Weed Control

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Granular Diuron: A Potential New Herbicide for Nursery Crops

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Index Words: Diuron, herbicide, weed control

Significance to Industry: This preliminary research indicates potential exist to develop a polymer coated diuron herbicide product. Additional research is needed to refine release rates, particle size, application rates, and plant tolerance and weed efficacy.

Nature of Work: One of the toughest battles that plant nurserymen face is the suppression of weeds in their containers. These weeds are not only aesthetically unappealing, but they can also interfere with a plant's ability to compete for water and nutrients.

Diuron is an older pre-emergence applied herbicide used in the cotton industry. In previous research, diuron has been shown to have potential for use in the nursery industry to provide postemergence control of oxalis (1, 2). The objective of this study was to evaluate two experimental granular formulations of Diuron for effectiveness of three weed species that are common in container nurseries: Spurge, Phyllanthus (chamberbitter), and Liverwort.

Three inch containers were filled with a 6:1 (v:v) pinebark:sand medium amended with standard nursery amendments, watered twice and treated on November 9, 2005.Three formulations: Direx 4L (spray), and two polymer coated, controlled release formulations of diuron: Diuron T-2 (granular slow-release – medium size), and Diuron T-3 (granular slow-release- mini-size) were tested at three different rates: 0.5 lb aia, 1.0 lb aia, and 2.0 lb aia. There was also a non-treated control. Each spray treatment was applied at the designated rate with a CO_2 backpack sprayer at 40 psi. Granular herbicides were applied with a hand-held shaker. Each treatment consisted of six single pot replicates.

Prostrate spurge (Chamaesyce humistrata) and chamberbitter (Phyllanthus urinaria) seeds were sown one day after application (25 seed/pot and watered in immediately. For the liverwort treatments, treated pots were placed around one-gallon containers of mature liverwort.

Weed counts were collected at 30, 60 and 90 days after treatment for spurge and chamberbitter and percent coverage of the container surface was rated for liverwort coverage similarly.

Results and Discussions: Excellent spurge control was obtained with Direx 4L spray applications at 1.0 and 2.0 lb aia (Table 1). With diuron T-2 spurge numbers at 0.5 lb aia were similar to the non-treated control containers. When applied at the 1.0 and 2.0 lb aia rate spurge numbers were less than the non-treated containers. In general, spurge numbers with diuron T-3 were similar. With chamberbitter there were no differences in control with any treatment. The chamberbitter had just begun to germinate when the study was terminated. Spray applications of Direx 4 L provided excellent pre-emergence control of liverwort at all rates. All rates are both granular formulations of diuron improved liverwort control compared to the non-treated plants. At the 1.0 and 2.0 rates improvement in liverwort control ranged from about 50 to 70% when compared to the non-treated containers.

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Table 1. The effects of diuron on control of 3 common nursery weeds.

			90 DAT[z]		
			Weed Number[y]		Percent Coverage[x]
Treatment	Herbicide	Rate of Application	Spurge	Phyllanthus	Liverwort
1	Direx 4L	0.5 lb/aia	2.3b	1.8ab	0.0d
2	Direx 4L	1.0 lb/aia	0.2c	2.7ab	0.0d
3	Direx 4L	2.0 lb/aia	0.2c	2.2ab	0.0d
4	Diuron T-2	0.5 lb/aia	4.2ab	1.5b	62.50b
5	Diuron T-2	1.0 lb/aia	3.0b	1.8ab	39.2bc
6	Diuron T-2	2.0 lb/aia	3.2b	1.5b	25.8c
7	Diuron T-3	0.5 lb/aia	3.2b	1.7ab	62.5b
8	Diuron T-3	1.0 lb/aia	4.3ab	4.2a	48.3bc
9	Diuron T-3	2.0 lb/aia	2.7b	1.8ab	37.8bc
10	Non-Treated	-	5.5a	1.8ab	86.7a

[z]DAT = Days after treatment.

[y]Weed Number = Number of weeds germinated per container.

[x]Percent Coverage = percent coverage of liverwort per container.

[w]means (within a column) with different letters are significantly different, according to Duncan's Multiple Range test (α=0.05).

Lesser Celandine (*Ranunculus ficaria* L.): A New Weed for North Carolina

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Index Words: *Ranunculus ficaria*, invasive

Significance to Industry: This study was conducted to determine the distribution and habitats of the five subspecies of *Ranunculus ficaria* L. in the United States. *R. ficaria* is widely sold as an ornamental in Europe (1) and was likely introduced to the United States as a garden plant in the early to mid-1800's. It has become invasive in moist areas and landscapes in the Northeast and Pacific Northwest of the US. Currently, all five sub-species are present in the United States and their ranges are expanding.

Nature of Work: *Ranunculus ficaria* L. is known to occur and is invasive in the Northeast and Pacific Northwest (2). It was first reported for North Carolina in 2005 (3) and there is concern that it may become invasive locally. Since its introduction in the mid-1800's it has escaped from cultivation into natural areas and expanded its range.

For this study 319 domestic specimens of *Ranunculus ficaria* were examined from 45 herbaria. Label data was captured and included collector name, number, date, county and state of collection, and any available habitat information. If specimens were missing information, such as date or location, they were excluded from the study. Each specimen was identified to subspecies level using an updated key (1). Distribution maps were created using ArcGIS 9.1 showing the distribution of *R. ficaria* every ten years from the 1860's to the present. The same maps were created separately for each subspecies.

Results and Discussion: All five subspecies *sensu* Sell (1) occur in the United States. The habitat and distribution of the five subspecies overlap in the US. In Europe the subspecies *bulbilifer* ranges from 35 N latitude to 60 N latitude (4). All five subspecies of *R. ficaria* should be expected throughout this range in North America, from northern Canada south to central North Carolina and Tennessee.

The species spreads mainly vegetatively through tuberous roots and axillary bulbils which form after flowering (1, 4). It has limited ability to produce seed and lacks a long distance dispersal mechanism, which makes spread of the species slow. However, the species multiplies easily along riverbanks forming dense mats where there is seasonal flooding. About 46% of specimens examined were collected adjacent to waterways; and bulbils likely disperse short distances downstream facilitating spread of the species along moving waterways (4). This dispersal mechanism was confirmed through primary observation in Wake County, North Carolina in 2006. The species was distributed along a drainage ditch, through a culvert under the road, and into a local waterway where it continued downstream. The species is also a weed of lawns, landscapes and irrigated horticultural areas. About 16% of domestic specimens were collected in these habitats including those in North Carolina. The two subspecies, *calthifolius* (Reichenb.) Arcangeli and *bulbilifer* Lambinon account for 67% of all specimens collected in the US. However, in North Carolina the subspecies is *ficariiformis* (F.W. Schwartz) Rouy & Fouc which accounts for only 4% of domestic specimens. It does not appear that any one subspecies is any more invasive than another. They all slowly encroach into the natural landscape. Though *R. ficaria* does not disperse rapidly, it forms dense mats in moist areas to the exclusion of native species, and has been observed competing well with other invasive species such as English ivy (*Hedera helix*), Japanese honeysuckle (*Lonicera japonica*), and periwinkle (*Vinca minor*).

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Field Evaluation of Herbicide Treated Mulches

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Index Words: Mulch, Herbicide, Weed Control

Significance to Industry: Weed control is essential for both nursery growers and landscape professionals. Many of the herbicides applied in the ornamental industry are granular; two of those reasons being reduced phytotoxicity compared to the respective liquid formulation and ease of application. However, it is often essential to apply herbicides 3-5 times per growing season in container nurseries (3), and usually twice a year in field nurseries and landscapes with supplemental glyphosate applications or hand-weeding. Increasing the duration of weed control while keeping phytotoxicity levels low would be advantageous for growers and landscape professionals.

Nature of Work: It has been found that mulches treated with various herbicides are effective for weed control (1, 2, 4). Work done at The Ohio State University has shown that weed control can be extended to 303 days with herbicide treated bark nuggets in containers (data not published). However, it is not known how long herbicide treated mulches are effective in a field or landscape situation. The objectives of this study were: 1) to compare efficacy of over-the-top (OTT) sprays without mulch to OTT sprays under mulch, OTT sprays on top of mulch, herbicide treated mulch, mulch alone, and bare, untreated soil at 30, 60, 90, and 120 days after treatment (DAT) and 1 year after treatment (YAT), and 2) to compare phytotoxicity of the treatments, methods, and dates described above.

The two experiments conducted were efficacy (experiment 1) and phytotoxicity (experiment 2). Each experiment was replicated in time, trial 1 starting on May 1, 2004 and ending April 15, 2005, and trial 2 starting on May 11, 2005 and ending April 21, 2006. The experiments were conducted at the Waterman Farm of The Ohio State University, Columbus, OH. The plots in experiment 1 contain no crop plants. Evaluations of efficacy and phytotoxicity were conducted at 30, 60, 90, and 120 DAT and 1 YAT. Efficacy was evaluated by taking visual ratings of 3 X 3 ft (0.9m) plots and dry weights from 1 X 1 ft (0.3 m) sections of the plot. Efficacy ratings were on a scale of 0 (no control) to 10 (complete control) and ≥ 7 (commercially acceptable). In experiment two, dogwood shrubs (*Cornus alba*) (both years) and crabapple tree liners (*Malus* x'Indian Summer) (year 1 only) were evaluated. A visual rating score of 1 (no injury) to 10 (complete kill) and ≤ 3 (commercially acceptable) were used for the shoots. Measurements of height × width were also taken on the dogwoods. One week after planting, treatments were applied. The five chemicals applied were oryzalin, (Surflan AS) at 2 lb ai/acre, flumioxazin, (SureGuard WDG) at 0.34 (ai) lb ai/acre, acetochlor (Harness) at 2.5 lb ai/ac, dichlobenil (Casoron CS) at 4 lb ai/acre and a combination of oryzalin and flumioxazin. Mulches were applied untreated, over the top of soil surfaces sprayed with the different herbicides. Mulches were also applied untreated to untreated soil surfaces and then sprayed with the different herbicides in the field. Two bark types were evaluated, pine nuggets and shredded hardwood. Pretreated bark mulch treatments were prepared by placing the mulches on a sheet of plastic, as a single layer (pieces of mulch side by side with minimal overlap) thick and sprayed over the top with the different herbicide treatments and allowed to dry for 48 h. Treated barks when dry and untreated mulches were applied directly to evaluation plots in varying amounts according to the mulch thickness. The mulches were applied as close as possible to a single layer. The herbicide treated mulches and herbicide-mulch application methods were compared to sprays of the five chemicals applied directly to the surfaces of the plots, the two untreated mulches applied to the plots and a weedy check (no herbicide, no mulch).

Results and Discussion: *Experiment 1 – phytotoxicity.* No phytotoxicity was evident from any of the treatments on the crabapples (data not shown), so they were excluded from trial 2. There was death among the dogwoods in both years of the study that was not treatment related, but instead due to hot, dry weather and lack of water shortly after planting. However, Dunnett's t-test was performed to show differences in comparison to controls. Six treatments provided significantly higher visual ratings over the controls combined over the four evaluation dates and the two years (Table 1). Four of the six most phytotoxic treatments included both Surflan and SureGuard. However, if not sprayed directly on the dogwoods (treated mulch), Surflan and SureGuard had no effect on the dogwoods. There were no treatments providing higher visual ratings than the control 1 YAT averaged over both trials (data not shown), which was probably due to the high death rate and poor growth of the controls. It should be mentioned that there was high weed competition with the control plants, and the lack of mulch around the control plants to conserve water may have contributed to the high death rate and poor growth of the controls.

Experiment 2 – efficacy. There were many treatments that were effective for weed control across all dates in both trials combined (Table 1). None of the OTT sprays or treatments that involved OTT sprays on top of, or below hardwood mulch provided visual ratings ≥7, and only the Surflan+SureGuard treated hardwood provided a visual rating of 7. Twelve out of fifteen treatments that involved an herbicide in combination with pine bark (over, under, or treated) had visual ratings of ≥7. At 1 YAT averaged over both trials, there were 10 treatments that provided visual ratings of ≥7, and all of those included pine nuggets (Table 1). None of the OTT sprays or the treatments involving hardwood mulch provided visual ratings of ≥7 at 1YAT. SureGuard, Surflan, Harness, and SureGuard+Surflan applied OTT all provided acceptable control at 30 DAT (data not shown); however, by 90 DAT, only SureGuard+Surflan provided acceptable control. With the addition of pine nuggets, these herbicides can provide control up to 1 YAT. Data from this trial supports that mulches should and can be used to enhance the efficacy of herbicides, applying the herbicides above, below, or to treat the mulch. Phytotoxicity can be reduced by the use of herbicide treated mulch.

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Table 1. Phytotoxicity and efficacy visual ratings of herbicide treated mulch field study.

Treatment	Phytotoxicity[z]	Efficacy[y]	Efficacy 1 YAT[x]
Control	4.6	0.18	1.63
Surflan OTT[w]	7.2*	4.7	2.73
Harness OTT	5.8	4.8	2.93
SureGuard OTT	5.4	4.4	3.83
Casoron OTT	6	1.8	2.43
Surflan+SureGuard OTT	9.8*	6.2	3.41
Surflan under HW	4.2	5.6	6.23
Harness under HW	5.6	5.3	3.33
SureGuard under HW	7.6*	6.5	5.03
Casoron under HW	5.3	5.6	4.17
Surflan+SureGuard under HW	5.2	6.3	5.33
Surflan over HW	3.8	4	3.63
Harness over HW	3.4	5	3.53
SureGuard over HW	6.1	5.7	4.77
Casoron over HW	3.9	6	5.83
Surflan+SureGuard over HW	7.6*	6.2	5.43
Surflan under PN	4.2	7	5.83
Harness under PN	3.4	7.2	4.93
Sureguard under PN	5.4	7.3	6.03
Casoron under PN	2.9	7.2	8.23
Surflan+SureGuard under PN	7.7*	8.8	7.23
Surflan over PN	2.7	7.5	5.83
Harness over PN	3.2	7.2	7.43
Sureguard over PN	5.3	8.9	8.13
Casoron over PN	2.2	6.8	8.73
Surflan+SureGuard over PN	7.5*	7.6	8.43
Surflan treated HW	4.2	5.6	5.16

Harness treated HW	4.3	5	3.13
SureGuard treated HW	3.4	5.8	5.73
Casoron treated HW	2.9	4.3	3.87
Surflan+Sureguard treated HW	2.7	7	6.43
Surflan treated PN	3.5	6.6	4.63
Harness treated PN	3.9	7.1	7.23
SureGuard treated PN	2.2	7.1	7.13
Casoron treated PN	2.6	6.2	7.22
Surflan+SureGuard treated PN	3	8.3	7.63
Untreated HW	4.8	1	2.43
Untreated PN	3.1	2.7	4.03

[z]Phytotoxicity visual ratings averaged over 30, 60, 90, and 120 DAT in 2004 and 2005 combined in herbicide treated mulch field study, those marked by * are different from control, using Dunnett's t-test (α = 0.05).

[y]Efficacy visual ratings averaged over 30, 60, 90, and 120 DAT in 2004 and 2005 combined in herbicide treated mulch field study, all treatments significantly different from control using LSMeans (α=0.05).

[x]Efficacy visual ratings 1 YAT averaged over both trials in herbicide treated mulch field study, all treatments significantly different from control using LSMeans (α=0.05).

[w]OTT = over the top, HW = hardwood, PN = pine nuggets.

Plant Size, Growing Medium and Herbicide Application Method, Formulation and Rate Influence Phytotoxicity of Flumioxazin to Plumbago

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Index Words: flumioxazin, oxyfluorfen, pendimethalin, BroadStar, SureGuard, OH2, *Plumbago auriculata*

Significance to Industry: This study confirmed that various long-held ideas regarding factors that affect phytotoxicity when using preemergence herbicides were valid for flumioxazin (BroadStar/SureGuard). Two of the three granular formulations applied broadcast over-the-top at the 1× rate to plumbago liners that had been watered in and whose foliage was dry caused no phytotoxicity. However, phytotoxicity occurred when flumioxazin was applied 1) at a higher (4×) than labeled rate, 2) as a granular material to wet foliage (however, there were differences among the formulations in regards to long-term damaging effects), 3) to liners that had not been watered in, and 4) as a soil drench. In addition, phytotoxicity was greater in an all pine bark medium than in a standard potting mix. Also, granular flumioxazin was phytotoxic to plumbago when it was applied directly to the soil but not when it was applied at the same rate (area basis) broadcast over-the-top, likely due to the deflection of the granules by the plumbago foliage. Finally, larger plumbago plants with well-developed root systems did not sustain long-term damage from flumioxazin, even when the granular formulation was applied to wet foliage.

Nature of Work: The successful use of preemergence herbicides to control weeds during containerized production is dependent as much on the herbicides' being safe to use on a given crop as on their ability to control problem weeds. BroadStar (flumioxazin) is a preemergence herbicide labeled for use on woody ornamentals. Growers have reported phytotoxicity when BroadStar was applied to plumbago (*Plumbago auriculata* Lam.). Flumioxazin damage to another shrub, *Deutzia gracilis*, has been reported previously (1). Phytotoxicity caused by preemergence herbicides can be affected by many factors such as foliar wetness at time of application, growing medium, application rate, herbicide formulation and crop developmental stage (2). The objective of this study was to see how these factors affected phytotoxicity when using flumioxazin on plumbago.

This experiment was conducted under full-sun conditions at the University of Florida/IFAS' Mid-Florida Research and Education Center in Apopka, FL. On 3 December 2004, 2-inch liners of Imperial Blue plumbago were transplanted into 6-inch diameter round standard plastic pots (T.W. molded, Dillen Products, Middlefield, OH). Pots were filled with a standard perennial potting mix of pine bark:*Sphagnum* peat:sand (60:30:10 by vol) amended with 5.0 lbs/yd^3 of dolomite and 0.5 lbs/yd^3 of a micronutrient + magnesium supplement (STEP Hi

Mag, Scotts, Marysville, Ohio) or with 100% pine bark mini-nuggets. Liners to be treated with BroadStar VC1453 prior to watering-in were not transplanted until the day the treatments were applied. Ready-to-sell Imperial Blue plumbago plants in one-gallon pots were obtained from a commercial nursery so that effects of treatments on established plants could also be determined. All plants, except as mentioned above, were watered with 0.50 inch per day using solid set overhead irrigation for two days prior to herbicide application.

To apply the broadcast over-the-top herbicide treatments, each plant was removed from the plot and placed in a one-square foot herbicide calibration tray where the herbicide was applied by hand, then the plant was returned to its plot. For treatments of plants with wet foliage, a hand-held hose was used to moisten the foliage. Herbicide contact with foliage was avoided for the soil-applied treatments. For the herbicide + disk treatments, the disks (woven black polypropylene ground cover used to prevent herbicide from splashing up on the plumbago foliage) were placed in the pots after the herbicides were applied. The drench applications of SureGuard 51WDG were applied by removing the pots from the plots and slowly adding 12 oz of the drench solution to each pot. These pots were then set aside for 24 hours to avoid all overhead watering. All treatments were applied at random within each replication. Two hours after the final herbicide application, all plants, except the drench treatment plants, were watered with 0.75 inch of water using the overhead sprinklers; thereafter, all pots were irrigated daily with 0.5 inch of water.

Phytotoxicity was evaluated at 1, 3, 7 and 14 days after treatment (DAT) using a rating scale of 1 = no damage; 2 = slight damage, marketable; 3 = moderate damage, unmarketable; 4 = severe damage; and 5 = plant dead. Root growth was evaluated at 79 DAT by making visual estimates of the percentages of the outside of the medium balls covered with live roots. Plants were harvested at 92 DAT for top dry weights. Tissue was dried for 14 days at 160ºF. Data were analyzed by analysis of variance and means comparisons between the controls and herbicide treatments (by potting medium) were by Dunnett's procedure at $P \leq 0.05$. When necessary to approximate normal distributions, percentage data were transformed using the square root transformation. The design was a randomized complete block with three replications and the experimental units were individual plants.

Results and Discussion: *Acute phytotoxicity.* Liners. Phytotoxicity was evident one day after treatment (DAT) in the pine bark-grown plumbago treated with flumioxazin (Table 1). In the standard potting medium, significant damage symptoms first appeared at 3 DAT and were observed in all treatments where flumioxazin was applied when foliage was wet. By 14 DAT, phytotoxicity was also evident in the SureGuard drench and BroadStar 4× plots. There was no foliar damage from any of the treatments when the foliage was dry or the herbicide was applied directly to the soil, indicating that there was no redistribution of the flumioxazin from the potting medium to the foliage. Established plants. Phytotoxicity was only observed in the treatments where BroadStar was applied to wet foliage (data not shown).

Root ball coverage. Liners. The factors that reduced root coverage were the high (4×) application rate, not watering the plants prior to herbicide treatment, and the application of BroadStar directly to the soil surface (Table 1). Although the soil surface and over-the-top broadcast treatments used the same BroadStar application rate on a unit area basis, the foliage of the plumbago deflected some granules so that the effective application rate to the pots was likely lower in the over-the-top treatments. Established plants. Root ball coverage was not affected by herbicide treatments, indicating that established plants were less sensitive than liners to flumioxazin (data not shown).

Plant shoot dry mass. Liners. Plants treated with OH2 weighed the same as the untreated controls whereas those treated with flumioxazin had reduced dry shoot mass except when the VC1453 and VC1509 formulations were applied over-the-top at the label rate to plants that had been watered in prior to treatment and had dry foliage at the time of application. Also, for the VC1509 formulation, dry shoot mass was the same as for the controls even when it was applied to wet foliage. Established plants. Herbicide treatments had no effect on shoot biomass (data not shown).

Plant survival. Liners. All plumbago liners growing in the 100% pine bark mix were killed when flumioxazin was applied, probably due to the greater porosity and fewer herbicide binding sites of the pine bark that allowed more herbicide to contact liner roots. Although there were some plant deaths in the flumioxazin-treated pots containing the standard mix, no treatment was significantly different from the control (Table 1). Established plants. None of the established plants were killed by the flumioxazin, indicating greater tolerance by established plants than liners.

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Table 1. Effects of herbicide formulation and rate, application conditions and methods, and potting medium on phytotoxicity to Imperial Blue plumbago liners.

Treatment	Active ingredient(s) (a.i.)	Application rate (lb a.i./A)	Potting medium[z]	Initial irrigation[y]	Application method[x]	Foliage wetness at time of application[w]	Acute phytotoxicity (1–5)[v]				Root coverage on medium surface[t] (%)	Plant top dry weight (g)	Plant survival (%)
							1 DAT[u]	3 DAT	7 DAT	14 DAT			
Control - standard mix	—	—	standard	—	—	—	1.0	1.0	1.0	1.0	22.0	4.88	100
OH2	oxyfluorfen + pendimethalin	2.0 + 1.0	standard	before	over-the-top	dry	1.3	1.3	1.7	1.3	13.1	4.82	100
BroadStar 0.25G VC1453	flumioxazin	1.5 (4×)	standard	before	over-the-top	dry	1.3	1.0	2.7	3.3*[s]	0.1*	0.46*	33
BroadStar 0.25G VC1453	flumioxazin	0.375	standard	before	over-the-top	dry	1.0	1.0	1.3	1.0	6.0	1.91	67
BroadStar 0.25G VC1453	flumioxazin	0.375	standard	after	over-the-top	dry	1.0	1.0	1.7	2.0	0.1*	0.41*	67
BroadStar 0.25G VC1508	flumioxazin	0.375	standard	before	over-the-top	dry	1.0	1.0	1.3	1.8	3.3	0.95*	100
BroadStar 0.25G VC1509	flumioxazin	0.375	standard	before	over-the-top	dry	1.0	1.0	1.3	1.0	8.9	2.89	100
BroadStar 0.25G VC1508	flumioxazin	0.375	standard	before	over-the-top	wet	1.7	3.7*	3.3*	3.7*	1.9	1.09*	67
BroadStar 0.25G VC1509	flumioxazin	0.375	standard	before	over-the-top	wet	2.0	3.7*	3.0*	3.3*	5.0	2.52	100
SureGuard 51WDG\	flumioxazin	0.375	standard	before	soil drench	dry	1.0	1.3	2.0	3.3*	2.0	1.09*	100
BroadStar 0.25G VC1453	flumioxazin	0.375	standard	before	soil surface; ground cover disk	dry	1.0	1.0	2.0	1.0	1.2*	1.41*	100

BroadStar 0.25G VC1453	flumioxazin	0.375	standard	before	soil surface	dry	1.0	1.0	1.7	2.0	0.6*	1.35*	33
BroadStar 0.25G VC1453	flumioxazin	0.375	standard	before	over-the-top	wet	1.0	3.0*	3.3*	3.3*	2.0	1.35*	100
Control - pine bark	—	—	pine bark	—	—	—	1.0	1.0	1.5	1.0	3.3	2.66	100
BroadStar 0.25G VC1453	flumioxazin	0.375	pine bark	before	soil surface	dry	1.3**[s]	1.0	1.3	2.0**	0.0	0.46**	0**

[z]Potting medium type either a standard perennial mix (60% pine bark:30% Sphagnum peat:10% sand; by volume) or 100% pine bark.

[y]Pots with transplanted liners were either irrigated for two days before the herbicides were applied or irrigated for the first time immediately after the herbicide (VC1453) was applied.

[x]Herbicides were applied as granules to the soil surface, granules broadcast over-the-top of the foliage or as aqueous soil drenches.

[w]Applied herbicide to either wet or dry foliage.

[v]Phytotoxicity ratings: 1 = no damage, 2 = slight damage, 3 = moderate, 4 = severe damage, 5 = plant death.

[u]DAT = days after treatment.

[t]Root coverage determined visually by estimating the percentage of the medium surface area in contact with the pot that was covered with roots (percentages were transformed using the square root transformation prior to statistical analysis).

[s]Mean separation (by potting medium type) within columns by Dunnett's procedure ($P \leq 0.05$); * = different from standard potting mix control, ** = different from 100% pine bark medium control.

Bedding Plant Host Preference for Dodder

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Index Words: *Cuscuta*, dodder, host preference, resistance, color beds, bedding plants

Significance to Industry: In landscape beds with a history of dodder infestations it is advisable to avoid planting petunia, vinca, impatiens or coleus. Landscape managers with dodder-infested beds may reduce the need for chemical control treatments by planting less susceptible species such as scaevola, begonia, gomphrena, ornamental sweet potato, verbena, marigold or portulaca.

Nature of Work: Dodder (*Cuscuta* spp.) is a summer annual, obligate parasitic weed of increasing importance in greenhouse-grown and landscape plantings of flowering annual bedding plants. Once attached to the host, dodder cannot be selectively removed and the host must be either killed with a non-selective herbicide or removed with the weed. The seeds of dodder are long-lived; therefore, once the soil is infested with dodder a long-term management plan is needed. The only herbicide labeled for selective control of dodder in diverse landscape plantings is DCPA (Dacthal) (1). However, Dacthal must be applied preemergence, with high rates and multiple applications to achieve full season control; and, Dacthal is an expensive treatment. Clearly, alternative dodder control guidelines are needed. Some vegetable crops have been screened for host resistance to dodder but no such reports were available for bedding plants. A previous trial suggested that bedding plants differ in their susceptibility to parasitism by dodder (2). In this project we conducted a dodder host preference screening of thirteen annual bedding plant species to confirm these earlier findings.

Bedding plants were potted into 1-gallon (3-liter) pots using a pine bark + sand (7:1 v/v) substrate on June 14, 2006. Species included petunia, calibrachoa, salvia, portulaca, verbena, ornamental sweet potato, marigold, gomphrena, scaevola, vinca, impatiens, coleus, and begonia (cultivars of each are listed in Table 1). The first ten species were in full sun; the latter three were placed in 50% shade. Plants were overhead watered daily. Plants were allowed to establish for two weeks then ¼ teaspoon per pot of lespedeza dodder (*Cuscuta pentagona*) seeds were scattered on the substrate surface. Twelve replicates of each species were seeded. Percent crop canopy occupied by field dodder was visually evaluated about 8 weeks after seeding.

Results and Discussion: Significant differences in dodder growth were seen among species (Table 1). Petunia, impatiens, and vinca were clearly the most preferred hosts with over 80% canopy coverage. Calibrachoa and coleus each had greater than 50% canopy coverage by dodder. In contrast, vinca had less than 50% canopy coverage by dodder, and neither calibrachoa nor coleus had greater than 6% canopy coverage in the 2002 experiment (2). Victoria

Blue salvia, marigold and portulaca each had between 10% and 14% canopy coverage by dodder. In 2002 a different species of salvia (*Salvia splendens* 'Red and White') was used in the trial, with greater than 80% coverage by dodder (2). Scaevola, begonia, gomphrena, ornamental sweet potato, and verbena each had less than 5% canopy coverage by dodder. Results with these species were similar in 2002.

These data clearly demonstrate that differences in dodder host preference exist among common shade-tolerant and sun-tolerant bedding plants. In landscape beds with a history of dodder infestations it is advisable to avoid planting petunia, vinca, impatiens or coleus. Landscape managers with dodder-infested beds may reduce the need for chemical control treatments by planting less susceptible species such as scaevola, begonia, gomphrena, ornamental sweet potato, verbena, marigold or portulaca. Differential results between the 2002 and 2005 experiments also suggest that varietal differences in dodder host specificity may exist, particularly with calibrachoa and coleus. Furthermore, dramatic difference in host preference between the salvia species used in 2002 and 2005 suggest that we cannot make accurate predictions of dodder host preference between related bedding plant species.

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Table 1. Percent bedding plant canopy occupied by lespedeza dodder.

Species	Common Name	%
Catharanthus roseus 'Pacifica White'	Vinca	93 a
Petunia x 'Wave White '	Petunia	93 a
Impatiens x 'Dazzler Coral'	Impatiens	87 b
Calibrachoa x 'Liricashower Rose'	Calibrachoa	66 c
Coleus x *hybridus* (unspecified "sun-type" variety)	Coleus	51 d
Tagetes erecta 'Safari Orange'	Marigold	14 e
Salvia farinacea 'Victoria Blue'	Salvia	12 e
Portulaca grandiflora 'Yubi Summer Joy Rose'	Portulaca	10 ef
Scaevola aemula	Scaevola or fan flower	4 fg
Begonia semperflorens-cultorum 'Super Olympia White'	Begonia	2 g
Gomphrena globosa 'Lavender Lady'	Gomphrena	2 g
Ipomoea batatas 'Sweet Caroline Burgundy'	Sweet potato	1 g
Verbena hybrida 'Aztec Silver Magic'	Verbena	0 g

Means followed by the same letter are not significantly different based on a Waller-Duncan k-ratio t-test at α=0.05.

Control of Beach Vitex with Postemergence Herbicides

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Index Words: invasive, landscape plant, *Vitex rotundifolia*

Significance to Industry: It is important to find solutions to problems stemming from the introduction of invasive plants. *Vitex rotundifolia* L. f. (Beach Vitex) was introduced to the Carolinas in the mid -1980's as a landscape plant with attractive flowers, striking foliage, and salt tolerance. It was planted in many coastal areas of the Carolinas and has become invasive on primary and secondary dunes. As a result of the extensive growth of Beach Vitex, native beach grasses are excluded and sea turtles are experiencing nesting difficulties. Three herbicide application methods were evaluated to control container grown Beach Vitex using the following herbicides: AquaMaster™ (glyphosate), Habitat™ (imazapyr), Raptor™ (imazamox), Renovate™ (triclopyr), and Stingray™ (50% glyphosate, 1.12% carfentrazone). All herbicides effectively controlled Beach Vitex with the dip/clip and cut/spot methods using undiluted herbicides. In the foliar spray study, all treatments provided greater than 90% control except the low rate (2.5% v/v) of AquaMaster™ and Renovate™.

Nature of Work: Beach Vitex (*Vitex rotundifolia* L. f.) was introduced to the Carolinas in the 1980's as a landscape plant. It produces many seeds, but the main method of propagation on the beach is through long runner branches that root easily. In the areas where it was planted in coastal regions of North and South Carolina, it is dominating the primary dune areas and excluding native species (1). In places where Beach Vitex is present, it has created monocultures by shading out native species (2). Sea turtle enthusiasts believe that the thick growth of Beach Vitex prevents egg-laying activities by inhibiting the turtle's ability to navigate to appropriate egg laying locations.

Since this plant is problematic, a task force involving multiple agencies and volunteers was created to detect and eliminate Beach Vitex from the North and South Carolina coast before it spreads further and develops into a significant invasive pest problem. The objective of this research is to evaluate the effectiveness of five herbicides and three methods of herbicide application at controlling Beach Vitex in order to develop chemical control programs for Beach Vitex infested coastal areas. The following five herbicides were selected for evaluation in this study: AquaMaster™ (glyphosate), Habitat™ (imazapyr), Raptor™ (imazamox), Renovate™ (triclopyr), and Stingray™ (50% glyphosate, 1.12% carfentrazone).

Four-month old seedlings (12 to 20 in. height) of Beach Vitex plants in 1-gallon pots were used in this study. Three application methods were used for the five herbicides in two different experiments. In the foliar spray study, herbicide solutions were mixed with water to a total volume of 8.3 oz at rates of 2.5%

and 5.0% (v/v) herbicide concentration. A non-ionic surfactant was used for all treatments at the rate of 0.5 % (v/v). Applications were made by spray bottles calibrated to deliver 0.17 oz of spray in four sprays to each plant. This was approximately 45 gallons per acre. The treatments were made in a greenhouse, and the plants were allowed to dry overnight before they were arranged in a randomized block design with five single plant replications and an untreated control. Visual injury was determined on a scale of 0% to 100% with 0% showing no injury and 100% completely defoliated and brown. Visual ratings were made at 30, 90, and 240 days after treatment. Analysis of variance was performed and means were separated using LSD values at $\partial = 0.05$.

The second study evaluated dip/clip and cut/spot herbicide application methods. For the dip/clip treatments, the clippers were dipped in undiluted herbicide coating the blades prior to clipping the stems. Herbicide remaining on the clipper blades following dipping was transferred to the stems as they were cut. Two nodes remained below the cut. For the cut/spot treatments, the plant was cut leaving two nodes from the base of the plant. Immediately after cutting, 0.017 oz of undiluted herbicide was applied to the top of the recently cut stem using a 0.034 oz syringe (without needle). These treatments were evaluated as a means to minimize herbicide contact with non-target plants such as would be found in Beach Vitex infestations on beach dunes. Treatments were arranged in a randomized block design with four single plant replications. An untreated, clipped treatment and an untreated, unclipped treatment served as controls for the study. Fresh shoot and root mass was recorded 240 days after treatment. Analysis of variance was performed on the data and means were separated using LSD values at $\partial = 0.05$.

Results and Discussion: The initial evaluation of the foliar spray study (Table 1) at 30 days after treatment revealed that Stingray™ provided > 90% control of Beach Vitex with no differences between the low (2.5%) and high (5.0%) concentrations. Renovate™ and AquaMaster™ had comparable levels of control > 45%. Habitat™ and Raptor™ were ineffective at 30 days and were no different than the untreated control. At the day 90 evaluation, applications of Stingray™, Habitat™, and AquaMaster™ injured Beach Vitex > 78%. The other treatments showed < 71% control at this evaluation period. At the day 240 rating, all treatments provided > 90% control except for the low rates of AquaMaster™ and Raptor™.

As a foliar spray, Stingray™ demonstrated a high level of control that took effect rapidly and lasted for at 8 months. Raptor™ and Habitat™ were slower to provide effective control; however, by 8 months, they became indistinguishable from Stingray™, Renovate™, and AquaMaster™ (high rate). It should be noted that these treatments were applied to container grown plants that were approximately 4 months old. Results will probably be different when applied to larger Beach Vitex plants in the field. These herbicides were chosen because they are either labeled for aquatic uses or are in the process of getting an aquatic label.

Only one plant re-grew from any of the dip/clip or cut/spot treatments (Table 2). The root and shoot fresh masses were similar for all the treated plants. The unclipped controls had greater shoot mass than the clipped controls because they had more shoot mass at the start of the experiment. All herbicide treatments applied were effective at controlling the Beach Vitex plants.

Future research will seek to use different concentrations of herbicides for the dip/clip and cut/spot application methods instead of using undiluted herbicides. In this experiment, all treatments were effective. Field studies are imminent for application of knowledge learned in the greenhouse experiments to larger more established plants.

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Table 1. Visual Beach Vitex control 30, 90, 240 days after treatment with two rates of five herbicides applied by foliar spray.

		Control (%)		
Herbicide	**Concentration (%)**	**30 Days**	**90 Days**	**240 Days**
AquaMaster™	2.5	42 b	78 ab	75 b
AquaMaster™	5.0	44 b	99 a	99 a
Habitat™	2.5	8 c	88 a	100 a
Habitat™	5.0	13 c	100 a	100 a
Raptor™	2.5	7 c	58 b	94 a
Raptor™	5.0	8 c	62 b	100 a
Renovate™	2.5	43 b	60 b	12.4 c
Renovate™	5.0	42 b	71 b	96 a
Stingray™	2.5	96 a	99 a	90 a
Stingray ™	5.0	94 a	99 a	100 a
Untreated	0.0	0 c	0 d	0 d
LSD		20.6	16.0	12.4

Visual rating based on 0 = no injury and 100 = complete control. Means followed by the same letter are not different according ANOVA with ∂ = 0.05.

Table 2. Shoot and root fresh mass 240 days after Beach Vitex was treated with 5 herbicides by two application methods.

Herbicide	Application Method	Shoot mass (g)	Root mass (g)
[redacted]			
LSD		7.54	9.01

Means followed by the same letter are not different according ANOVA with ∂ = 0.05.

Viability of Beach Vitex (*Vitex rotundifolia*) Seeds: an Invasive Coastal Plant

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Index Words: invasive, landscape plant, seed viability, seed bank, tetrazolium, *Vitex rotundifolia*

Significance to Industry: *Vitex rotundifolia* L. f. (beach Vitex) was introduced into the Carolinas in the mid-1980's as a salt-tolerant woody ground cover that grows well on dunes and has attractive flowers and foliage. It was planted in coastal areas and has become invasive on primary and secondary dunes. The extensive growth of beach Vitex excludes native beach grasses and causes nesting problems to sea turtles. Beach Vitex spreads by horizontal stems and also produces many seeds. This research indicates that beach Vitex seed were similar in size and seed numbers per capsule with an average of 1.2 viable seeds/capsule. Viable beach Vitex seed were found in the sandy soil at two locations. The majority of seed were in the top 2 inches and the seed number appears to decrease over time following elimination of parent plants from the area. One and a half years after removal of plants 81 viable seeds per square foot were present at the cleared location and 238 viable seeds per square foot were present in soil under Vitex vegetation. Thus, there is a viable seed bank present, which could present problems to management though it does appear to decrease over time.

Nature of Work: Beach Vitex (*Vitex rotundifolia* L. f.) was introduced to the Carolinas in the 1980s as a landscape plant. It produces many seeds, but the main method of propagation on the beach is through long running branches that root very easily (4). Seeds are contained within spherical, black fruit with a persistent calyx of diameter approximately 0.2 in (3); fruits are hard and non-fleshy containing one to four seeds in separate compartments. ChongMin and EulSoo (2) studied germination rates of beach Vitex and found germination rates of 71% in the laboratory and 30% in sea sand with no difference between dry and moist stratification. There is little known about the seed viability characteristics of beach Vitex. It produces many seeds, but seedlings do not appear to be the primary means of spread. Viable seed, seed weight, and physical characteristics were investigated for beach Vitex capsules from 2003, 2004, and 2005 seed lots.

Three lots of beach Vitex capsules were hand collected in December 2003, 2004 and 2005 near Pawley's Island, South Carolina. They were air-dried and stored in plastic bags at room temperature (77ºF) until they were used in this study. Four lots of 100 capsules from each year were measured with a digital caliper and weighed. Capsules were bisected equatorially and placed in 0.85 oz (25 ml) of a 1% 2, 3, 5-triphenyltetrazolium chloride (Sigma-Aldrich, St. Louis, MO) solution in the dark over night at 68ºF (1). The number of seeds per capsule and their viability were determined. Each capsule contained from one to four seeds. Seeds were counted, and those that stained pink as a result of exposure to the tetrazolium solution were considered viable.

Two Vitex infested sites were selected to examine the soil seed bank. One location had beach Vitex present at the time of sampling (Pawley's Island), and the other had been purged of above ground beach Vitex plant parts 1.5 years earlier (Forget-Me-Not). Twenty sites were sampled at "Forget-Me-Not" with five sites sampled from each of four separate transects running from the flat behind the dune up to the flat top of the dune. Nine locations were sampled at the "Pawley's Island" site where beach Vitex was still actively growing with three sites sampled along each of three transects running across the top of the dunes from inland seaward.

Each site was sampled to a depth of 6 in using a 4 in diameter metal pipe. Samples were separated out by 2-in increments to give three samples per site from the following depths: 0 to 2 in, 2 to 4 in, 4 to 6 in. After screening the sand and debris, capsules were bisected equatorially and placed in Petri dishes in 0.85 oz of a 1% 2, 3, 5-triphenyltetrazolium chloride (Sigma-Aldrich, St. Louis, MO) solution in the dark over night at 68ºF (ISTA, 1985). The number of seeds per capsule and their viability was determined. Each capsule contained from one to four seeds. Seeds were counted, and those that stained pink as a result of exposure to the tetrazolium solution were considered viable.

Results and Discussion: There were no differences between 2003, 2004, 2005 seed lots for capsule diameter, capsule weight, seed number per capsule, and viable seed per capsule (Table 1). It is interesting to note that our results show only an average of 1.25 viable seed per capsule out of a possible 4 seed per capsule. This corresponds closely with visual observations in the germination studies where most capsules had one seedling emerging from each capsule (data not shown).

At both locations sampled, most of the capsules present were found in the top 0-2 in of substrate. There were significantly more capsules found in the top 2 in than at either of the other depths at both locations tested. There was no difference in capsule number between locations at any depth (Table 2). Significantly higher numbers of seeds and viable seeds were also present in the top 2 in than in the lower samples in all cases.

There were more viable seeds present in the top segment of the soil from the currently vegetated location than in any other sample collected. These findings illustrate that the newer seeds are also more likely to be viable than the older seeds. The cleared location had 529 ± 108 capsules per square foot to a depth of 6 in as opposed to 304 ± 74 capsules per square foot for the site that was still vegetated. The same analysis was carried out for seeds per unit area to discover that the cleared site had 116 ± 21 seeds per square foot while the vegetated site had 326 ± 87 seeds per square foot. Viable seeds were found to be present at rates of 81 ± 17 and 238 ± 66 viable seeds per square foot for the cleared and vegetated sites respectively.

This research suggests that any attempts at eliminating this plant from dunes should be accompanied by follow up practices to deal with seedlings. Our findings indicate that viable seeds will be present and able to emerge for some time following removal of plants from the area. These seedlings might be capable of reestablishing stands of beach Vitex over time if they are ignored. In fact, our research group observed many beach Vitex seedlings at the location that had been cleared. These observations agree with our conclusions that the soil seed bank is sufficient to facilitate regrowth of this plant in areas that have been cleared.

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Table 1. Capsule and seed characteristics of 2003, 2004, and 2005 beach Vitex seed lots.

Seed Characteristics	2003	2004	2005
Capsule diameter (in)	0.25	0.26	0.27
Capsule wt. (oz/100 capsules)	0.17	0.18	0.17
Capsule wt. (mg/capsule)	48	50	48
Seed #/Capsule	1.3	1.3	1.6
Viable seed/capsule	1.2	1.3	1.4

There were no statistical differences detected between years at $P = 0.05$ according to ANOVA.

Table 2. Number of capsules, seed, and viable seed per 12.5 in^3 of soil at three depths. Two locations were sampled: Forget-Me-Not had Vitex vegetation removed 1.5 yr. prior to sampling and Vitex plants were present at Pawley's Island site when sampled.

Location	Depth (in)	Capsules/ 12.5 in^3	Seed/ 12.5 in^3	Viable Seed/ 12.5 in^3
Forget-Me-Not	0-2	41.1 a	8.6 b	5.8 b
	2-4	3.3 b	1.0 c	0.8 b
	4-6	0.3 b	0.3 c	0.3 b
Pawley's Island	0-2	23.3 b	25.4 a	18.6 a
	2-4	1.3 b	1.1 c	0.6 b
	4-6	1.0 b	1.0 c	1.0 b
LSD =		18.7	7.4	5.8

Values within a column followed by the same letter are not different according to LSD at $P = 0.05$.

Herbicide Use in Propagation of Nursery Crops

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Index Words: Pre-emergent herbicides, isoxaben, oxadiazon, oxyfluorfen+oxadiazon, *Loropetalum chinense*

Significance to Industry: *Loropetalum chinense* 'Ruby' (R. Br.) is a broadleaf, evergreen nursery crop propagated in outside beds during the summer. These conditions are ideal for germination and growth of weed species. A successful weed control program in the field is in part dependent upon starting with a weed free liner. In this study three pre-emergent herbicides were applied to cuttings of *Loropetalum chinense* 'Ruby' at three different rooting levels. Results indicated timing of herbicide application determines effectiveness of pre-emergent herbicides in propagation.

Nature of Work: Weeds are a major issue in production of nursery crops even more so in propagation (4). Currently hand weeding is the major form of weed control in propagation but can suppress growth of cuttings through mechanical disruption (2). In 2001 no pre-emergence applied herbicides were labeled for use on non-rooted cuttings and few herbicides were labeled for use on liners (1, 3). A reason for lack of herbicide use in propagation is because of safety issues with herbicide use in en-closed areas. The objective of this study was to determine if three commonly used herbicides could be used safely during propagation, of *Loropetalum chinense* 'Ruby'.

On August 2, September 8, and November 4, 2005 propagation flats were treated with three pre-emergence applied herbicides to evaluate affects on rooting of *Loropetalum chinense* 'Ruby'. Gallery (isoxaben) at 1lb/aia, Ronstar 2G (oxadiazon) at 4lb/aia, and Regal 0-0 (oxyfluorfen + oxadiazon) at 3lb/aia were applied either before sticking, when cuttings were lightly rooted, or when cuttings were fully rooted. Terminal cuttings 7 to 9cm were stuck in 3.5inch containers utilizing a pinebark:sand 6:1 (v:v) medium amended with Polyon 17-6-12 @ 9lbs/yd^3, Micromax @ 1.5 lbs/yd^3, and dolomitic lime @ 5.0lbs/yd^3. Each cutting was dipped in Dip 'N' Grow 1part:5parts water (2000 ppm IBA) for 4 seconds prior to sticking. This study is a 3×3 factorial with 9 replications of 9 containers per replication in a completely randomized design.

Before sticking propagation flats were treated an hour before cuttings were stuck and watered in with a 0.25inch. All pots were placed in outdoor cold frames with overhead mist every 5 minutes for five seconds from 8am to 7pm. Thirty-eight days after sticking (DAS) September 8, 2005 a separate group of lightly rooted cuttings not previously treated were pulled from the mist beds for an hour at 8:00am, to allow drying prior to treatment. Thereafter the foliage was brushed off and plants watered in with a 0.25inch and returned to mist. On November 4, 2005 (94 DAS) the final treatment (fully rooted) was applied the same as the second treatment and left under mist for one week before being moved to a retractable shade house for overwintering.

Data was collected 65 and 248 DAS. At 65 DAS, shoot number per cutting and average length of three longest shoots were counted/measured. Four plants from each replication were randomly selected to determine number of primary roots, average length of three longest roots, and root fresh weight (grams). After over-wintering April 7, 2006 (248 DAS) growth indices and percent root rating (0-100 scale) were taken prior to potting in full gallons.

Results and Discussion: *Before Sticking at 65 DAS* – Gallery had no affect on shoot growth or root growth (Table 1). Whereas Ronstar and Regal 0-0 suppressed new shoot and root growth compared to the non-treated control. For example, Ronstar and Regal 0-0 suppressed shoot length by 44 and 37%, and root length by 30 and 16% compared to the non-treated control.

Lightly rooted at 65 DAS – Compared to the non-treated control there was no treatment affect on new shoot growth or root fresh weight (Table 1). Slight suppression in root length occurred in all herbicide treatments compared to the non-treated control with the exception of Ronstar. Gallery and Ronstar had slightly less root numbers compared to Regal 0-0 and non-treated control.

Before sticking 248 DAS – Gallery and Ronstar were similar but had less shoot growth than the non-treated control plants while Regal 0-0 caused severe reduction in growth indices and rootball (Table 2).

Lightly Rooted at 248 DAS – No treatment affect was observed among new shoot growth in any treatments (Table 2). Root ratings were slightly less for Ronstar and Regal 0-0 compared to the non-treated control however there were no differences among herbicide treatments.

Fully rooted at 248 DAS – A slight difference in new growth was observed for all treatments compared to the non-treated control. Gallery and Ronstar applied to fully rooted cuttings had more rootball coverage compared to before and lightly rooted applications. Gallery and the non-treated control had similar root ratings in the fully rooted application. Ronstar and Regal 0-0 suppressed root ratings compared to the non-treated control cuttings with Regal 0-0 suppressing root growth more than Ronstar.

Data collected at 65 DAS indicated Gallery applied before sticking to be a good pre-emergence herbicide for use in propagation. However growth indices and root ratings 248 DAS revealed suppression occurred with use of Gallery before sticking. When Gallery was applied to lightly rooted cuttings there were no growth differences compared to the non-treated plants at any time during the study. Application of Gallery to fully rooted cuttings caused slight suppression of growth indices; however there were no differences in root growth. Both Ronstar and Regal 0-0 tended to cause suppression in both shoot and root growth throughout the study; with Ronstar causing less suppression than Regal 0-0.

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Table 1. The influence of herbicide application during propagation 65 days after sticking on *Loropetalum chinense* 'Ruby'.

	Before Sticking[z]				Lightly Rooted[y]			
	Gallery	Ronstar	Regal 0-0	Control	Gallery	Ronstar	Regal 0-0	Control
Shoot Number[x]	3.6a[t]	1.3c	1.4c	3.0b	2.7a	2.7a	2.8a	3.0a
Shoot Length[w]	4.3a	2.3b	2.6b	4.1a	4.5b	3.8b	5.9a	4.1b
Root Number[v]	11.5ab	10.1bc	8.7c	12.6a	10.8b	10.5b	12.7a	12.6a
Root Length[u]	22.7a	15.4c	18.5b	22.0a	19.9b	21.4ab	19.8b	22.0a
Root Weight[t]	0.6a	0.3b	0.4b	0.6a	0.6a	0.5a	0.5a	0.6a

[z]Before Sticking = herbicide prior to sticking cuttings.

[y]Lightly Rooted = herbicide applied to lightly rooted cuttings (3-4 roots).

[x]Shoot Number = number of new shoots per rep.

[w]Shoot Length = length of three longest shoots ÷ 3 (cm).

[v]Root Number = number of primary roots per replication.

[u]Root Length = length of three longest roots ÷ 3 (cm).

[t]means (across columns within application times) with different letters are significantly different, according to Duncan's Multiple Range test (α=0.05).

Table 2. The influence of herbicide application during propagation 248 days after sticking on *Loropetalum chinense* 'Ruby'.

	GI[z]			Root Rating[y]		
	Before Sticking	Lightly Rooted	Fully Rooted	Before Sticking	Lightly Rooted	Fully Rooted
Gallery	19.8b[x]	30.2a	28.0b	22.1b	29.5ab	30.7ab
Ronstar	20.5b	42.7a	27.2b	19.7b	27.8b	28.4b
Regal 0-0	10.2c	22.1a	20.9b	9.3c	24.5b	22.5c
Control	38.3a	38.3a	38.3a	35.4a	35.4a	36.2a

[z]Growth indices = Height + width at widest point + width perpendicular ÷ 3.

[y]Root rating was an estimate of the percentage of the rootball surface covered with roots (0-100).

[x]means (within a column and for each factor) with different letters are significantly different, according to Duncan's Multiple Range test (α=0.05).

Preventative Liverwort Control with Zerotol Injected into Irrigation Water

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Index Words: *Marchantia polymorpha*, weed control, propagation

Significance to the Industry: Liverwort (*Marchantia polymorpha*) is most problematic in propagation. Most propagation systems are in enclosed structures where chemical control options are limited. Furthermore, the humid conditions of most propagation systems makes a suitable environment for establishment and spread of liverwort. Data herein demonstrate that Zerotol injected through the irrigation system can provide preventative liverwort control. Injection of Zerotol at rates evaluated in this research reduced liverwort establishment and spread compared to non-treated controls, however, it did not completely eliminate the presence of liverwort. Future research will evaluate stronger dilutions in an effort to further improve control with this application technique.

Nature of Work: Liverwort spread sexually by spores and asexually by splashing gemmae. Spores are microscopic and airborne, and thus are impossible to exclude from propagation areas. Gemmae are small asexually produced clonal fragments that accumulate in specialized structures on liverwort thalli (leaves) called gemmae cups. Gemmae splashing allows liverwort colonies to spread quickly from a single plant. Zerotol has been used as a general sanitation agent for controlling some diseases in greenhouse production. There is anecdotal evidence that Zerotol provides liverwort control when injected through irrigation systems, especially in propagation houses. The objectives of this study were to determine if Zerotol injected once or twice each week provides preventative liverwort control.

Two similar experiments were conducted to evaluate the potential for dilute applications of Zerotol to provide preemergence liverwort control. The experiments were conducted in a peaked, retractable roof greenhouse. Fifteen independently irrigated plots were constructed, each 5’ long and wide. The irrigation main-line was split into 5 separate irrigation lines, each passing through one of four Dositron injectors (the fifth line received no injection materials and serves as a control). The five irrigation lines were each randomly assigned to three plots each. All containers in this project were potted with 100% Douglas fir bark amended with 1.5 lbs/yd^3 Micromax and 16 lbs/yd^3 Osmocote 18-6-12. All containers were topdressed with an additional 6 grams Osmocote to promote liverwort growth. Within each 5’x5’ plot, 4 recently potted containers were placed immediately adjacent to a single container heavily infested with liverwort. The liverwort-infested container served as a source of gemmae and spores for the recently potted containers. All data were collected on infestation of the recently potted containers. The four Dositron injectors were calibrated to dilute Zerotol at 2 rates (1:500 or 1:1000, Zerotol:water). These rates were injected either

1 or 2 times each week. Zerotol injection began on April 24, 2004. Irrigation was supplied (and thus Zerotol) at a rate of 0.5 inches per day, split in 2 cycles. Data collected included liverwort growth (coverage of the container surface) through 9 weeks after application. Plant injury was rated weekly through 9 weeks after application.

The second experiment was conducted similarly with the following exceptions. Dositron injectors were set at dilution factors of either 1:500 or 1:1300. In addition to evaluating control similar to that described above, two containers with actively growing Japanese maple (*Acer palmatum*), purple coneflower (*Echinaceae purpurea*), and azalea (*Rhododendron* 'Rosebud') were also evaluated for phytotoxicity.

Results and Discussion: In experiment 1, Zerotol diluted to 1:500 reduced liverwort growth throughout the experiment. However, by 60 DAT only injections that occurred twice each week provided satisfactory control. Even at 1:500 dilution applied two times each week, liverwort still ultimately colonized containers. When injected at 1:1000 dilutions, liverwort growth was reduced compared to non-treated controls through 45 DAT. However, 60 DAT only this dilution applied twice each week provided some control over non-treated containers but even this would be considered commercially unacceptable. Although no treatment provided perfect control, Zerotol injected at a dilution of 1:500 two times each week substantially reduced liverwort growth.

In the second experiment, only the dilution of 1:500 applied two times each week provided better control than non-treated pots. While no visual symptoms of injury were observed on any of the three species tested, azalea growth was reduced. Previous work by the author (unpublished) documented injury to new growth of several plant species with stronger dilutions and more frequent applications. Injury was characterized by small necrotic spots on new growth with some foliar wrinkling. It was believed that the injury was a contact burn-like injury. As soon as treatments ceased, plants rapidly grew past the injury and it was no longer noticeable 30 days after final application. In this experiment no visual symptoms of injury were observed, however, it is possible that new growth was injured.

Table 1. Liverwort coverage of the container surface (%) after regular injections of Zerotol through irrigation lines.

Dilution factor[z]	Frequency[y]	30 DAT[x]	45 DAT	60 DAT
1:500	1	7 cd[w]	25 c	45 b
	2	2 d	5 d	13 c
1:1000	1	22 b	57 b	76 a
	2	11 c	36 c	53 b
Control		33 a	76 a	92 a

[z]Dilution factors represent the relative portion of Zerotol to water (Zerotol:water).

[y]Frequency represents the number of irrigation events each week in which Zerotol was injected.

[x]Days after initial treatment.

[w]Means separated with Fisher's protected LSD ($\alpha = 0.05$).

Table 2. Liverwort control and plant injury from regular injections of Zerotol through irrigation water.

			Shoot dry weight (g)		
Dilution factor[z]	Frequency[y]	Liverwort coverage (%)	Maple	Coneflower	Azalea
1:500	1	23 a[x]	60.0	9.2	8.4 ab
	2	2 b	49.8	7.3	7.0 b
1:1300	1	28 a	46.5	8.0	7.3 b
	2	23 a	57.1	8.4	9.9 a
Control		17 a	61.9	8.7	9.6 a

[z]Dilution factors represent the relative portion of Zerotol to water (Zerotol:water).

[y]Frequency represents the number of irrigation events each week in which Zerotol was injected.

[x]Means separated with Fisher's protected LSD (α = 0.05).

Evaluation of Preemergence Herbicides for Control of Yellow Nutsedge in Herbaceous Perennial Landscape Beds

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Index Words: yellow nutsedge, *Cyperus esculentus L.*, herbicide phytotoxicity, plant injury, herbicide efficacy

Significance to Industry: Effective weed control is important in landscape bed maintenance. Results from this study can help landscape personnel plan yellow nutsedge control program by choosing effective and safe products for herbaceous perennials.

Nature of Work: Yellow nutsedge (*Cyperus esculentus L.*) is a common weed in the residential and commercial landscape plantings that can significantly reduce the overall aesthetic quality of the properties. Several herbicides have been tested for yellow nutsedge control and their efficacy has been evaluated for the landscape scenarios (1). In addition, tolerance of ornamental plants to preemergence herbicide application has been evaluated in ornamental grass (2) annual bedding plants (3), and some woody ornamentals (1). However, no extensive evaluation has been conducted on herbaceous perennials, a group of ornamental plants that are increasingly popular in landscape plantings. The objectives of this study were to evaluate the effectiveness of newly available and standard preemergence herbicides for yellow nutsedge control in landscape beds and to investigate plant injuries due to the herbicides in seven herbaceous perennials.

The experiment was conducted at the LSU AgCenter Hammond Research Station in Hammond, LA. Twenty raised landscape beds (10' x 9') were made using a Side Winder Super Pivot bed shaper (TurfTeq LLC., New Holland, PA) in March 2005, with a 2-foot alley between individual experimental plots. The soil was a sandy silt loam with 1.03% organic matter content and soil pH at about 5.3. As a common landscape practice, pine bark was incorporated at a rate of 7 ft^3 per 1000 ft^2 landscape bed, and control-released fertilizer Osmocote 14-14-14 was incorporated at a rate of 1 lb N per 1000 ft^2. To ensure a uniform yellow nutsedge infestation, tubers (Azlin Seed Service, Leland, MS) were planted on April 7 at a rate of 2.5 lb per 1000 ft^2. Tubers were washed with cold water (13Cº) before being planted to promote germination (4). Based on yellow nutsedge count in the field three weeks after planting, germination rate was estimated at 59.3%, resulting in a nutsedge density of 267 plants per 100 ft^2.

Herbaceous perennials *Cuphea hyssopifola* (Mexican heather), *Gaura lindheimeri* 'Siskiyou Pink', *Lantana hybrida* 'New Gold', *Liriope muscari* 'Big Blue', *Phlox sabulata* 'Candy Strip', *Ruellia brittoniana* (Mexican petunia) 'Katie', and *Verbena canadensis* 'Homestead Purple' were transplanted from 4-inch pots to field plots on April 19.

Five preemergence herbicides: sulfentrazone, trifluralin + isoxaben (Snapshot), flumioxazin (BroadStar), pendimethalin (Pendulum), and S-Metolachlor (Pennant) were applied at 0, 1X (recommended), 2X, and 4X rates (Table 1) on April 21. Experimental design was a randomized complete block design with 4 replications. Each of the twenty landscape beds was divided into four equal size plots. One plant of each of the seven herbaceous perennial species were planted in each plot and treated with one of the four rates of an herbicide. Sulfentrazone and Pendulum were applied with a compressed CO_2 backpack sprayer equipped with a single 8005 flat fan nozzle calibrated to deliver 60 gallon per acre at 30 psi. The three granular products were broadcast with a hand-held shaker. Overhead irrigation was provided with micro sprinklers (Xeri-Sprayer, Rain Bird Corp., Azusa, CA) immediately after treatments.

A second application was applied 4 weeks later on May 19. Nutsedge control was estimated weekly after the first application for an 8-week period. From weeks 1 to 3, control was estimated by counting the number of yellow nutsedge plants in each treatment plot. Due to the un-weilding nutsedge numbers, control from weeks 4 to 8 was estimated as percent control effect (%). Plant injury was visually estimated at weeks 2, 4, 6, and 8 using a scale of 0 to 10, where 0 = no injury and10 = plant death. Plant height and width were measured at the same time as plant injury rating. The analysis of variance (ANOVA) was performed by using PROC GLM (SAS Institute Inc. Cary, NC), and means were compared with the appropriate Fisher's protected LSD at $\alpha = 0.05$.

Results and Discussion: Yellow Nutsedge Control. S-Metolachlor (Pennant) provided the best yellow nutsedge control (89~99%) throughout the experiment (Table 1). Flumioxazin (BroadStar) was less effective at its recommended rate (69% and 84% at weeks 4 and 8, respectively), but obtained good control (80~94% at week 4 and 95~100% at week 8) at higher-than-recommended rates. Sulfentrazone provided effective control (88~100%) after the second application. Similar control effects of S-Metolachlor on yellow nutsedge have been reported in field crop studies (5). Pendimethalin (Pendulum) and trifluralin + isoxaben (Snapshot) had poor control (0~6% and 25~33%, respectively) of yellow nutsedge even after two applications.

Plant Injury. Different injury symptoms were observed among plant species and herbicides and included leaf burn, leaf chlorosis, reduced flowering, and stunted growth (data not shown). Generally, the second application caused more significant injury than the first application ($p < 0.0001$, data not shown) possibly because temperature was higher and plants were larger (more active uptake) at the time of the second application. Before the second application, most plant species exhibited tolerance when herbicides were applied at their recommended rates. Exceptions were Liriope that was moderately injured by fluminoxain and sulfentrazone (Table 2, ratings = 4.0 and 2.3, respectively) and Guara that was injured by sulfentrazone (rating = 2.8). When herbicides were applied at higher than recommended rates, fluminoxain also caused moderate damage on phlox and Mexican petunia, and sulfentrazone resulted in moderate phytotoxicity on lantana. After the second application, fluminoxain caused severe damage on phlox and Mexican petunia at the recommended rate and moderately injured Mexican heather and Liriope (Table 2). Sulfentrazone resulted in only minor injuries when applied at the recommended rate, but was damaging at higher rates, Guara, Mexican heather, and Liriope were severely damages when sulfentrazone was applied at 4X rate. All plants tested were tolerant to trifluralin + isoxaben except Mexican petunia. Pendimethalin and S-Metolachlor caused minor phytotoxicity that was negligible. Verbena was the most tolerant species compared with other tested perennials.

Based on these results, S-Metolachlor (Pennant) provided the best yellow nutsedge control and caused little phytotoxicity on the herbaceous perennial plants. Flumioxazin (BroadStar) and sulfentrazone also provided effective control but resulted in severe plant injury.

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Table 1. Control effects of five preemergence herbicides on yellow nutsedge at 4 and 8 weeks after the first treatment based on visual estimation of percent control efficacy (%), where 0 = no control effect and 100% = complete control.

Herbicide		**Rate**		**Week 4**	**Week 8**
Trade Name	**Active Ingredient**		**a.i./A**	**%**	**%**
BroadStar 0.25G	flumioxazin	1X	0.375 lb	69 bcd	84 b
		2X	0.75 lb	80 ab	95 ab
		4X	1.5 lb	94 a	100 a
Snapshot 2.5 TG	trifluralin + isoxaben	1X	2.5 lb	33 ef	23 d
		2X	5.0 lb	30 fg	25 d
		4X	10.0 lb	59 d	53 c
Pendulum 2G	pendimethalin	1X	2.0 lb	6 hi	0 d
		2X	4.0 lb	25 fgh	15 d
		4X	8.0 lb	13 ghi	0 d
Pennant 7.62EC	S-Metolachlor	1X	2.5 lb	89 a	91 ab
		2X	5.0 lb	96 a	95 ab
		4X	10.0 lb	99 a	98 ab
Sulfentrazone	sulfentrazone	1X	0.25 lb	51 de	88 ab
		2X	0.5 lb	66 cd	98 ab
		4X	1.0 lb	88 ab	100 a
Untreated Control		--	--	0 i	0 d
$LSD_{0.05}$				19	14

Table 2. Plant injury ratings at 4 and 8 weeks estimated visually using a scale of 0 (no injury) to 10 (plant death).

Herbicide	**Rate a.i./A**	**Mexican Heather**		**Guara**		**Lantana**		**Liriope**		**Phlox**		**Mexican Petunia**		**Verbena**	
Week	lb.	4	8	4	8	4	8	4	8	4	8	4	8	4	8
flumioxazin	0.375	0.4 b	5.5 c	0 c	0 c	0 c	1.3 cd	4.0 a	3.4 c	1.0 cd	8.5 a	0.4 c	7.3 b	0.1 bc	0.3 bc
	0.75	0.3 b	7.3 b	0 c	0.3 c	0 c	1.5 c	2.3 b	3.3 c	1.9 bc	8.5 a	1.8 b	9.3 a	0.5 ab	0.1 bc
	1.5	0.4 b	9.8 a	0 c	0.8 c	0 c	6.5 a	4.3 a	5.3 b	4.5 a	9.5 a	4.8 a	9.3 a	0.4 bc	1.8 a
trifluralin + isoxaben	2.5	0.1 b	0 e	0 c	0 c	0 c	0.3 cd	0 c	0.3 d	0.1 de	0.1 e	0 c	0.1 d	0.3 bc	0.8 b
	5.0	0 b	0 e	0 c	0 c	0 c	0.5 cd	0 c	0.5 d	0 e	0.5 de	0 c	0.5 d	0 c	0 c
	10	0 b	0 e	0 c	0 c	0 c	0.8 cd	0 c	0.1 d	0.3 de	1.6 cd	0.9 bc	4.0 c	0.1 bc	0.8 b
pendimethalin	2.0	0 b	0 e	0 c	0 c	0 c	0 d	0 c	0.5 d	0 e	0 e	0 c	0 d	0 c	0 c
	4.0	0 b	0 e	0 c	0 c	0 c	0 d	0 c	0 d	0 e	0 e	0 c	0.1 d	0 c	0 c
	8.0	0 b	0 e	0 c	0 c	0 c	0 d	0 c	0 d	0 e	0 e	0 c	0.1 d	0 c	0 c
S-Metolachlor	2.5	0 b	0 e	0 c	0 c	0 c	0 d	0 c	0 d	0 e	0 e	0 c	0 d	0.1 bc	0 c
	5.0	0 b	0 e	0 c	0 c	0 c	0 d	0 c	0 d	0 e	0 e	0 c	0.1 d	0.1 bc	0 c
	10	0.1 b	0 e	0 c	0 c	0 c	0 d	0 c	0 d	0 e	0 e	0 c	0.3 d	0.1 bc	0 c
sulfentrazone	0.25	0.3 b	0.1 e	2.8 b	1.3 c	0.5 b	0.9 cd	2.3 b	3.1 c	0.3 de	2.3 c	0.6 c	0.1 d	0.3 bc	0.1 bc
	0.5	0.4 b	2.5 d	2.8 b	5.0 b	0.6 b	1.5 c	3.5 ab	6.0 b	0.6 de	2.0 c	0.8 c	0.5 d	0.4 bc	0.4 bc
	1.0	1.4 a	9.0 a	8.0 a	10.0 a	2.0 a	4.8 b	4.5 a	8.3 a	2.8 b	3.8 b	0.5 c	0.6 d	0.9 a	0.1 bc
Untreated Control		0 b	0 e	0 c	0 c	0 c	0 d	0 c	0 d	0 e	0 e	0 c	0 d	0 c	0 c
LSD $_{0.05}$		0.48	1.51	1.60	1.69	0.34	1.38	1.74	1.60	0.89	1.44	0.88	1.62	0.46	0.66