tuber inoculation,. The herbicide/surfactant mixtures were applied to the plants from above with a CO_2-pressurized backpack sprayer delivering 230 liter/ha (25 gal/A) through an 8003 flat fan nozzle.

A growth index: (height + $width_1$ + $width_2$)/3, where $width_2$ was 90° to $width_1$, was calculated prior to treatment and again at 8 weeks after treatment (8WAT), with the final index reflecting new growth. Visual phytotoxicity evaluations were taken 4WAT and 8WAT using a scale of 0-100 (0 = no damage and 100 = dead plants). Purple nutsedge control was compared to untreated plants and evaluated on the basis of weed density on a scale of 0% (no control) to 100% (complete control) at 4 and 8WAT. Treatments were arranged in a completely randomized design with 9 single-container replications within a crop species.

Results and Discussion: Seed-oil-based crop oils (Scoil® and Sun-It II®), and organosilicone (Action "99"®) adjuvants combined with Manage® provided greater control of purple nutsedge 8WAT than the non-ionic (X-77®) or paraffin-based crop oil (Agri-Dex®) adjuvants (Fig. 1). Lack of herbicide translocation to purple nutsedge rhizomes and tubers was apparent from the considerable regrowth of plantlets 8WAT, which occurred in Agri-Dex® treatments and for both Manage® rates applied without additional surfactant. Agri-Dex® and Manage® at both rates caused immediate chlorosis of purple nutsedge, followed by foliar death by 4WAT. However, 3/4x Manage® and Agri-Dex® provided only 58% purple nutsedge control 8WAT. Moderate control of nutsedge resulted from 1/2x Manage® and X-77®. Still, 3/4x Manage® and X-77® provided only 70% control. Use of the 3/4x rate of Manage® in combination with either Scoil®, Sun-It II®, or Agri-Dex® adjuvants provided no additional increases in purple nutsedge control. Purple nutsedge control was improved only slightly when X-77® or Action "99"® were mixed with 3/4x Manage®.

Manage at the 1/2x rate reduced growth of liriope and daylily when combined with X-77®, Action "99"® and Agri-Dex® adjuvants (Fig. 2). At this rate, neither Scoil® nor Sun-It II® reduced the growth of these species. At the 3/4x rate, Manage® reduced growth of liriope and daylily, regardless of surfactant used. Daylily was severely stunted by the higher Manage® rate combined with either Action "99"® or Agri-Dex®, and caused the death of some plants in each of these treatments by 4WAT. Manage® caused initial foliar chlorosis to both species, regardless of rate or adjuvant used (Fig. 3). Plants treated with Manage® combined with X-77®, Scoil®, or Sun-It II® adjuvants had recovered significantly by 8WAT, although daylily still displayed some foliage discoloration. Manage® and Action "99"® caused early foliar chlorosis to liriope and necrosis of treated daylily foliage. By 8WAT, new growth of liriope exhibited less chlorosis. Agri-Dex® combined with Manage® caused immediate foliar chlorosis on both species, with foliage becoming severely necrotic by 4WAT.

Significance to Industry: Manage at 1/2 the standard rate mixed with Scoil® and Sun-It II®, which are seed-oil-based crop oils, provided the most effective control of purple nutsedge in containerized liriope and daylily without significantly reducing their growth. The non-ionic surfactant X-77®, which represents the type of adjuvant recommended for use with Manage®, provided only moderate purple nutsedge control. Both Action "99"®, an organosilicone adjuvant, and the paraffin-based crop oil, Agri-Dex, caused severe phytotoxicity to liriope and killed some daylilies.

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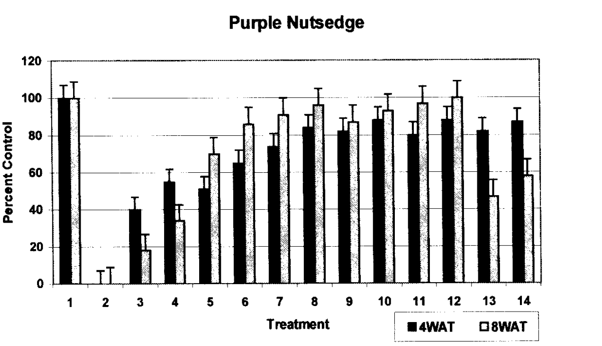


Treatments
1. Handweeded Control
2. Nutsedge Control
3. ½xM Control
4. ¾xM Control
5. ½xM+X-77
6. ¾xM+X-77
7. ½xM+Scoil
8. ¾xM+Scoil
9. ½xM+Action "99"
10. ¾xM+Action "99"
11. ½xM+Sun-It II
12. ¾xM+Sun-It II
13. ½xM+Agri-Dex
14. ¾xM+Agri-Dex

Figure 1. Influence of adjuvants and Manage herbicide on purple nutsedge control.

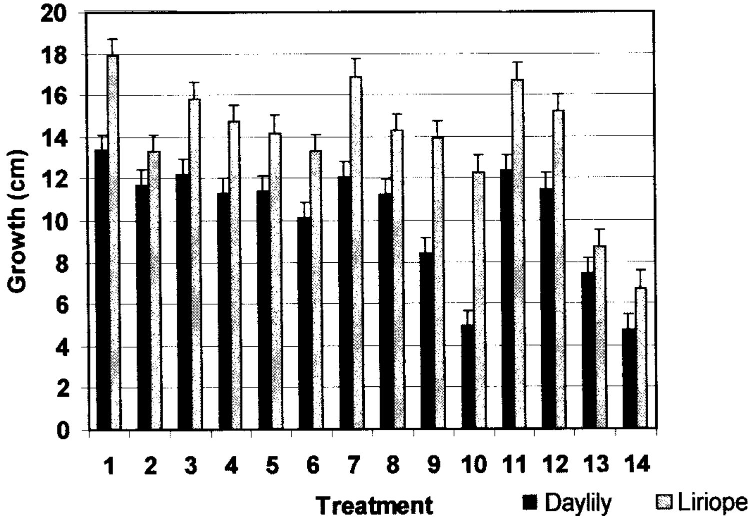
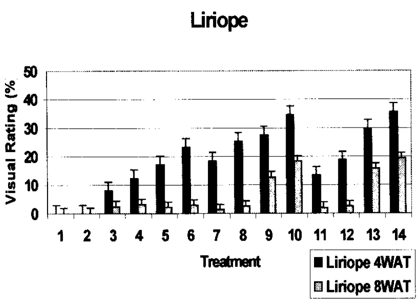


Figure 2: Influence of adjuvants and Manage herbicide on growth of 'Big Blue' liriope and 'Stella d' Oro' daylily.



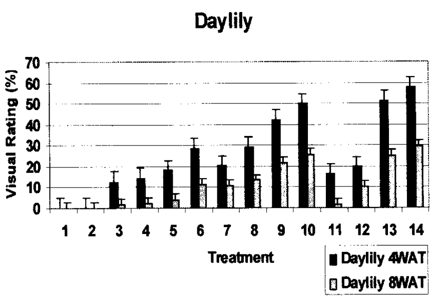


Figure 3: Visual evaluation of phototoxicity by adjuvants and Manage herbicide to 'Big Blue' liriope (left) and 'Stella d' Oro' daylily (right).

Posternergence Spurge Control in Container-Grown Liriope

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Index words: weed size, container-grown crops, Euphorbia supina

Nature of Work: Prostrate spurge *(Euphorbia supina) is* a serious weed problem in container nurseries. It propagates by seed and can grow to maturity in 4 to 8 weeks. Previous research has shown effective preemergence herbicides for controlling prostrate spurge include Rout (oxyflorufen + oxadiazon), a combination of Ronstar (oxadiazon) and Surflan (oryzalin), or a combination of Ronstar and Barricade (prodiamine) (3). However, a survey of container nurseries in Alabama reported prostrate spurge as being the weed most often uncontrolled by preemergence herbicides (2). Liriope (Liriope *muscari* 'Big Blue' and 'Variegata') is a herbaceous perennial in the lily family *(Liliaceae).* Used for groundcover, edging, and massing, it has become popular in urban landscapes and a major crop in nursery production. Nurseries in Alabama have reported difficulty in controlling prostrate spurge in liriope production. This may partly be due to reluctance by nurserymen to apply herbicides immediately after division in fear they will cause root inhibition. Cost effective, postemergence weed control alternatives to hand weeding spurge from container-grown liriope would be a useful tool for nurserymen. Therefore, an experiment was conducted to evaluate several herbicides for postemergence spurge control in container-grown liriope.

The first test was conducted at the Mobile Experiment Station in Mobile, AL. Container-grown 'Big Blue' liriope were over seeded with spurge seed on September 16, 1997. Containers were treated with the following herbicides on October 1, 1997, when the spurge were 0.4 to 0.8 in. wide: Manage at 0.0075, 0.015, and 0.03 lb ai/A; Image at 0.0625, 0.125, and 0.25 lb ai/A; Trimec Southern (MCPP + 2,4-D + dicamba) at 1.0, 2.0, and 4.0 pt./A; and Roundup (glyphosate) which was prepared as either a 0.125%, 0.25%, or 0.5% solution and applied at 20 gal/A which resulted in rates of 0.1, 0.2, or 0.4 lb ai/A. Herbicides were applied with a CO_2 sprayer at 20 gal/A. All treatments consisted of 10 single plant replicates in a randomized complete block design. Data collected included percent spurge control 9 and 20 DAT, spurge shoot fresh weight (SFW) 30 DAT, and a bib count of liriope the following spring (May, 1998) on 'Variegata' liriope. Single bibs of 'Variegata' in 4 in. pots were treated on July 28, 2000 with Finale at 0.25, 0.5, or 1.0 lb ai/A, and Roundup which was prepared as either a 0. 25%, 0.5%, or 1.0% solution and applied at 40 gal/A which resulted in rates of 0.4, 0.8, or 1.6 lb ai/A. Herbicides were applied with a $C0_2$ sprayer. At the time of treatment, ‘Variegata’ were 6.7 to 7.9 in. tall (foliage fully extended) and prostrate spurge were 10 to 13.8 in long; plants were mature and bearing seed. Data collected included percent spurge control 7 and 21 DAT, spurge shoot fresh weight (SFW) 21 DAT, a injury rating from I to 5 (1 = no injury and 5 = plant death) on ‘Variegata’ 7, 14, 21, and 28 DAT. All treatments consisted of 8 single plant replicates in a completely randomized design.

Results and Discussion: In the first experiment Manage and Image did not provide adequate spurge control (Table 1). At 9 DAT, the high rate of Trimec Southern appeared to control spurge, however, spurge began to recover from this injury by 20 DAT. Control from Roundup was initially poor, but by 20 DAT the high rate used (0.4 lb ai/A) provided 96% control. At 30 DAT, spurge SFW from Roundup rates of 0.2 and 0.4 lb ai/A were 0.0 g compared to 8.6 g for non-treated controls. Only the high rate of Trimec Southern caused injury to ‘Big Blue’ (data not shown) and all plants had similar bib numbers the following spring compared to non-treated controls.

In the second experiment at 7 DAT, Finale at 0.5 and 1.0 lb ai/A provided excellent postemergence spurge control (94 and 98%, respectively) while Roundup provided poor control (Table 2). By 21 DAT, the high rates used of Finale and Roundup (1.0 and 1.6 lb aVA) provided 100% and 93% control respectively, however, it appeared spurge began to recover from the low and middle rates used of both herbicides. Shoot fresh weight data followed a trend similar to spurge control data at 21 DAT. Contrary to the first study, Roundup at 0.4 lb ai/A provided poor control, this could be due to larger and more mature spurge used in the second experiment. Other studies have shown that larger weeds are typically more difficult to control than smaller ones (1). By 28 DAT, no injury was observed on ‘Variegata’.

Significance to Industry: These preliminary data indicate that Roundup at 1.6 lb ai/A, and Finale at the labeled rate of 1.0 lb ai/A provide excellent postemergence control of mature spurge causing no injury to ‘Big Blue’ or ‘Variegata,’ however, long-term effects from these herbicides are still being evaluated. Also it appears smaller spurge are effectively controlled by lower rates (0.4 lb ai/A) of Roundup. This may provide nurserymen with a cost-effective alternative to hand-weeding when their preemergence weed control programs fail.

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Table 1. Effect of selected herbicides on spurge control and 'Big Blue' bib numbers.

Herbicide	Rate (lb ai/A)	Spurge control (%) 9 DAT[z]	Spurge control (%) 20 DAT	Spurge fresh wt (g)	'Big Blue' bib number[y]
Manage	0.0075	0	20	6.5	11.4
Manage	0.0150	0	0	6.8	11.0
Manage	0.0300	0	0	9.8	9.7
Significance		NS[x]	NS	NS	NS
Image	0.0625	0	10	9.0	11.5
Image	0.2150	0	10	6.1	10.3
Image	0.2500	0	0	6.5	10.6
Significance		NS	NS	NS	NS
Trimec Southern	0.57	0	20	4.5	10.3
Trimec Southern	1.14	0	10	3.1	10.6
Trimec Southern	2.28	85	62	1.4	7.7
Significance		L***Q***	L***Q*	NS	NS
Roundup (0.125%)	0.1	0	24	3.9	9.3
Roundup (0.25%)	0.2	15	83	0.0	11.9
Roundup (0.5%)	0.4	45	96	0.0	11.6
Significance		L***	Q***	NS	NS
Control		0	0	8.6	11.6

z Days after treatment.
y Data taken the following spring (1998).
x NS, L, or Q represent no significant, linear, or quadratic responses within a herbicide.
*, **, and *** represents significance at alpha = 0.05, 0.01, and 0.001.

Table 2. Effect of Finale and Roundup on spurge control.

Herbicide	Rate (lb ai/A)	Spurge control (%) 7 DAT	21 DAT	Spurge fresh weight (g)
Finale	0.25	73	47	2.3
Finale	0.50	94	87	0.3
Finale	1.00	98	100	0.0
		L***Q*	L***Q***	L***Q***
Roundup (0.25%)	0.4	15	11	4.8
Roundup (0.5%)	0.8	20	16	3.7
Roundup (1.0%)	1.6	56	93	0.1
		L***Q*	L***Q***	L***
Control		2	5.0	3.6

Effects of Plateau on Wildflower Plantings

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Nature of Work: Plateau 2AS (imazapic; Cyanamid) is an imidazolinone herbicide to which many native wildflowers are tolerant (3, 5, 6). Many broadleaf weeds, grasses, and sedges are controlled or suppressed. It can be broadcast pre- or postemergence either at the time of seeding or to young seedlings; however, tolerance to Plateau can vary considerably with wildflower seed source, genotype, or variety according to cautionary statements on the label (2). Variation in tolerance was noted in a recent study in which there was a seed source (ecotype) by Plateau treatment interaction for some wildflower species when phytotoxicity was evaluated (1). The objective of the studies conducted in 1999 and 2000 was to evaluate the effect of Plateau on established plantings of Florida ecotypes of native wildflowers.

On May 12, 1999, Plateau 2AS at 0.094 or 0.188 lb ai/A (0.105 or 0.21 kg ai/ha) was applied over-the-top to field-grown blanketflower [*Gaillardia pulchella* Foug.] (seed sown in February 1998) or lanceleaf coreopsis [*Coreopsis lanceolata* L.] (seed sown in February 1998) that were flowering. Latron AG-98 (nonionic spreader-activator; Rohm & Haas) at 0.25% (v/v) was included in the sprays. Treatments were applied with an XR 110-04 VP nozzle using a compressed air backpack sprayer calibrated to deliver 50 gallons per acre (468 liters/ha). Plots were 4 ft X 8 ft (1.2 X 2.4 m), with four (coreopsis) or five (blanketflower) replications per treatment. Nontreated plots and plots treated with Latron AG-98 alone were included. Phytotoxicity was rated on a scale of 0=no injury to 100=total crop death (increments of 10) at 1, 2, 4, and 8 weeks after treatment (WAT); however only results at 8 WAT are presented.

In the 2000 study, lower rates were evaluated because of the injury observed in 1999 (see Results and Discussion). Broadcast treatments of Plateau at 0.031, 0.062, or 0.094 lb ai/A (0.035, 0.069, or .105 kg ai/ha) applied as a single or split application (about 4 weeks apart) were evaluated on dye flower [*Coreopsis basalis* (A. Dietr.) S.F. Blake] (seed sown December 1999) and black-eyed susan [*Rudbeckia hirta* L.] (seed sown February 1999). On March 15, 2000, Plateau at 0.016, 0.031, 0.047, 0.062, or 0.094 lb ai/A (0.018, 0.035, 0.052, 0.069, or 0.105 kg ai/ha) (plus the nonionic surfactant Latron B-1956 at 0.25% v/v) were applied to black-eyed susan and dye flower that were about 2 to 4 inches (5.1 to 10.2 cm) tall and not flowering. Treatments were applied with a tractor-mounted side-boom fitted with five 8004 flat fan nozzles calibrated to deliver 43 gallons per acre (402 liters/ha). All plots treated with 0.016 and 0.047 lb ai/A (0.018 and 0.052 kg ai/ha), and half the plots treated with 0.031 lb ai/A (0.035 kg ai/A) were retreated on April 12, 2000 in the same manner as before. A nontreated and a hand weeded treatment were also included. There were eight replications (plots) per treatment per species. Each plot was 5 ft X 9 ft (1.5 m X 2.7 m). Phytotoxicity was evaluated at 2, 4, and 8 weeks after the first application using the same rating scale as in 1999. Percent weed coverage was also recorded. A modified Daubenmire scale (4) was used to determine percent weed coverage for two 2-ft X 1-ft (0.6-m X 0.3-m) quadrants per plot at 0, 4, and 8 weeks after the first application. Phytotoxicity and weed coverage data were transformed by arcsine square root before analysis but retransformed means are presented. Means were separated using Duncan's Multiple Range Test. Only results for 8 weeks after the first application are presented.

Results and Discussion: Lanceleaf coreopsis. Imazapic delayed reflowering for at least 4 weeks but by 8 weeks all plants had rebloomed (Table 1). No foliar injury was observed.

Blanketflower. Plateau caused severe rate-dependent injury, with 0.188 lb ai/A (0.21 kg ai/ha) causing near total destruction of treated plots (Table 1). Typical injury symptoms were chlorosis, necrosis, and death of the apical meristem.

Dye flower. All herbicide treatments reduced weed coverage yet caused significant injury (Table 2); however, phytotoxicity values of 20 or less were considered acceptable. Therefore, only the single application of 0.031 lb ai/A (0.035 kg ai/A) resulted in acceptable injury while it reduced weed coverage as effectively as any other treatment. All three split applications caused significantly more damage than a single application (results not shown). Typical phytotoxicity symptoms were stunting, delayed flowering, and slight stand loss.

Black-eyed susan. Plateau at 0.031 lb ai/A (0.035 kg ai/A) was the only herbicide treatment that did not cause significant injury (Table 2); however, it did not reduce weed coverage either. All other herbicide treatments resulted in less weed coverage. The planting had a heavy stand of purple cudweed [*Gnaphalium purpureum* L.] and annual trampweed [*Facelis retusa* (Lam.) Sch. Bip.] that was not effectively controlled by Plateau. Applying Plateau as a single or split application had no effect on phytotoxicity or weed coverage (results not shown). Typical phytotoxicity symptoms were purplish foliage, death of the apical meristem, slight chlorosis, and stunting.

Significance to Industry: Application of Plateau to established stands of Florida ecotypes of lanceleaf coreopsis, blanketflower, dye flower, or black-eyed susan caused some degree of injury and/or delayed flowering. Those desiring to use Plateau 2 AS to reduce weed competition in established plantings should consider using 0.016 to 0.031 lb ai/A (0.018 or 0.035 kg ai/A), which is equivalent to 1 to 2 oz product per acre.

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Disclaimer: Trade names and companies are mentioned with the understanding that neither endorsement is intended nor is discrimination implied for similar products or companies not mentioned.

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Table 1. Effects of Plateau on established plantings of lanceleaf coreopsis [*Coreopsis lanceolata*] and blanketflower [*Gaillardia pulchella*] 8 weeks after a single application on May 12, 1999.

	Phytotoxicity[y]	
Plateau[z] (lb ai/A)	Lanceleaf coreopsis	Blanketflower
Nonweeded	0 a[x]	0 a
Latron AG-98 only[w]	0 a	0 a
0.094	0 a	70 b
0.188	0 a	90 c

[z] Latron AG-98 at 0.25% (v/v) in all Plateau sprays.
[y] Phytotoxicity rating scale - 0 (no injury) to 100 (complete crop destruction); increments of 10.
[x] Means with different letters within a column are significantly different at the 5% level as determined by Duncan's Multiple Range Test.
[w] Water plus Latron AG-98 at 0.25% (v/v).

Table 2. Effects of Plateau on established plantings of dye flower [*Coreopsis basalis*] and black-eyed susan [*Rudbeckia hirta*] 8 weeks after the initial application on March 15, 2000. Applications were 4 weeks apart.

		Dye flower		Black-eyed susan	
Plateau[z] (lb ai/A)	No. of applications	Phytotoxicity[y]	% Weed coverage	Phytotoxicity[y]	% Weed coverage
Nonweeded	—	4 f[x]	67 a	7 c	41 a
Weeded	—	3 f	1 c	10 c	4 c
0.031	1	18 e	20 b	24 bc	29 ab
0.016	2	46 cd	26 b	36 ab	20 bc
0.062	1	33 d	17 bc	45 a	21 b
0.031	2	60 b	17 bc	51 a	20 bc
0.094	1	52 bc	18 bc	39 ab	16 bc
0.047	2	77 a	19 b	45 a	16 bc

[z] Latron B-1956 at 0.25% (v/v) was included in all Plateau sprays.
[y] Phytotoxicity rating scale - 0 (no injury) to 100 (complete crop destruction); increments of 10.
[x] Means with different letters within columns are significantly different at the 5% level as determined by Duncan's Multiple Range Test.

Sicklepod (*Cassia obtusifolia*) Control In Field Nursery Stock

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Index Words: preemergence, postemergence, clopyralid, isoxaben, norflurazon, oxyfluorfen, simazine, oryzalin

Nature of the Work: In the southeastern United States field nursery crop production is expanding. As nurseries expand onto fields that were previously in row-crops such as soybeans, nurseries are increasingly encountering sicklepod (*Cassia obtusifolia*). Sicklepod is a summer annual broadleaf weed in the legume family (Fabaceae). Little information is available on the efficacy of nursery herbicides on this weed. Reeder et al. (1) observed acceptable control of sicklepod in field nursery stock with Predict (norflurazon) at 3 lb ai/A; however, this dose is higher than the labeled dosage. In that study Reeder also reported poor preemergence control of sicklepod with Pendulum (pendimethalin) at 3 lb ai/A, Surflan (oryzalin) at 3 lb ai/A and 1 lb ai/a of Gallery (isoxaben), Princep (simazine), or Goal (oxyfluorfen). In that study, Predict injured several species of ornamentals; therefore, it would be desirable to have safer alternatives for sicklepod control in field nursery stock. The maximum labeled rates for Pendulum, Surflan, Princep and Goal are greater than those tested by Reeder et al. and should be tested for efficacy on sicklepod. Additionally, other herbicides labeled for use in field nursery stock such as Barricade (prodiamine) and Ronstar (oxadiazon) need to be evaluated for activity on sicklepod. Nonselective herbicides such as Roundup-Pro (glyphosate) and Gramoxone (paraquat) are commonly used for postemergence control of sicklepod in field nurseries. Until recently no selective postemergence herbicide was labeled for sicklepod control. Lontrel (clopyralid), a selective postemergence herbicide with activity on sicklepod, has recently been labeled for use in field-grown woody ornamentals. In this experiment our objectives were to compare preemergence and selective postemergence herbicides at labeled rates for sicklepod control in field nursery crops.

The experiment was conducted at the Horticultural Crops Research Station in Castle Hayne, NC in a field with a history of heavy sicklepod infestations. The field was plowed and disked on April 26, 1999. Herbicides were applied in a randomized complete block design with four replicates, using a CO_2 pressurized sprayer calibrated to deliver 30 gallons per acre. Plot size was 6.7 ft wide by 20 ft long; a 2 ft. wide untreated strip separated each plot. Preemergence herbicides were applied on April 27, 1999. Preemergence herbicides included simazine, isoxaben, norflurazon, oryzalin, prodiamine, oxadiazon, oxyfluorfen, and imazaquin (See Table 1 for application rates). Seven inches of rain fell at that site within seven days after treatment, resulting in standing water on the field for at least one day. Postemergence herbicides, imazaquin, oxyfluorfen, and clopyralid (See Table 2 for doses), were applied on June 14, 1999 when the sicklepod was approximately 2 to 4 inches tall at had 4 to 6 leaves. Percent sicklepod control was visually evaluated periodically throughout the season.

Results and Discussion: Isoxaben, norflorazon, and imazaquin controlled sicklepod preemergently (Table 1). Oryzalin provided moderate control. Simazine, prodiamine, oxadiazon, and oxyfluorfen did not control sicklepod preemergently. Effective treatments provided control through mid-July (10 weeks after treatment) but by September, control had decreased in all preemergence treatments. Similarly, Reeder et al. (1) reported good control of sicklepod with norflurazon at 3 lb ai/A, and poor control with simazine and oxyfluorfen. However, our data for Gallery differ significantly from Reeder et al. (1) who reported poor control with the same rate of Gallery that provided excellent control in our test. It is possible that the heavy rains following application may have affected our results with isoxaben, and this treatment should be reevaluated under different environmental conditions.

Postemergence applications of imazaquin and oxyflurofen did not control sicklepod (Table 2). However, clopyralid controlled sicklepod 100% with very little regrowth by September.

Significance to the Industry: This experiment showed that sicklepod is not adequately controlled by many of the herbicides commonly used in field nursery crops – including Surflan, Princep, Barricade, Goal, Ronstar, and Image. Gallery controlled sicklepod in this test but not in previously reported studies. Predict controlled sicklepod preemergently in this test and previous reports. Lontrel provided 100% postemergence sicklepod control. Predict and Lontrel appear to be the most promising treatments for sicklepod control in field nursery stock, but both herbicides have the potential to injure some ornamentals. Nursery managers should carefully evaluate the safety of these herbicides on nursery crops before use.

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Table 1. Preemergence herbicide efficacy on sicklepod.

Herbicide	Active ingredient	(lb ai/A)	Percent Control 6 WAT*	Percent Control 10 WAT
Princep 4L	Simazine	2	22 de**	28 c
Gallery 75DF	isoxaben	0.75	99 a	92 ab
Gallery 75DF	isoxaben	1.0	99 a	95 a
Predict 80 DF	norflurazon	2.4	94 ab	86 ab
Surflan 4AS	oryzalin	4	58 c	70 b
Barricade 65DG	prodiamine	2	6 e	30 c
Goal 2E	oxyfluorfen	2	29 d	12 c
Ronstar 50WP	oxadiazon	1.5	30 d	37 c
Image 1.5L 2 appl. 6 wk apart	imazaquin	0.38	94 ab	86 ab

*WAT = weeks after treatment.

**Means within a column followed by the same letter are not statistically different at the 5% level.

Table 2. Postemergence herbicide efficacy on sicklepod.

			Percent Control	
Herbicide	Active ingredient	(lb ai/A)	3 WAT*	12 WAT
Image 1.5L	imazaquin	0.5	50 b**	36 b
Goal 2E (+ 0.25% nonionic surfactant)	oxyfluorfen	0.5	32 b	41 b
Lontrel 3L	clopyralid	0.25	100 a	95 a

*WAT = weeks after treatment.

**Means within a column followed by the same letter are not statistically different at the 5% level.

Susceptibility of Common Nursery Weeds to Preemergence Herbicides

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Index Words: Dose-response, *Cardamine hirsuta, Euphorbia maculata, Eclipta prostrata, Digitaria sanguinalis*

Nature of Work: As few as one weed per pot can significantly reduce the growth of container-grown nursery crops (1); consequently, preemergence herbicides are essential weed management tools in the container nursery industry. Despite the availability of numerous, effective herbicides, many weeds continue to escape control measures. The overall goal of this project is to develop a method to better predict when herbicide concentrations have dissipated below the effective concentration levels. Such methodology will both help reduce the need for hand weeding and improve environmental stewardship. Before such a method can be developed and implemented, the concentrations of herbicides that effectively reduce weed competition must be determined. These experiments were conducted to document the selectivity and effective doses of common nursery herbicides.

Two field experiments were conducted in 1999 to compare the efficacy of preemergence herbicides on common weeds of container nursery crops. The first experiment was conducted in Raleigh, NC. Four-quart pots were seeded with large crabgrass (*Digitaria sanguinalis*) and spotted spurge (*Euphorbia maculata*). Preemergence herbicide applications were made on 6/11/99; treatments are listed in Table 1. Weed control evaluations were made on 7/15/99 and 8/24/99. The second field experiment was conducted in Castle Hayne, NC. Three-gallon pots were seeded with large crabgrass, spotted spurge, hairy bittercress (*Cardamine hirsuta*), and eclipta (*Eclipta prostrata*). Preemergence herbicides were applied on 3/31/99 and 4/1/99. A second application of all treatments was made on 6/23/99; treatments are listed in Table 2. Weed control evaluations were made on 6/14/99 and 8/5/99. In both tests, the potting substrate was bark + sand (7:1 v/v). All granular applications were made using a shaker jar, while spray applications were made using a CO_2 pressurized backpack sprayer calibrated to deliver 30 gallons per acre. In both tests, the experimental design was a complete randomized block with four triple-pot replications.

A non-replicated preliminary herbicide dose-response experiment was conducted in the greenhouse in March 2000. Large crabgrass, spotted spurge, hairy bittercress, and eclipta were planted in 3 $^1/_2$ inch square pots in two different potting substrates; bark + sand (7:1 v/v) and sand alone. Gallery (isoxaben) was applied at 0.0156, 0.0313, 0.0625, 0.125, 0.25, 0.5, 1.0, and 2.0 lbs ai/A. Shoot fresh weights were measured between 4 and 6 weeks after treatment depending on the species.

Results and Discussion: In the first field experiment neither Treflan (trifluralin) nor Gallery alone controlled large crabgrass or spotted spurge (Table 1). Surflan (oryzalin), Pendulum (pendimethalin), OH2 (oxyfluorfen + pendimethalin), Snapshot TG (isoxaben + trifluralin) and Gallery + Surflan controlled both species at the first rating period (four weeks after treatment). By the second rating date (ten weeks after treatment), large crabgrass was controlled by either Surflan or Gallery + Surflan, while spurge was only controlled by the latter. By this date, control with all other treatments was less than 54 percent on both species. In the second field experiment, eclipta was not controlled with any treatment (Table 2). Gallery controlled bittercress, but not spurge, crabgrass, or eclipta. Surflan, OH2, and Snapshot TG each controlled both large crabgrass and spurge. OH II was highly effective on bittercress, while Snapshot TG and Gallery controlled it on the first rating date but not the second.

In the greenhouse experiment, 1 lb ai/A Gallery (the use-rate), in the bark:sand media, controlled eclipta 43%, large crabgrass 66%, and bittercress and spotted spurge 100% (Figure 1). When the rate was reduced to 0.5 lb ai/A ($^1/_2$ X), control dropped significantly; for spotted spurge by 54% and for large crabgrass by 56%. For eclipta and bittercress, when the rate is reduced to $^1/_4$ X rate, control drops by 31% and 35%, respectively. Similarly, in the two field experiments, Gallery control was weak on large crabgrass. Spurge control in the greenhouse was 100% at the use rate, but control dropped significantly when the rate was reduced. In the field, Gallery control of spurge was weak even at the use rate. Bittercress and eclipta control by Gallery were similar in the greenhouse and field container studies, with Gallery being quite effective on bittercress but not effective on eclipta. While the trial was preliminary, it was clear with each species that Gallery had greater activity in the sand-only media compared to the bark + sand (7:1 v/v) media. It was expected that the organic constituents in bark would bind Gallery, reducing the concentration available for uptake by the weeds. This differential control suggests that nurseries that using different potting substrates might observe different levels of weed control with the same herbicide.

Significance to Industry: Based on the container studies, effective large crabgrass and spurge can be obtained with Surflan, OH2, Snapshot, Pendulum. Bittercress control can be obtained with OH2, Snapshot, and Gallery. Effective eclipta control was not obtained with the treatments tested. These experiments have also helped identify the effective dose ranges for various herbicides on four common container nursery weeds. From these and follow-up tests, aqueous concentrations of herbicides required for residual weed control can be estimated. This information will then be used to develop bioassay or immunoassay systems for growers to predict when herbicide levels have dissipated to ineffective levels.

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Table 1. Preemergence herbicide efficacy on large crabgrass and spurge, Raleigh, NC.

		Crabgrass Control (%)		Spurge Control (%)	
Herbicide	Rate (lbs ai/A)	7/15/99	8/24/99	7/15/99	8/24/99
Surflan 4 AS	4	100a	90a	99a	53b
Treflan 5 G	4	68b	18bc	38b	0d
Pendulum 2 G	4	80ab	30bc	100a	25c
OH II 3 G	3	87ab	28bc	90a	8cd
Snapshot 2.5 TG	5	90ab	43b	94a	0d
Gallery 75 DF	1	31c	5c	57b	5d
Gallery + Surflan	1 + 4	100a	100a	100a	87a

Table 2. Preemergence herbicide efficacy on common nursery weeds, Castle Hayne, NC.

Herbicide	Rate lbs ai/A	Crabgrass Control (%)		Spurge Control (%)		Eclipta Control (%)		Bittercress Control (%	
		6/14/99	8/5/99	6/14/99	8/5/99	6/14/99	8/5/99	6/14/99	8/5/99
Surflan 4 AS	4	99a	100a	98a	75a	10a	55a	75b	70b
OH II 3 G	3	93a	100a	100a	83a	38bc	33a	98a	100a
Snapshot 2.5 TG	5	86a	93a	88a	78a	53b	35a	90ab	75b
Gallery 75 DF	1	20b	0b	45b	8b	23bc	43a	94a	73b

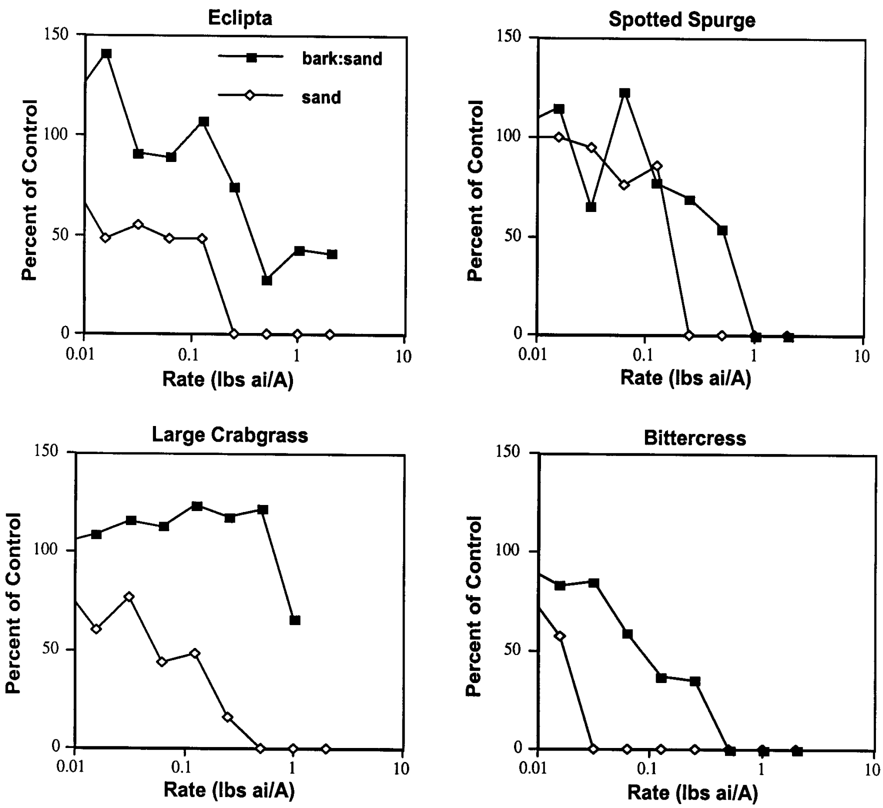

Figure 1. Dose-response of Gallery on fresh weights, expressed as a percent of the untreated controls, of four common container nursery weeds in bark + sand potting substrate (7:1 v/v) (solid squares) and sand alone (open diamonds) potting substrates plotted on a logarithmic x-axis.

Constructed Wetlands Using Ornamental Plants to Remediate Golf Course Pesticides

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Index words: Constructed wetlands, phytoremediation, metalaxyl, simazine.

Nature of Work: Extensive use of pesticides can lead to significant risk for non-target organisms, both onsite and in adjacent aquatic and terrestrial ecosystems. One promising method for reducing risk from pesticide use is phytoremediation by ornamental wetland plant species. The result may be low cost, effective remediation requiring low maintenance and inputs with the additional benefit of aesthetically pleasing constructed wetlands. Ongoing research in our laboratory has investigated the use of several ornamental wetland plant species to remediate pesticide waste in constructed wetlands. We examined the ability of artificial gravel-based, recirculating subsurface-flow wetlands constructed without plants, with ornamental wetland species, or with native wetland species to assimilate simazine and metalaxyl.

Wetland cells (6 ft wide, 24 ft long, and 3 ft deep with a 20 ft dividing wall at the center were constructed to allow recirculation throughout the cell. All cells were filled to 2.75 ft with crushed and washed 1/2-in. gravel. Six wetland cells were used: two cells were planted with *Typha latifolia* (Typha); two cells were planted with a mixture of *Acorus graminus, Canna hybrida, Pontedaria cordata* and *Myriophyllum aquaticum* (Mix); and two cells were left without plants (Control). Cells were established with plants in August 1997. Four 1.5 ft deep PVC sampling wells were placed evenly throughout each cell. Simazine and metalaxyl were chosen as model pesticides due to their differing water solubility (1,2). Simazine is moderately water soluble (6.2 mg/L, 0.00075 oz/gal) and metalaxyl is highly water soluble (8.4 g/L, 1.02 oz/gal). To simulate the rinsing of sprayer equipment, formulated pesticide was dissolved in 150 gallons of tap water. Princep 4L was used for the simazine exposure and Subdue 2E for the metalaxyl exposure. Each wetland cell was emptied, refilled with the pesticide mixture, and then the water level was brought to within 2 inches of the gravel surface. Wetland cells were exposed to both simazine and metalaxyl at various times during 1998 and 1999. Pesticide concentrations were monitored throughout the exposure for up to 34 days; all samples were analyzed using SDI RaPID assays.

Pesticide half-lives were calculated by determining the appropriate dissipation model for each cell, and determining the time for half of the original pesticide to dissipate.

Results and Discussion: In 1998, the half-lives of simazine for the control, mix and typha cells (Figure 1) were 3.7, 8.6, and 5.9 d, respectively. The half-life for the control cell, without plants, was significantly lower ($P< 0.05$) than that of the mix cell, with ornamental plants. In 1999, the half-lives for simazine in the cells were 1.3, 1.7, and 1.5 d, respectively. No differences were found between the cell types in 1999; however, they were all significantly lower ($P< 0.05$) than the 1998 values.

In 1998, the half-lives of metalaxyl for the control, mix and typha cells (Figure 2) were 6.6, 12.8, and 4.5 d, respectively. The half-life for the mix cell was significantly higher ($P< 0.05$) than that of both the typha and control cells. In 1999, the half-lives for metalaxyl in the cells were 5.5, 4.6, and 4.6 d, respectively. No differences were found between the cell types or between the years 1998 and 1999, except the half-life of the mix cell was significantly lower ($P< 0.05$) in 1999 than in 1998.

Reasons for the rapid dissipation of simazine and metalaxyl are still unknown. Published values for the half-life of metalaxyl in water can range from 21.7 to 70.2 d, whereas the half-life for simazine in ponds is approximately 30 d (3, 4, 5). These values depend on several processes, such as aquatic photolysis, aerobic and anaerobic metabolism, etc. However, literature half-life values (Table 1) for these processes are much higher than those found in this study.

Significance to Industry: The results of this study suggest that gravel-based, subsurface-flow constructed wetlands using ornamental plants may be a valuable tool to reduce the concentration of pesticides in water. Half-life values were significantly reduced as compared to those in found in the environment.

There are several benefits to constructed wetlands designed to use ornamental wetland plants. Such constructed wetlands may add to the aesthetics of golf course landscape, while providing low cost, effective remediation requiring low maintenance and inputs. They may also promote the idea of using ornamental wetland plants to both the golf course industry and the public, thereby increasing the market of such species.

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Table 1. Various half-lives of metalaxyl and simazine found in the literature (3, 4).

Chemical Process	Metalaxyl	Simazine
Aquatic photolysis (natural light)	400 d	382 d
Aerobic aquatic metabolism*	55 d	71 d
Anaerobic aquatic metabolism*	30 d	ND

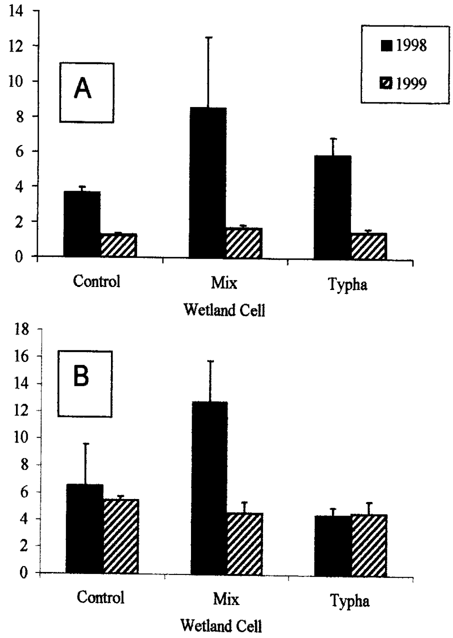

Figure 1. Half-lives of simazine (A) and metalaxyl (B) during the exposure of a gravel-based, subsurface-flow constructed wetlands planted with *Typha latifolia* (Typha); *Acorus graminus, Canna hybrida, Pontedaria cordata* and *Myriophyllum aquaticum* (Mix); or left without plants (Control).

Degradation of Gallery (Herbicide) in Simulated Gravel-Based Retention Basins

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Index Words: Gallery 75DF, isoxaben, herbicide degradation, irrigation runoff

Nature of Work: Pest control in containerized nursery crops is very important. Weeds compete with crops for water, space, and nutrients, and when present in containers can cause the plants to be undesirable to consumers. Weeds can also lead to a decrease in crop growth of 47-75% depending upon the crop, the weed, and the weed density (1). The use of herbicides to control weeds is often the most cost-effective method, as many non-chemical control measures are inefficient. Hand pulling weeds, for example, is costly, labor intensive, and removes soil from containers. Fungicides and insecticides are also very important in controlling plant damage caused by pathogens and insects.

Pesticides are used by most growers of container-grown crops. A major concern, however, is that pesticides often leave the sites of application in nursery runoff water. Nursery personnel often apply granular herbicides to the crops three or more times per year. Depending upon container spacing, up to 80% of the granules may miss the target and end up on the surface of the bed (2). With the use of overhead irrigation, the herbicides can quickly be transported to containment ponds, surrounding soils, or even groundwater sources before degradation occurs (3,4). In one study, oryzalin (a component of Rout herbicide) was detected in runoff water at a concentration of 4 mg/l just 15 minutes after application at a nursery site (3). In another study, 20% of the applied isoxaben and 7% of the applied trifluralin (components of the herbicide Snapshot 2.5 TG) were detected in irrigation water over a 36 day period (4).

Increasingly strict regulations and concerns about the buildup of chemicals in the environment are forcing industries to find new methods of water decontamination. There are also concerns that herbicide residues in recycled nursery water could cause phytotoxicity problems in crops if levels get too high (3).

An experiment was designed to help reduce chemicals in nursery runoff water and to prevent some of the problems listed above. Setup of the experiment was as follows. Twelve 50-gallon Rubbermaid® troughs with dimensions 52x31x12 in. were placed in a field at Musser Fruit Research

Center in Seneca, SC. They were filled with granite pea gravel to a depth of 10 in. The tanks were filled with water to a level approximately 1 in. below the gravel surface, approximately 10 gallons in volume. Holes were drilled into one end of each tank about 9 in. from the bottom, and short sections of garden hose were connected to each tank to allow for drainage and water sampling. There were four treatments with three replications for each treatment. The treatments included different flow rates and the addition of aged pine bark in the amount of 1% of the total volume of gravel in each tank. Each tank received 37.8 mg of Gallery 75DF herbicide (isoxaben) suspended in either 2 or 3 1/3 gallons of water. Half of the tanks received two gallons of water per day, and half received three and one-third gallons of water per day. The different flow rates resulted in different retention times for total replacement of the water in each tank. Addition of 2 gallons per day yielded a retention time of 5 days, while addition of 3 1/3 gallons yielded a retention time of 3 days. Peters 20-20-20 plus micronutrients fertilizer was added at a concentration of 100 mg/L to all tanks prior to addition of the herbicide to stimulate microbial growth.

Water samples were collected immediately after applying the herbicide, and then every day for 14 days to monitor the rates of degradation. Runoff from the tanks was collected in five-gallon buckets and measured to record total volume. From the runoff, samples were collected in pint-sized silanized jars. Isoxaben was extracted by column chromatography and analyzed with high pressure liquid chromatography (HPLC) (5).

Results and Discussion: Isoxaben concentrations were determined by utilizing an analytical-grade isoxaben as an external standard (20 mg/L) with 92.5% purity (Dow AgroSciences, Indianapolis, IN). Once the isoxaben concentration was calculated in a sample, total isoxaben was determined by multiplying the concentration (mg/L) by the volume of runoff (L). The three replicates were averaged to obtain one number for each treatment per day. ANOVA tests for the treatments were conducted for each day using SAS software. Results are summarized in Figure 1 on the following page.

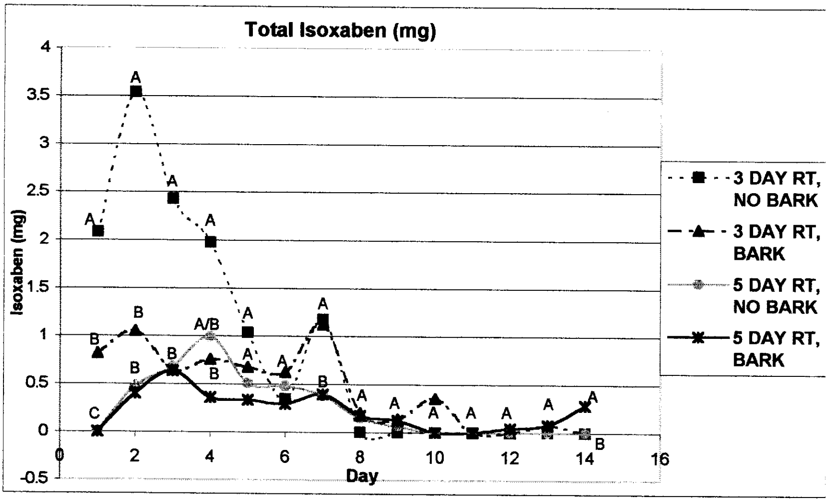

Figure 1 . Summary of total isoxaben in runoff from tanks over a 14-day period. Different letters on the same day indicates significant difference (a=0.05)

A few trends were observed among the four treatments. The treatment with a 3-day retention time and no bark had the highest amount of herbicide present in the runoff in terms of the amount present on a particular day and the total sum in the runoff during the 14-day period. This treatment also appeared to dissipate the isoxaben the most quickly. The treatment with the 3-day retention time plus bark showed a little more fluctuation in the amount of isoxaben in the runoff during the latter portion of the sampling period. There was greater persistence in this treatment compared to the treatments with no bark, and greater total isoxaben lost from the tanks compared to the 5-day retention time treatments. The treatment with the 5-day retention time and no bark showed a lower total amount of isoxaben in the runoff than the 3-day retention time treatments. In the final treatment with the 5-day retention time plus bark isoxaben appeared to dissipate by day 10, but then a low concentration appeared in the runoff on day 14. It is possible that isoxaben previously bound to bark was being released or it may be a degradation product.

Significance to Industry: The concepts associated with this experiment can be adapted for use in the container nursery industry. Large contained gravel areas at the ends of nursery beds could be built to capture runoff water and hold it for a period time, after which it could be routed to a containment pond. This would decrease or eliminate the need for expensive remediation treatments and would reduce the risk of developing phytotoxicity problems from pesticide buildup in recycled irrigation water.

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Reducing Off-site Movement of Herbicides in Runoff Water - To Spray or Not to Spray?

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Index Words: Container plant production, herbicide formulation, isoxaben, trifluralin.

Nature of Work: A decade ago, researchers at Clemson began investigating the fate of pesticides applied to container nurseries with an emphasis on movement and persistence in runoff water. Herbicides were detected in runoff water (short-term) (1,6) and collection ponds (long-term) (8), and research progressed to reducing herbicides transported from application site. Channelling runoff through grass waterways reduced herbicide quantities that moved in runoff water (2), cyclic irrigation resulted in less runoff equating to less herbicide transport (4), and implementation of integrated pest management strategies resulted in less herbicide applied without a reduction in container plant quality (3). Many herbicides are available in both granular and sprayable formulations. Despite higher costs, nursery managers prefer granular products due to ease of application and reduced risk to applicator. But, previous research indicated that large quantities of herbicide are released from the granular carrier over time possibly polluting off-site waters (1). The goal of this project was to compare the movement in runoff water of herbicides applied in granular and sprayable forms at a container nursery.

Isoxaben and trifluralin were spray applied as Gallery 75DF and Treflan 4EC, and broadcast applied, using granular Snapshot TG (2% trifluralin + 0.5 % isoxaben), to production beds at Gilbert's Nursery, Chesnee, SC. Each bed was 295' X 60', contained 3 gallon plants spaced at 18" X 24", and there were three replications of each treatment. The study was initiated in August1999 and repeated in Oct. 1999. Application rates were 1 lb a.i./A isoxaben and 4 lb a.i./A trifluralin. Irrigation after application was three cycles, 30 minutes duration each with a 90 minute rest period between cycles. Runoff was collected at weirs installed at the downward slope of the beds. Three samples were collected for each irrigation cycle on the day of application (DOA) and 1 and 2 days after application (DAA). Runoff samples were extracted onto C_{18} solid phase columns and analyzed by HPLC to determine herbicide concentration. Measurement of flow height at the weirs allowed determination of runoff volumes and quantification of amounts of herbicide transported.
Data analysis consisted of the General Linear Model Procedure means separation test (alpha = 0.05). A full factorial ANOVA indicated no significant interaction between treatment and repetition and the data were averaged over the two experiments.

Results and Discussion: Greatest isoxaben and trifluralin concentrations were detected on the DOA from the first runoff sample (Chart 1). Trifluralin concentrations detected were 0.6 ppm from the spray treatment and 0.2 ppm from the granular treatment. Trifluralin concentrations were higher from the spray treatment throughout the first irrigation cycle. On 1 and 2 DAA, concentrations were similar for most sample periods though greater from the granular formulation in one third of the samples. The highest isoxaben concentration detected was 2.2 ppm from both treatments in the first runoff sample. Isoxaben concentrations were similar between treatments on the DOA, but on 1 DAA, were higher for the granular application through all sampling times. On 2 DAA, concentrations were again greater from the granular treatment for three of nine samples.

Total trifluralin amounts found were <0.5% of the amount applied and were similar for both treatments (Table 1). Losses were greater from the spray treatment on the DOA , but greater from the granular application on 1 and 2 DAA. Total isoxaben amounts recovered were less from the spray treatment than from the granular application (Table 1). Similar treatment amounts were found on the DOA but larger amounts were detected in the granular treatment on 1 and 2 DAA. This is similar to results for metolachlor in which a larger amount of herbicide was detected from a broadcast spray than a broadcast granule on the day of application but smaller amounts were found on 1-16 days after application with total losses greater from the granule (7). However, results differ from research on dithiopyr and simazine in which larger total amounts in runoff were detected from spray applications (5, 7).

Amount of herbicide transported in runoff water is dependent upon the chemical nature of the compound, environmental conditions, application conditions, and duration, intensity and timing of subsequent rainfall or irrigation. Trifluralin has a higher vapor pressure than isoxaben and losses would be expected to be greater from a spray application particularly when environmental conditions favor volatilization. Air temperature was 89F (31°C) for the August application and 48F (17°C) in October, clearly conducive to volatility. Isoxaben is more water soluble than trifluralin and is also somewhat polar in nature (hydrophilic) resulting in the large amounts of isoxaben detected in runoff water. The granular formulation of isoxaben may have reduced losses due to photodegradation and volatility as compared to the sprayable formulation resulting in greater amounts transported in runoff water. Weed control was equally effective (100% at 60 DAA) from both treatments.

Significance to Industry: Sprayable formulations of herbicides are much less expensive than granular formulations but application requires more specialized equipment. Spray application may also reduce amounts of herbicides transported in runoff water. In this study, 20% less isoxaben was detected in runoff water from a sprayable formulation than a granular formulation. Trifluralin amounts were similar for both application techniques. If protection of the environment is of concern, the decision whether to spray or not to spray should be based on the chemical properties of the selected herbicide.

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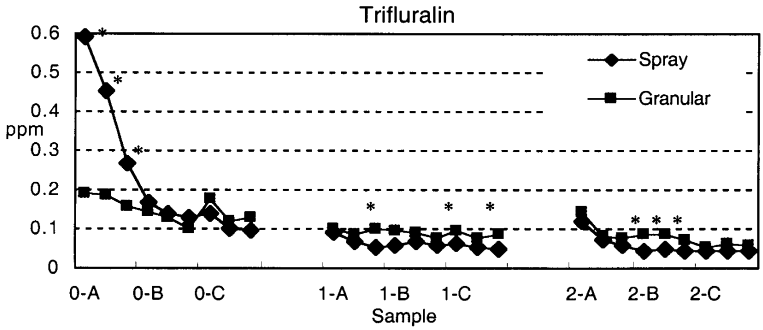
Chart 1. Concentrations (ppm) of isoxaben and trifluralin in runoff water from the spray and granular treatments for sampling times on day of application (0) and one (1) and two (2) days after application for irrigation cycles A, B and C. Means denoted with an asterisk (*) are different between treatments for sampling times.



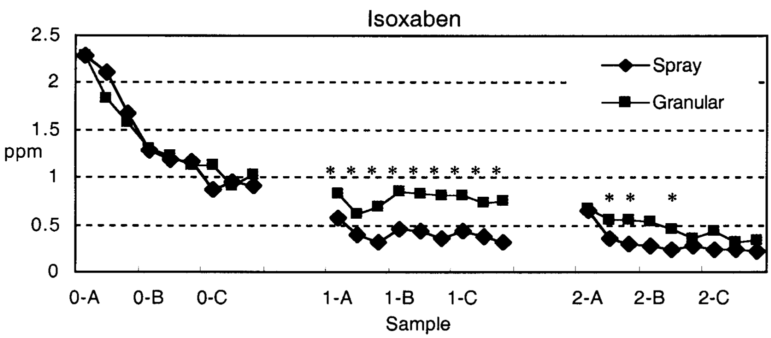


Table 1. Amounts recovered (grams and as a percent of applied amount) in runoff water of isoxaben and trifluralin from the spray and granular treatments on the day of application (DOA), 1 day after application (1DAA), two days after application (2DAA) and as a total for the study.

Treatment		Spray		Granular		LSD *P*=0.05
		g	% applied	g	% applied	g
Isoxaben	DOA	8.02	4.6	7.92	4.5	2.35
	1DAA	2.63	1.5	4.86	2.8	1.45
	2DAA	2.13	1.2	3.28	1.8	1.16
	Total	**12.78**	**7.3**	**16.06**	**9.1**	1.72
Trifluralin	DOA	2.24	0.3	1.63	0.2	0.42
	1DAA	0.76	0.1	1.14	0.2	0.26
	2DAA	0.59	0.1	0.83	0.1	0.25
	Total	**3.59**	**0.5**	**3.61**	**0.5**	0.60

Weed Scouting in Container Nurseries

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Index Words: weeds, scouting, pest management, containers

Nature of Work: The first step in any pest management program is to identify and quantify the pest problem. This is typically accomplished through scouting. Currently, there are no published methods for weed scouting in container nurseries. Therefore, our objective was to develop a weed scouting protocol as part of a best management practices program for container nurseries of eastern North Carolina. Program objectives were to (a) document incidence of important weed species and (b) develop guidelines for monitoring nursery weeds.

Existing scouting procedures from other crops were researched and evaluated for their applicability to nursery crops. Intensive and well regimented scouting protocols often used in mono-culture cropping are not well suited to nurseries, due to (a) the diversity of crops present, (b) the patchy distribution of weed populations and (c) the very low threshold for weed populations in nursery crops.

The goals and methods of weed scouting differ from those used for arthropods and diseases. When scouting for weeds, the main objective is to compile an inventory of weed species present and note their relative importance in the production system. Determining exact population levels is not required. The data collected during scouting will enable the nursery pest management operator to continually monitor the effectiveness of the weed management program and to make appropriate adjustments and changes as well as identifying key weed species that are escaping control.

In 1997 nine wholesale nurseries in eastern N.C. were scouted monthly. During these scouting events weed inventories were compiled identifying “important” weeds, these being weeds that are: (a) most prevalent; (b) perennial; (c) noxious; (d) new weeds and (e) weeds that are escaping control methods. Seasonal shifts in weed species composition were also recorded. In 1998, five local nurseries were scouted every other week and in 1999, scouting was expanded to include arthropods and diseases. In order to maintain such a high intensity scouting program, only two nurseries were scouted weekly from May to July. Site one was comprised of 60 acres divided into 70 blocks while site two was comprised of approximately 40 acres containing 90-100 blocks. Crops at both sites were mostly woody shrubs, some herbaceous material, and container trees. During these scouting events, methods adapted from those developed by Dr. Andrew Senesac in the Long Island Field Nursery Weed IPM Scouting Program (personal communication) as well as methods used for orchard weed management by Skroch *et al.* (3) were refined to better suit a container nursery system.

Nurseries were scouted using a uniform pattern of scouting, walking through the center of each block. In each scouting event, an inventory of weeds present was created, highlighting the "most important" weeds. We also looked for patterns to determine if the weeds were spread evenly throughout the block or found only in specific areas (clumps). These patterns could be indicative of non-uniform herbicide application or weed seed spread.

Results and Discussion: Over the duration of our scouting events, mid and late summer weed populations, in almost all of the nurseries, were dominated by prostrate/spotted spurge (*Euphorbia humistrata* or *E. maculata*), yellow woodsorrel (*Oxalis stricta*), hairy bittercress (*Cardamine hirsuta*), longstalked phyllanthus (*Phyllanthus tenellus*), eclipta (*Eclipta prostrata*) and common groundsel (*Senecio vulgaris*). Weeds of secondary importance were annual grasses, sedges, sowthistle (*Sonchus oleraceus*), fireweed (*Erechtites hieracifolia*), dogfennel (*Eupatorium capillifolium*) and mulberry weed (*Fatoua villosa*) a relatively new introduction to North Carolina. Using 1999 scouting data, the percentage of scouting blocks with importance values $\geq$ 2 were calculated for each weed species present at both sites one and two (Table 1). At site one the predominant weeds were common groundsel, eclipta, fireweed, spurge and yellow woodsorrel where as at site two the dominant weeds were common groundsel and hairy bittercress.

Weed scouting data, collected during the 1995 -1996 Western New York Nursery IPM program, show that late summer scouting adequately inventoried weeds present in nurseries, and emphasized the need for regular weed scouting in all nursery blocks (2). However, our observations indicate that in the southeastern United States multi-season scouting is necessary to adequately describe weed populations. Also, scouting events must occur before containers are hand weeded in order to properly estimate weed populations. Our weed scouting methods, adapted from those developed by Dr. Andrew Senesac, adequately described weed populations and was well suited to the container nursery industry. These conclusions are based on a scouting program that was limited to May through August. However, nursery crop IPM must be a year-round endeavor. Cool-season pests continue to emerge and impact crop growth and quality even in the winter months. Before nursery IPM scouting protocols can be implemented the system must be tested and adapted to the 12-month management calendar of container nurseries.

Significance to Industry: Weed scouting enables growers to improve weed management and crop quality through the proper timing of herbicide applications, use of the most appropriate herbicide and early detection of infestations and new weeds.

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Table 1. Influence of quinoclamine and meadowfoam seed meal on the percentage of substrate surface covered by *Marchantia*.

Product	Application Rate[1]	Days after application 15	30	60
Untreated		80 a[2]	85 a	100 a
Quinoclamine	low	0 b	4 b	18 cd
Quinoclamine	high	0 b	0 c	10 d
Meadowfoam	low	0 b	0 c	32 b
Meadowfoam	high	0 b	0 c	22 bc

[1] Quinoclamine rates were: 1.1 (low) or 2.2 oz ai per 1000 sq. ft.; meadowfoam seed meal rates were: ¼ cup per pot and ½ cup per pot.
[2] Means in columns followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Using Quinoclamine and Meadowfoam Seed Meal to Control Liverworts in Containers

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Index Words: *Marchantia polymorpha*, *Limnanthes alba*, Mogeton

Nature of Work: The predominent liverwort species commonly infesting container grown plants in the Pacific Northwest is *Marchantia polymorpha*. *Marchantia* spreads by airborne spores, splashed gemmae, and fragmentation to rapidly infest moist substrate 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).

Quinoclamine (trade name Mogeton) is manufactured in Japan (Agro Kanesho Co. Ltd., Tokyo), and commonly sold in Japan and Northern Europe for control of liverworts. This product does not currently have any registered uses in the United States or Canada. Emergency registrations are currently being pursued in Washington and Oregon.

Meadowfoam (*Limnanthes alba*) is a winter rotational crop grown by Oregon's grass seed producers for production of high-valued oil. Oregon State University has had a crop improvement program for meadowfoam since the 1960s. 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 suggest that meadowfoam seed meal is useful for control of selected plant pests. Meadowfoam seed meal is being developed by Natural Plant Products, a subsidiary of the Oregon Meadowfoam Growers.

The objective of this study was to determine if quinoclamine or meadowfoam seed meal were 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 September 1999. The substrate was amended with 8 lbs. dolomitic limestone per cubic yard of substrate (pH two weeks after potting was 6.6). 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 December, all pots were infested with *Marchantia*. Pots were treated with over-the-top sprays of quinoclamine at 1.1 or 2.2 oz. ai/1000 sq. ft,1/4 cup or 1/2 cup of meadowfoam seed meal applied as a substrate top-dress, 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: Both quinoclamine and meadowfoam seed meal provided excellent control of *Marchantia* at 15 and 30 days after treatment (Table 1), but good control was lost by 60 days after treatment. While the meadowfoam seed meal provided good residual control of *Marchantia* 30 days after treatment, quinoclamine provided slightly better control of *Marchantia* than meadowfoam seed meal 60 days after treatment. There was no phytotoxicity to *Rhododendron* from either control product at the rates tested. Meadowfoam seed meal had several qualities that were objectionable: 1) there was a tendancy for meadowfoam-treated pots to grow grass; 2) meadowfoam seed meal-treated pots had an objectionable odor; and 3) meadowfoam seed meal-treated pots tended to grow a whitish fungus on the surface of the treated pots. Meadowfoam seed meal is currently being pelleted with mint oil to kill contaminating grass seed and mask the odor. Pellets also provide a uniform product for application with mechanical spreaders.

Significance to Industry: As in northern Europe, quinoclamine appears to be a useful herbicide for controlling *Marchantia*, but registration with U.S. EPA is needed. Meadowfoam seed meal appears to be a useful material for *Marchantia* control, but registration with U.S. EPA is still needed. While quinoclamine provides a traditional herbicide spray for *Marchantia* control, meadowfoam seed meal provides a natural alternative product for *Marchantia* control.

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

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

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Index Words: Crape Myrtle, Gallery 75 DF, 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 weed control programs, which consisted of Regal 0-0 followed by RegalStar G, and Gallery 75DF tank mixed with Ronstar 50WP followed by Snapshot 2.5 TG (Table 1) (1, 2). These combinations were applied over a period of one year. 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, #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'. 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, 1999 and October 15, 1999: Regal 0-0, and Gallery 75 DF tank mixed with Ronstar 50 WP. On April 15, 1999, June 15, 1999, and August 16, 1999 the following herbicide combinations were applied: RegalStar G (following Regal O-O) and Snapshot 2.5 TG (following Gallery + Ronstar). The 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 25%; 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 GLM Procedure Waller-Duncan K-ratio t test was used for percent coverage and dry weed weight data.

Results and Discussion: Percent surface weed coverage varied among treatments (Table 2). The weed control program of Regal O-O followed by RegalStar G provided the best reduction of surface weed coverage. The combination of Regal O-O and RegalStar G provide a 62% decrease in surface coverage compared with the Gallery 75 DF, Ronstar 50 WP/ Snapshot 2.5 TG program. Both weed control programs had decreased surface weed coverage compared with the control program of no herbicides.

The weed control program of Regal O-O and RegalStar G reduced weed dry weight by 80% compared with the control, while Gallery 75+ Ronstar/ Snapshot 2.5 TG reduced weed dry weight by 44% when compared with the control (data not shown). There were no differences in weed dry weight between the two herbicide programs.

Weed species observed during this study 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 - February 15, 2000 because of the canopy created by the crape myrtles. This canopy provided bittercress with an ideal microclimate to allow it to survive throughout the summer growing season.

Significance to Industry: Based on the results of this study Regal O-O followed by RegalStar G during the growing season provided the best weed control system for controlling a variety of nursery weeds. By helping producers understand the many options they have for container weed control we can reduce labor cost 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	Percent surface weed coverage
Regal O-O RegalStar G	6c
Gallery 75 DF + Ronstar 50 WP Snapshot 2.5 TG	16b
Control	34a

Means with the same letter are not significantly different. $P \leq 0.0001$

Evaluation of Alternative Weed Control Options for Ornamentals Grown in Large Containers

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Nature of Work: Today, chemical weed control in nurseries is a standard practice, but concern exists among growers and environmentalists about potential threats from run-off water to nearby surface water. Granular herbicide formulations are normally used for container weed control (3, 4). Up to five herbicide applications per year are common (3). The greatest potential for surface water contamination from granular herbicide applications to container grown plants is from nontarget losses (herbicide falling between the pots) (2). Since most nurseries apply 0.5-0.7 inches of irrigation daily during the growing season (1), potential exists for movement of large quantities of herbicides into nearby surface water. Research has demonstrated the viability of non-chemical weed control methods (some allelopathic) for agronomic crops. Furthermore, alternative weed control methods in preliminary work with ornamental horticultural crops have exhibited some success. The potential for surface water contamination from nontarget herbicide losses coupled with the possibility of crop damage from high levels of herbicides in recycled run-off water makes the investigation of alternative weed control methods a timely issue. Therefore the objective of this study was to determine the relative ability of non-chemical methods to suppress weed growth compared to traditional chemical methods.

Uniform quart liners of two ornamental species, 'Natchez' crape myrtle (*Lagerstroemia indica x faurei)* and 'Nellie R. Stevens' holly (*Ilex x),* were planted in 57 liter containers on June 16 and October 13, 1999 respectively. Plants were grown on a gravel container pad using overhead irrigation. Growing medium was 100 % pine bark amended with 2.27 kg of dolomitic limestone and 0.68 kg of Micromax (the Scotts Co., Maryville, OH), per m^3. Twenty- five prostrate spurge *(Euphorbia supina* Raf.) seeds were seeded into each crape myrtle container and twenty-five bittercress (*Cardamine hirsuta* L.) seeds were seeded into each holly container after weed control treatment to ensure uniform weed pressure. Data collected included: weed number per container (data not shown), weed control rating (expressed based on % of container covered by weeds), and fresh weight of weeds in each container was collected at 90 day intervals. Treatments included: Rout 3G (2% oxyfluorfen + 1%

oryzalin)- 3.27 kg ai/ha as a broadcast application (ROUTB), Rout 3G- 3.27 kg ai/ha as an individual container application (ROUTC), recycled newspaper pellets (RCYL)as a 2.2 cm mulch (4.4 cm upon watering), recycled newspaper pellets coated with Spin-Out (copper hydroxide) as a 2.2 cm mulch (RCYL), Spin-Out-coated fabric disks fitted around the plant stem (DISKS), ground kenaf mulch 4.4 cm thick, waste tire crumbles mulch 4.4 cm thick (TIRES), wheat straw mulch, 4.4 cm thick, oat straw mulch, 4.4 cm thick, cereal rye straw mulch, 4.4cm thick, paper mill sludge as a 4.4 cm mulch (PMSL), handweeded control, and weedy control. The experiemntal design was completely random and consisted of 8 single replications.

Results and Discussion: Newspaper pellets without Spin-Out did not adequately control weed species in the crape myrtle experiment (%), however good control (> 90%) was seen in the holly experiment (Tables 1 and 2). Both experiments had adequate weed control with the Spin-Out coated RCYL (on average >75%). DISKS exhibited excellent weed control (> 90%) in both experiments, except for the holly experiment at 180 DAT. The TIRE treatment also had excellent control (> 90%) in both experiments compared with both the handweeded and conventional chemical treatments. The TIRE treatment exhibited better control in the holly experiment due to the size of the rubber particles. Those used in the crape myrtle experiment were smaller and tended to mix with the soil and facilitate weed growth, but the larger particles stayed on top and had excellent weed control. The agronomic mulches of kenaf, wheat, oats, and rye provided sporadic control in the early part of the experiment that declined as the experiment continued. PMSL did not provide acceptable control in either experiment. The only treatment that exhibited a decrease in height compared to the chemical weed control options was the kenaf mulch, however the caliper of the crape myrtles with the exception of RCYL with Spin-out, did not show any significant increases from the other treatments (Table 3). The holly experiment had no differences in growth (data not shown).

While growth was similar between most weed control treatments compared to the hand-weeded control, uncheaked weed growth can lead to reduced plant growth due to competition for nutrients and water. Additionally, sales may be reduced due to unsightliness of containers. The treatments that performed the best were the DISKS, RCYL with Spin-out, and TIRE with average weed control ratings of 94.4%, 91.8%, and 97.2% control, respectively compared to an average of 78.6% control with ROUTB. This control is very acceptable and could be recommended, especially considering that Rout 3G 3.27 kg ai/h showed less control.

Significance to Industry: Traditionally, nurseries were designed for ease of production, emphasizing aspects such as location of production beds, storage, and loading areas in relation to traffic flow, but little or not emphases was placed on potential for surface water contamination (5). However, legislation and environmental concerns dictate that existing nurseries or new nurseries be restricted to less desirable sites that limit the possibility of environmental pollution. The production of ornamental plants in larger container sizes (five gallons and up) represents an increasing market share and also represents a production segment where nontarget herbicide losses are high. Therefore, the increased value of crops grown in larger container sizes and higher nontarget herbicide losses for larger containers does allow for the consideration of alternative methods of weed control that must be applied on a per-container basis. These weed control alternatives will be adaptable to any region producing ornamental container plants. However, alternative weed control methods may be more critical for production areas in California, Texas, and Florida where strict regulations are already in place regarding nursery water issues such as recycling and potential surface water contamination. Therefore, consideration must also be given to environmental factors which may indicate that a program having a smaller cash net return may actually be the best management practice for long term profitability and sustainability. With the exception of PMSL and kenaf mulch alternative non-chemical weed control methods provided weed control comparable to chemical methods and superior to hand-weeded controls.

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Table 1. Influence of weed control methods on fresh weight

Treatment	Fresh Wt			
	90 DAT		180 DAT	
	crape	holly	crape	holly
	g/container			
Rout 3G 3.27kg ai/ha (brdcst)	75.3cd	40.7bcd	18.9d	65.5de
Rout 3G 3.27kg ai/ha (per/pot)	61.4cd	25.4bcd	16.2d	28.2de
Recycled Newspaper	221.4a	70.6ab	205.5a	62.4de
Recyld nwspr w/Spin-out	49.1cd	8.7bcd	53.1cd	0e
Fabric Disks w/ Spin-out	27.2d	1.9d	0.8d	124.5cdc
Kenaf	236.5a	57.9abc	47.2cd	53.6de
Shredded Tire	12.01d	7.8d	9.8d	0e
Wheat	75.22cd	24.8bcd	1.9d	169.4cd
Oat	95.87cd	66.5ab	28.9cd	143.8cde
Cereal Rye	63.63cd	63.8ab	15.5d	433.6a
Paper mill sludge	125.27bc	33.3bcd	158.4ab	238.7bc
Handweeded	211.59ab	104.4a	95.2bc	379.6ab
Weedy control	57.63cd	42.53bcd	45.3cd	170.9cd
LSD	91.6	49.5	71.2	155.8

Table 2. Influence of various weed control methods on weed ratings

Treatment	Weed Ratings											
	DAT											
	30		60		90		120		150		180	
	Crape	Holly	Crape	Holly	Crape	Holly	Crape	Holly	Crape	Holly	Crape	Holly
	%											
Rout 3G 3.27 kg ai/ha (brdcst)	25.0ab	6.8ab	70.6a	5.3bc	68.7a	8.7b	1.3c	5.5b	6.8ef	5.0bc	20.6def	33.1bcd
Rout 3G 3.27 kg ai/ha (per/pot)	13.2c	3.1bc	50.6abc	1.8cd	38.2bc	6.3b	1.3c	1.4bcd	5.3ef	0.6c	7.3ef	6.7efg
Recycled newspaper	2.7de	0c	23.1efg	0cd	84.4a	0.3b	17.5a	0.4cd	81.2a	0c	90.0a	0g
Recyld nwspr w/Spin-out	1.0e	0c	8.8fg	0.4cd	28.8cd	0.6b	6.3cb	0.7cd	21.2de	0.6c	25.6de	4.3fg
Fabric Disks w/spin-out	1.0e	3.2bc	2.5g	1.7cd	17.5cd	3.1b	1.25c	0d	2.2f	3.6 bc	2.2f	29.4cde
Kenaf	8.8cde	0c	46.8bcd	2.0cd	65.0ab	5.5b	4.4bc	1.4bcd	28.7d	3.1bc	41.3bcd	9.4defg
Shredded Tire	1.0e	0c	0.8g	1.8cd	6.2d	0b	5.0bc	0d	10.0ef	0c	8.8ef	0g
Wheat	2.6de	0c	25.8efg	2.0cd	28.2cd	11.1b	1.3c	3.1bcd	1.8f	10.6bc	4.4ef	29.2cde
Oat	10.8cd	0c	35.6cde	2.4cd	25.6cd	4.4b	1.9c	1.3cd	10.0ef	5.4bc	25.0de	38.4bc
Cereal Rye	3.7de	0c	23.8defg	2.6cd	24.4cd	10.0b	4.4bc	2.1bcd	9.6ef	14.4b	14.7ef	45.0bc
Paper mill sludge	3.6de	3.7abc	31.8cdef	2.8cd	80.5a	3.8b	10.6ab	1.6bcd	55.6b	13.1b	60.6bc	43.1bc
Handweeded	26.3a	6.3ab	61.8ab	7.2b	66.8a	47.5a	7.5bc	11.8a	47.5bc	40.6a	62.5b	88.4a
Weedy control	17.2bc	7.5a	38.2cde	12.8a	33.2cd	59.3a	10.1b	4.3bc	35.6cd	13.7b	40.0cd	57.2b
LSD	8.4	4.1	23.1	3.9	26.9	15.9	6.9	4.2	17.7	12.2	21.9	24.3

Table 3. Influence of various weed control methods on height and caliper of crape mrytles .

Treatment	Height and Caliper DAT Height		Caliper
	crape	g/container	crape
Rout 3G 3.27kg ai/ha (brdcst)	190 abc		22.05bc
Rout 3G 3.27kg ai/ha (per/pot)	188abc		20.63b
Recycled Newspaper	176 bc		21.74 bc
Recyld nwspr w/Spin-out	198 ab		25.56 a
Fabric Disks w/ Spin-out	178 abc		22.33 bc
Kenaf	144 d		23.51 ab
Shredded Tire	206 a		21.73
Wheat	178 abc		22.41 bc
Oat	187 abc		19.79 c
Cereal Rye	169 cd		20.31 c
Paper mill sludge	168 cd		21.05 bc
Handweeded	177 bc		21.35 bc
Weedy control	183 abc		20.29 c
LSD	28.5		3.12