Weed Control

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Cottonwood Control in Nursery Containers

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Index words: woody weed species, poplar, weed control.

Significance to Industry: Several cottonwood species (*Populus* spp.) are native throughout the U.S. While cottonwood are essential to local ecosystems, they can also be a serious weed threat to nearby nurseries. Commonly used preemergence herbicides can be used to prevent establishment of these species in nursery containers. BroadStar provided the most effective preemergence control of black cottonwood.

Nature of Work: Cottonwoods are regionally abundant and native trees that can become weedy in container and field nurseries. Black cottonwood (*Populus trichocarpa*) is the species native throughout western Oregon, Washington, and British Columbia. Seed dispersal from mature cottonwood into nursery containers is the primary route of entry for cottonwood infestations. Black cottonwood is a dioecious species, with male and female flowers occurring on separate plants. Black cottonwood disseminate seeds mid May to early June in the northern Willamette Valley of Oregon. Seeds of cottonwood are attached to a white, cotton-like appendage called the coma which aids in wind dispersal. Upon release, seeds of cottonwood must land in a suitable environment for germination. Viability of cottonwood seed is high for about two weeks, after which seeds lose all viability. Disturbed soil with no competing vegetation, coupled with abundant light and available water is necessary for germination and establishment. In natural ecosystems, riparian areas along streams, rivers, and lakes are ideal. Container crops are also conducive sites for germination, due to their exposed substrate surfaces (high light) and exposure to frequent irrigation or abundant rainfall during the time of seed release. If a seed lands in a suitable site, germination occurs in 8 to 24 hours. Seed viability is 94% (3) on the first day after release from the mother plant, but declines rapidly thereafter.

In addition to its value in natural ecosystems, cottonwood is cultivated throughout the U.S. for its veneer and pulp wood. Because of its commercial importance, herbicides have been evaluated for weed control among cottonwood (1, 2). However, the goal of these research endeavors was to evaluate herbicides for safe application among cultivated cottonwoods. Because cottonwood are weedy in nursery containers, the objective of this research was to evaluate commonly used preemergence herbicides for cottonwood control in container nurseries.

On May 15, 2006, #1 containers were filled with 100% Douglas fir (*Pseudotsuga menziesii* (Mirbel) Franco) bark amended with 16 lbs/yd^3 Apex 18N-2.6P-10K (Pursell Technologies, Sylacauga, AL), 5 lb of dolomitic lime, and 1.5 lbs/yd^3 Micromax micronutrients (Scott's Co., Marysville, OH). Granular herbicides (Table 1) were applied May 25 with a handheld shaker. A non-treated control group was also maintained. Containers were irrigated immediately after herbicide application with 0.5 in water. Containers were placed on a wagon and moved to beneath a mature black cottonwood tree to collect falling seed. The wagon was moved daily back to the nursery production site and irrigated, then returned to the tree. After 2 weeks of collecting seed, the containers were moved to the nursery production site for the remainder of the experiment. There were eight single container replications per treatment arranged in a completely randomized design. Data collected included cottonwood number 4 weeks after treatment (WAT) and cottonwood shoot dry weight (SDW) 10 WAT. Data were subjected to analysis of variance. Weed number data were square root transformed prior to analysis, but actual data are presented for clarity. Means were separated with Duncan's multiple range test ($\alpha = 0.05$).

Results and Discussion: When containers were finally moved back to the nursery production site, there were approximately 80 seed or seedlings per container. Most seed had germinated. By 4 WAT, BroadStar reduced weed numbers by 98%, similar to Regal O-O but more so than all other treatments.

At 10 WAT, BroadStar still provided the most effective control in terms of weed number with less than one plant per container. BroadStar reduced cottonwood numbers more than other herbicides, although average height and SDW were similar to Rout, Snapshot, and Pendulum. This indicates that the few surviving cottonwood in each container treated with BroadStar grew relatively large. Conversely, the greater numbers of seedlings that established in containers treated with Regal O-O, Snapshot, and Pendulum remained stunted with little growth.

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Table 1. Black cottonwood number, height, and growth in containers treated with preemergence herbicides.

		4 WAT[z]	10 WAT	
Herbicide	Rate (lb ai/A)	Number[y]	Number	SDW (g)
Regal O-O	3	2.9 de[w]	8.1 cd	2.9 c
Snapshot 2.5 TG	5	4.6 d	5.5 d	6.2 c
Pendulum 2G	4	5.4 d	7.5 cd	7.2 c
Ronstar G	4	12.8 c	13.0 v	15.1 b
BroadStar	0.3	0.8 e	0.9 e	4.5 c
OH II	3	20.9 b	25.4 b	22.1 ab
Non-treated control		32.5 a	39.3 a	25.4 a

[z] Weeks after treatment, which occurred on May 25.

[y] Black cottonwood number data were square-root transformed prior to analysis, but actual data are presented.

[x] Shoot dry weight of black cottonwood seedlings.

[w] Means within a column are similar according to Duncan's multiple range test.

Sustainable Methods for Weed Control in Nurseries

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Significance to Industry: Effective weed control is essential in nurseries and is one of the largest expenses for the industry. In order to achieve environmental sustainability and reduce chemical impacts such as herbicide leaching and runoff, alternative methods to herbicide use were tested. Results from this trial suggest that several materials covering the surface of the substrate can be valid alternatives to herbicides, while others provide inefficient weed control or serious plant damage.

Nature of Work: Weed control can be one the most costly risks in the production of container-grown nursery crops (14). Weeds compete with plants for water and nutrients thereby reducing growth and quality (10, 12, 13, 17). Research has shown that even a little weed in a small (1 gal) pot can affect crop growth (4), but this is highly dependent on weed and crop species present (5). For example, a large redroot pigweed (*Amaranthus retroflexus*) or a large crabgrass (*Digitaria sanguinalis*) plant per pot reduces the growth of 'Convexa' Japanese holly (*Ilex crenata*) by 47% and 60%, respectively (7). However, even if weeds do not reduce growth, a container plant with weeds is a less marketable product than a weed-free product (15).

Weed management in nursery crops has to take into account various facets: the minor effectiveness of herbicide treatments due to increased tolerance to weeds by herbicide, the high cost of manual removal of weeds and the need to reduce herbicide applications for environmental safeguard and workers health (1).

Problems associated with chemical use in container production include improper calibration, herbicide runoff from plastic or gravel (especially when chemical falls between containers) and the need for multiple applications (11). Previous research has shown that up to 80% of a granular formulation applied to container nurseries may end up on the bed surface and not within the pot, with the percentage lost being determinate by plant shape, spacing and pot size (9). Herbicides are used repeatedly during the year to control weeds in container, resulting in significant non-target losses (11). Nurseries growers estimate that they spend $500 to $4000/acre of containers for manual removal of weeds, depending on weed species being removed. Economic losses due to weed infestation have been estimated at approximately $7000/acre (5, 11). Thereby, nursery producers interested in non-chemical alternatives to control container weeds are increasing. Environmentally-friendly materials such as bark, mineral material, rice or peanut hulls, natural fiber disc (coconut and viscose) and hazelnut shells have been evaluated for controlling weeds in containerized crops with good results (6, 8).

This research was conducted in an experimental nursery located nearby Milan (Italy; 45°44' N, 9°04' E), during 2006 summer (May – October) to evaluate the effectiveness, degradation time, and costs of some environmentally-friendly materials used to control weeds in containers. One-year-old uniform rooted cuttings of *Photinia* x *fraseri* 'Red Robin' (120 plants), *Prunus laurocerasus* 'Rotundifolia' (120 plants) and *Thuja plicata* 'Atrovirens' (120 plants) were potted on May 2006 into 3 L (0.8 gal) plastic containers filled with a mixture of 4 sphagnum peat: 1 pumice (v/v) and amended with 4 $kg \cdot m^{-3}$ (6.8 lb/yd^3) of calcium carbonate. A controlled release fertilizer, Ficote® (15-8-12), was incorporated at the rate of 4 $kg \cdot m^{-3}$ (6.8 lb/yd^3) into the medium before potting. Plants were placed in six randomized blocks repeated four times.

The non-chemical materials used to prevent weed growth were: 1) discs made of coconut fiber; 2) discs constituted by vegetal fiber (90%) and synthetic fiber (10%); and 3) discs constituted by viscose fiber (98%) and polyvinylic alcohol (2%). As in previous works this material degraded quickly (1, 2), in this experiment two discs per pot have been used and; 4) Gerval® (Gerval Srl, Reggio Emilia, IT) constituted by a mineral grain mixture without chemical additives. This material was distributed over the substrate as a 1.5 cm (0.6 in) layer. The effectiveness of these materials was compared with a chemical control (a single application of 180 kg/ha (160 lb/acre) of Ronstar® (oxadiazon) in granular formulation) and with an untreated control. Plants were watered daily by overhead irrigation throughout the trial. Standard nursery procedures for pest control were followed. Plant height was measured at the beginning and at the end of the growing season. Shoot and root fresh and dry weight were recorded at the end of the growing season on four plants per species and treatment. Roots were cleaned from the growing medium with compressed air. To determine dry weight, leaves, stems and roots were put in oven at 105 °C till constant weight was reached. The weeds in the pots were counted and removed every 45 days. All data were subjected to one-way analysis of variance (ANOVA) using Statgraphics® Plus (Manugistic Inc., Rockville, MD) and means were separated by Duncan's multiple range test ($P \leq 0.05$). An economic evaluation of treatments was performed assuming a hourly cost of 22.32 € ($ 30.85) (3).

Results and Discussion*:* *effectiveness of weed control*: Ronstar® provided very satisfactory weed control for the whole growing season. The effectiveness of the different materials tested was directly related to their longevity in a production environment (Tab. 1). After a certain period, the progressive degradation of the materials covering the substrate surface allowed weed growth. Among the different materials, coconut fiber discs provided weed control as good as Ronstar®, because of its resistance to degradation; no degradation was observed during the time of the trial. Moreover, as observed in previous works (1, 2), coconut discs breakdown was so limited that they can be used the following season. Weed control with the vegetal and synthetic fiber discs didn't differ significantly from Ronstar® and coconut discs, but their longevity in containers limited them to one growing season. Fiber viscose discs had a quick degradation time and their efficacy in controlling weeds was limited after only 90 days from application. After 135 days, the fiber viscose disc was completely deteriorated and its effectiveness was similar to the untreated control. Gerval® provided acceptable weed control, depending on the crop species. As found in previous research (16), this product causes serious damage to the root flare because its rigidity does not allow secondary growth of the stem (Photo 1). This leads to phloem disruption and to stem fragility. Regardless of mulching materials, no significant difference of plant height and biomass production among treatments were shown in this experiment (data not reported).

Cost of weed control: Chemical control with a single application per year of Ronstar® had the lowest cost (0.04 € or $0.06/pot distribution), but this value doesn't take into account non-economic chemical impacts, such as environmental damage and non-target loss of the herbicide. .Weed discs can be applied efficiently. Total cost/disc (including installation) is 0.10 € or $0.14/pot for vegetal-synthetic fiber and viscous fiber, while it's 0.19 € or $0.26/pot for the coconut fiber. However, since the latter can be used for more than one growing season, its cost can be amortized in two or three years. Gerval® has the highest cost (0.34 € or $0.47/pot) among the tested products. Moreover, it requires a particular care for correct application. Product and application costs must be compared with the manual removal of weeds that costs from 0.27 € or $0.37/pot to 0.73 € or $1.00/pot according to the growing rate of the crop.

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Table 1. Average number of weeds removed from containers after 45, 90 and 135 days from potting (DFP).

***Photinia x fraseri* 'Red Robin'**						
	45 DFP		90 DFP		135 DFP	
Coconut discs	0.5	c[z]	3.8	b	1.7	bc
Vegetal and synthetic fiber discs	1.1	bc	2.8	bc	3.4	bc
Fiber viscose discs	1.8	b	1.3	cd	7.0	b
Mineral mixture (Gerval®)	0.2	c	0.6	d	2.7	bc
Chemical control (Ronstar®)	0.0	c	0.1	d	0.0	c
Untreated control	5.0	a	9.4	a	11.9	a
P-value	*0.000*		*0.000*		*0.000*	

***Prunus laurocerasus* 'Rotundifolia'**						
	45 DFP		90 DFP		135 DFP	
Coconut discs	0.3	cd	1.4	b	0.6	bc
Vegetal and synthetic fiber discs	0.7	b	1.1	b	0.6	bc
Fiber viscose discs	1.0	b	1.4	b	2.3	a
Gerval®	0.3	cd	0.4	b	1.3	b
Chemical control (Ronstar®)	0.1	d	0.1	b	0.1	c
Untreated control	1.8	a	4.1	a	2.5	a
P-value	*0.000*		*0.000*		*0.000*	

***Thuja plicata* 'Atrovirens'**						
	45 DFP		90 DFP		135 DFP	
Coconut discs	0.3	b	0.5	b	3.9	b
Vegetal and synthetic fiber discs	0.1	b	0.4	b	9.0	b
Fiber viscose discs	1.6	b	0.4	b	11.0	a
Gerval®	0.0	b	0.1	b	2.6	a
Chemical control (Ronstar®)	0.6	b	0.5	b	4.2	b
Untreated control	4.8	a	2.7	a	10.4	a
P-value	*0.000*		*0.000*		*0.000*	

[z] Means within the same column with different letters are significantly different, Duncan's multiple range test ($P \leq 0.05$).

Photo 1 – Gerval damage on root flare of *Photinia* x *fraseri*.

Control of Liverwort (*Marchantia polymorhia*) in Herbaceous Perennials

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Index words. *Marchantia polymorphia*, herbaceous perennials, nursery crops

Significance to the Industry. Liverwort (*Marchantia polymorphia*) is a common problem in many nursery containers, including herbaceous perennials. It would be advantageous to an herbaceous perennial grower for additional postemergence or preemergence control options for liverwort. This study demonstrates that there are postemergence options available for Liverwort control while also providing residual for premergence control, although application timing is a critical factor for herbicide application in herbaceous perennials.

Nature of work. It has been shown that flumioxazin (1) and diuron (1,2)can control liverwort preemergence; however, it is not known whether or not these products can control them postemergence. Flumioxazin and diuron are often phytotoxic to herbaceous perennials during active growth; however, it is not known what effect they have to dormant material. The objective of this study was to determine if liverwort could be controlled postemergence from four sprayable herbicides during overwintering of herbaceous perennials. Phytotoxicity and efficacy trials were conducted at The Ohio State University, Columbus, Ohio, starting on March 1, 2006. Ten herbaceous perennials were selected for phytotoxicity; coral bells (*Heuchera* 'Palace Purple'), yarrow (Achillea 'Anthea'), spiderwort (*Tradescantia* 'Mrs. Loewer'), sedge (*Carex* 'Silver Scepter'), beard-tongue (*Penstemon* 'Husker Red), shasta daisy (*Leucanthemum* 'Alaska'), purple coneflower (*Echinacea* 'Bravado'), jacob's ladder (*Polemonium caeruleum*), dwarf columbine (*Aquilegia* 'Cameo Pink & White'), and Siberian iris (*Iris* 'Butter and Sugar'). All species were vegetatively propagated in August of 2005 and put into #1 containers with a media consisting of 60% pine bark, 20% Rice hulls, 10% sand 5% technigrow (composted sewage sludge, Kurtz Brothers, Inc., Groveport, OH), and 5% stone aggregate. All species (with the exception of Shasta daisy) had just broken dormancy at the start of the trial, much to the dismay of the investigators. Treatments consisted of Zerotol (peroxyacetic acid plus additives) at 1.25 oz/gal solution (equivalent to a 1:100 dilution), SureGuard (flumioxazin) at 0.25 lb ai/ac, quinoclamine (will be marketed as Gentry in the U.S.) at 2 oz/gal solution, Diuron (diuron) at 1 lb ai/ac, and untreated control. Carrier volume was 25 gal/ac of water for all treatments using a CO_2 backpack sprayer equipped with Teejet™ 8002 evs nozzles spaced 19 in apart. Spray pressure was approximately 44 psi. Treatments were reapplied 4 weeks later on March 29, 2006. The label for Gentry at the time of application suggested using 100 gal/ac as a carrier volume (it is now 200 gal/ac), so this was used for the second application of Gentry using Teejet™ VS 7.5 nozzles with 19 in spacing and a spray pressure of 47 psi. Phytotoxicity was evaluated by taking visual ratings based on a 1-10 scale (1 representing no phytotoxicity, ≤3 commercially acceptable, and 10 death) at 1 and 2 weeks after each treatment. Plant heights and widths were taken at 1 DAT (day after treatment) and 8 WAT (weeks after treatment) for all species except the Spiderwort and Iris, only heights were taken for these two species because of their growth habit. For the efficacy trial, the same treatments described above were applied at the same time as the phytotoxicity trial to established liverwort in XL 250 containers (Nursery Supplies Inc., Fairless Hills, PA) with a Scotts 360 (Scotts Co., Marysville, OH) media. Efficacy was evaluated by taking visual ratings at 1 and 2 weeks after each treatment. Both trials were set up in a randomized complete block design with 4 single pot replications per treatment. Analysis of covariance using Dunnett's t-test was conducted for phytotoxicity data to compare treatments to the control using Proc Mixed in SAS. Analysis of covariance was also used for efficacy data in Proc Mixed; however, treatments were compared using least squares means to find the best treatments.

Results and Discussion: *Phytotoxicity.* Jacob's ladder, shasta daisy, beard-tongue, sedge, yarrow, purple coneflower, and spiderwort all showed phytotoxicity from the SureGuard treatment, with all those species except the sedge (with a phytotoxicity of only 2), being severely injured beyond commercially acceptable levels (Table 1). Sedge and purple coneflower did not show injury until after the second application. Jacob's ladder, shasta daisy, yarrow, and purple coneflower showed phytotoxicity from Diuron after the second application; the coneflower and yarrow were the only species severely injured from Diuron. None of the species were injured beyond commercially acceptable by Zerotol or Gentry. Columbine, in general, across all treatments did not grow well, which explains the high phytotoxicity levels, even with the untreated controls. The untreated coral bells had a high level of phytotoxicity because some of them either did not grow or died shortly after emergence.

Efficacy. Efficacy was quite high for the duration of the experiment from Gentry (Table 2). Approximately 3 weeks after the first application, both SureGuard and Diuron were causing the liverwort to turn brown. By the end of the experiment, all the liverworts were dead from the Diuron and almost dead with the SureGuard. It is the opinion of the author that the second application was probably not needed for the SureGuard and Diuron to control the liverwort. Gentry, on the other hand, provides little, if any residual, and the second application was needed to control the liverwort for the duration of the experiment (which may or may not have been from the lower application volume at the first application). Zerotol had little effect on the liverwort; some browning, which did not cause death, was all that was noticed. It should also be noted, that even though the trial was ended at 4 weeks after the second application, control of liverwort was achieved for approximately 6 months with the SureGuard and Diuron. Looking at reduced rates of these chemicals is warranted in herbaceous material, which often show phytotoxicity to these chemicals at the recommended rates. SureGuard and Diuron were applied as sprayables; granular forms exist which could alleviate some of the phytotoxicity, so they also should be studied. The perennials should also be dormant at time of application.

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Table 1. Phytotoxicity of selected herbaceous perennials using Zerotol, SureGuard, Gentry, and Diuron During Overwintering

Achillea ‘Anthea’

Treatment	2 WA1T[z]	4 WA1T	2 WA2T	4 WA2T
Zerotol	1.0	1.0	1.0	2.3
SureGuard	3.0 *[y]	3.2 *	7.0 *	7.2 *
Mogeton	1.0	1.0	1.0	1.3
Diuron	1.3	1.8	5.2 *	4.2 *
Control	1.0	1.0	1.5	1.0

Tradescantia ‘Mrs. Loewer’

Treatment	2 WA1T[z]	4 WA1T	2 WA2T	4 WA2T
Zerotol	1.0	1.0	1.7	1.3
SureGuard	4.0 *	5.5 *	7.0 *	3.5 *
Mogeton	1.0	1.0	2.0	1.5
Diuron	1.0	1.0	2.8	1.8
Control	1.0	1.0	1.3	1.3

Carex ‘Silver Scepter’

Treatment	2 WA1T[z]	4 WA1T	2 WA2T	4 WA2T
Zerotol	1.0	1.0	1.0	1.0
SureGuard	1.0	1.8	3.8 *	3.0 *
Mogeton	1.0	1.0	1.3	1.0
Diuron	1.0	1.8	2.3	1.5
Control	1.0	1.0	1.0	1.0

Penstemon ‘Husker Red

Treatment	2 WA1T[z]	4 WA1T	2 WA2T	4 WA2T
Zerotol	1.0	1.3	1.0	1.3
SureGuard	3.2 *	4.0 *	6.8 *	5.0 *
Mogeton	1.0	1.0	1.0	1.0
Diuron	1.3	1.0	1.8	1.8
Control	1.0	1.3	1.0	1.0

Leucanthemum ‘Alaska’

Treatment	2 WA1T[z]	4 WA1T	2 WA2T	4 WA2T
Zerotol	1.0	1.3	1.0	1.0
SureGuard	2.5	4.2 *	8.0 *	5.2 *
Mogeton	2.3	1.5	1.5	1.0
Diuron	2.5	1.0	3.5 *	2.8 *
Control	1.0	1.0	1.0	1.0

Echinacea ‘Bravado’

Treatment	2 WA1T[z]	4 WA1T	2 WA2T	4 WA2T
Zerotol	1.0	1.0	3.5	4.0
SureGuard	1.0	3.8	9.0 *	8.0
Mogeton	5.5	1.0	2.3	7.8
Diuron	3.3	4.0	8.5 *	9.8
Control	3.3	1.0	1.7	6.0

Polemonium caeruleum

Treatment	2 WA1T[z]	4 WA1T	2 WA2T	4 WA2T
Zerotol	1.0	1.3	2.0	1.0
SureGuard	6.0 *	6.8 *	7.2 *	5.8 *
Mogeton	1.8	1.0	2.8	1.5
Diuron	1.3	2.3	3.8 *	2.8
Control	1.3	1.5	1.0	1.5

Aquilegia ‘Cameo Pink & White’

Treatment	2 WA1T[z]	4 WA1T	2 WA2T	4 WA2T
Zerotol	1.5	3.5	3.8	8.0
SureGuard	2.8	3.5	6.8	6.3
Mogeton	1.8	1.5	2.0	4.5
Diuron	1.8	2.3	5.5	6.8
Control	1.5	1.5	4.0	7.8

Iris ‘Butter and Sugar’

Treatment	2 WA1T[z]	4 WA1T	2 WA2T	4 WA2T
Zerotol	1.0	1.0	1.0	1.3
SureGuard	1.0	1.0	3.0	4.3
Mogeton	1.0	1.0	1.5	3.5
Diuron	1.0	1.0	1.8	2.0
Control	1.0	1.0	1.0	6.3

Heuchera ‘Palace Purple’

Treatment	2 WA1T[z]	4 WA1T	2 WA2T	4 WA2T
Zerotol	1.0	1.0	1.3	1.5
SureGuard	1.0	1.0	3.5	4.5
Mogeton	1.0	1.0	1.0	1.5
Diuron	1.0	1.0	2.5	2.5
Control	2.5	3.3	3.7	5.5

z= WA1T: weeks after first treatment, WA2T: weeks after second treatment

y= Treatments denoted with * are significantly different from control at that evaluation date, based on Dunnett's t-test (α = 0.05)

Table 2. Postemergence control of liverwort using Zerotol, SureGuard, Mogeton, and Diuron

Treatment	2 WA1T[z]	4 WA1T	2 WA2T	4 WA2T
Zerotol	0.5 c[y]	0.0 c	0.0 d	1.8 c
SureGuard	4.0 b	3.0 b	6.2 c	9.2 ab
Mogeton	5.8 a	5.0 a	9.0 a	8.2 b
Diuron	0.5 c	0.0 c	7.5 b	10.0 a
Control	0.0 c	0.0 c	0.00 d	0.00 d

z= WA1T: weeks after first treatment, WA2T: weeks after second treatment

y= Treatments with similar letters in the same column are not significantly different, based on LSmeans (α = 0.05)

Mulch Depth Effects Weed Germination and Growth

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Index words: pine bark, container production, non-chemical control

Significance to the Nursery Industry: For many years pine bark mini-nuggets have been used for weed control in the landscape. Pine bark is readily available, economical and aesthetically acceptable to consumers. Our results show that pine bark mini-nuggets as a mulch can provide excellent weed control in container grown nursery crops. Furthermore, there is potential to reduce herbicide use in nursery production utilizing pine bark mini-nugget mulch as a form of weed control.

Nature of Work: Traditionally weed control during nursery production has been primarily managed through hand weeding and/or herbicides. However increased labor cost has made hand-weeding cost prohibitive as a sole weed control practice (2, 3). With increasing labor costs, pre-emergence applied herbicides have become standard practice for container-nursery weed control (1). However, environmental concerns over chemical weed control have caused the nursery industry to evaluate alternative weed control options (4). Our objective was to use pine bark mini-nugget mulch as a form of weed control in small containers.

On June 19, 2006, 3 gallon containers were filled with pinebark:sand (6:1) (v:v), amended with 14 lbs/yd^3 of 17-6-12 Polyon (control-release fertilizer), 5.0 lbs/yd^3 of dolomitic lime, and 1.5 lbs/yd^3 of Micromax, and irrigated to allow settling. Pine bark mini-nuggets to be used as mulch had a particle size distribution of: 11% between 1.0 and 2.0 inches, 68% between 0.5 and 1.0 inches, 14% between 0.25 and 0.5 inches, and 7% was less than 0.25 inch. Each weed species was evaluated in a separate set of containers. Three treatments consisted of broadcasting 25 spotted spurge (*Chamaesyce maculata)* (spotted spurge) or 25 eclipta (*Eclipta prostrata)* (eclipta) seed directly onto the potting substrate surface and then pine bark mini-nugget mulch was hand applied at 0, 0.5 and 1.0 in. Remaining treatments consisted of hand applying the pine bark mini-nugget mulch at 0.5 or 1.0 in. onto the potting substrate then overseeding the 25 spurge or eclipta seed. Weed number was recorded at 15, 30, and 60 days after seeding (DAS) and weed fresh weight was collected 60 DAS.

Results and Discussion: Eclipta number per container were less in mulched containers compared to non-mulched containers and were similar regardless of seed placement (Table 1). Our data was similar to previous research, indicating that an increase in thickness of mulch improves weed control (6). Fifteen and 30 DAS, weed number was reduced by 67 and 57% (0.5 in.) and 99 and 93% (1.0 in.) compared to the non-mulched treatment. Sixty DAS, weed number was reduced by 54% (0.5 in.) and 87% (1.0 in.) compared to the non-mulched treatment. Eclipta fresh weights were significantly less in both mulching depths; 49% (0.5 in.) and 89% (1.0 in.) less compared to the non-mulched treatment. Mulching to a depth of 1.0 in., resulted in better weed control compared to mulch applied at 0.5 in. on all dates. Additionally, there was an interaction between placement of seed and mulch depth in fresh weight of eclipta (data not shown). Eclipta seed placed either below or above 1.0 in. mulch had less fresh weight compared to all other treatments, with seeds placed 1.0 in. below mulch having the least fresh weight.

Spurge number was less in mulched containers compared to non-mulched containers (Table 1). Spurge seed placed below the mulch had greater spurge numbers per container at 30 and 60 DAS. While spurge FW was not significant with seed placement, fresh weight tended to be greater (0.06) when seed were placed below the mulch. Applying 1.0 in. mulch resulted in less weed number compared to 0.5 inch. Fifteen DAS spurge number was reduced by 61% (0.5 in.) and 99% (1.0 in.) compared to the non-mulched treatment. Thirty and 60 DAS weed number was reduced by 55 and 45% (0.5 in.) and 92 and 74% (1.0 in.) compared to the non-mulched. At 15 and 30 DAS an interaction between mulch depth and seed placement occurred (data not shown). Spurge seed placed 0.5 in. below mulch had a reduction in number by 39% whereas seed placed above 0.5 in. mulch had a reduction of 83% compared to the non-mulched 15 DAS. Spurge seed placed below or above 1.0 in of mulch had a reduction in weed number by 99 and 100% compared to the non-mulched treatment at 15 DAS and 90 and 95% at 30 DAS. Similarly, spurge seed placed below 1.0 in. mulch had an average FW of 1.5 ounces compared to 4.2 ounces when spurge seed was placed above 1.0 in. mulch.

Results indicate pine bark mini-nuggets applied at 1.0 in. depth can significantly reduce eclipta and spurge numbers in container-grown crops. Increased spurge numbers below mulch application suggest that mulch applied at potting may be more effective than when applied during the growing season to recently hand weeded containers. With eclipta, seed placement had no effect on weed numbers throughout the test.

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Table 1. Main effect means of using pinebark mini-nuggets to control *Eclipta alba* and *Chamaesyce maculata*.

	Eclipta				Spurge			
	Weed number			FW[z]	Weed number			FW
Experimental variable	**15 DAS[y]**	**30 DAS**	**60 DAS**	**60 DAS**	**15 DAS**	**30 DAS**	**60 DAS**	**60 DAS**
Placement of seed[x]								
Below Mulch	1.6	1.8	1.6	304	2.4	2.8	3.6	269.2
Above Mulch	1.4	2.6	2.1	343.6	0.6	1.3	2.3	166.7
Mulching depth								
0.5 inch	2.9	3.7	2.9	529.6	2.9	3.5	4.1	354
1.0 inch	0.1	0.6	0.8	118.1	0.1	0.6	1.9	81.9
Non-treated[w]	8.9	8.1	6.3	1040.4	7.5	7.8	7.4	644.5
Main Effects:	probability							
Placement	0.641	0.172	0.383	0.543	0.001	0.005	0.125	0.063
Mulch depth	<.001	<.001	<.001	<.001	<.001	<.001	0.013	<.001
Interaction	0.485	0.458	0.110	0.005	0.002	0.035	0.070	0.002

[z] Fresh weight (grams).

[y] DAS - days after seeding.

[x] Eclipta or spurge overseeded @ 25 seed per container below or above mulch.

[w] Non-treated - weeds were seeded directly onto the potting substrate, no mulch applied.

[v] Means (within a column) significant according to Least Significant Difference Test (α = 0.05).

Effect of Preemergence Herbicides on the Cold Hardiness of Container-grown Kurume Hybrid Azalea (*Rhododendron* x *hybrida* 'Tradition')

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Index Words: Azalea, Broadstar, cold acclimation, Dimension, dithiopyr, flumioxazin, Gallery, herbicides, isoxaben, Kurume hybrid, metolachlor, norflurazon, oryzalin, Pennant, plant hardiness, Predict, *Rhododendron* x *hybrida* >Tradition=, Surflan, Tradition azalea.

Significance to the Nursery Industry: Cold damage is a major concern to the nursery industry throughout the United States. Cold injury to nursery ornamentals is costly, and any information that could help prevent cold damage would be welcomed by the industry. Many containerized nurseries grow plants that are marginally hardy for their area, and often losses due to cold damage can be substantial. Acclimation of a plant to the cold is a complicated process influenced by many factors. Some of these factors are controllable and include fertility, watering regimes, and pesticide applications. Preemergence herbicides are often applied before plants are moved to over-winter houses, and may contribute to loss of cold hardiness in specific plants.

Nature of Work: Acclimation of a plant to the cold is a complicated process that can be influenced by many factors. One factor that has not been explored in great detail in the scientific community is the effect of various pesticides on plant cold acclimation. In the containerized nursery industry, preemergence herbicides are often applied in the fall before plants are placed in overwintering so as to reduce the amount of winter weeds within the containers. During this time period, most plants are beginning the process of cold acclimation. Since cold acclimation involves many metabolic and physical changes within the plant, preemergence herbicide applications may affect these processes. All herbicides have a mode-of-action by which they work to control or disrupt plants processes, and conversely, all plants have a means or mode-of-action by which they attempt to detoxify or eliminate the effect of herbicides. Some of these processes are well understood while others are not. Many of the preemergence herbicides used in the nursery industry are from families that can inhibit photosystem II, mitosis, cell wall or chlorophyll biosynthesis (Table 1). These systems are also important in cold acclimation and therefore the application of certain preemergence herbicides may affect cold acclimation. This study was designed to determine the effect of common preemergence herbicides on the cold acclimation process in 'Tradition' azalea leaves and stems.

Herbicide treatments were applied on October 1, 2004 (Table 1), and containers were moved to assigned test areas where they were arranged in a randomized complete block (RCB) design. There were 5 replications per treatment, and each treatment contained 3 subsamples. Sprayable herbicides were applied with a CO_2 backpack sprayer calibrated to deliver 20 gal/A. Granular herbicides were applied with a cheese shaker jar. Plants were maintained under shade for the duration of the study. No visual injury symptoms were noted to any treated azalea leaves or stems at 2, 4, and 8 weeks after treatment (WAT) and the visual herbicide injury ratings were discontinued. Plant samples used for the freeze study were taken at 10, 17, and 24 WAT. Minimum outdoor temperatures during the experiment was -10.1°C, and the average low was 6.0 °C. Laboratory cold hardiness evaluations were performed as described by Lindstrom and Dirr (1) to determine the maximum midwinter hardiness of leaves and stems.

Data were analyzed using analysis of variance and means were exposed to Fisher's least significant difference (LSD) test with a significance level of $\alpha \leq 0.05$. Test for interaction between treatment / temperature and treatment / date were highly significant with both the leaf and stem data ($\alpha<0.0001$), thus treatment data were presented separately for both temperature and date.

Results and Discussion: In general, the cold hardiness of leaves and stems increased regardless of preemergence herbicide treatment applied from early fall to midwinter (Tables 2-3). There was no clear trend that any herbicides reduced or increased cold hardiness of either leaves and stems of Kurume Hybrid Azalea (Tables 2-3).

There was no clear trend that the preemergence herbicides tested caused a loss or gain in cold hardiness in stems and leaves of 'Tradition' azalea when compared to the untreated control (UTC). However, some preemergence herbicides caused a significant increase or decrease in cold acclimation of stems and leaves at selected sampling dates and temperatures. More research is needed on the potential of preemergence herbicides, as well as other pesticides, to reduce the cold hardiness of ornamentals.

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Table 1. Herbicide treatment list.

Trade name	Active ingredient	Chemical family	Mode of action	Formulation	Rate kg ai/ha (lbs ai/A)
Dimension	dithiopyr	Pyridine	Inhibits mitosis	40 WSP	0.56 (5)
Gallery	isoxaben	Benzamide	Inhibits cell wall biosynthesis	75 DF	1.12 (1)
Surflan	oryzalin	Dinitroaniline	Inhibits microtubule production	4 AS	4.48 (4)
Pennant	metolachlor	chloroacetamide	Unclear	7.62 L	2.24 (2)
BroadStar	flumioxazin	N-phenylphthalimide	Inhibits protoporphyrinogen oxidase	0.25 GR	0.42 (0.375)
Predict	norflurazon	Pyzidazinone	Inhibits carotenoid biosynthesis	78.6 WG	3.36 (3)
UTC					

Table 2. Injury rating of *Rhododendron* x *hybrida* 'Tradition' leaves sampled on December 10, 2004, January 10, 2005 (10 WAT), February 14, 2005[z].

	Temperature (C)					
	-12	-15	-18	-21	-24	-27
Trade Name	**December 10, 2004 - Injury Rating[y]**					
Dimension	0.0 c	2.3 a	3.0 a	3.0 a	3.0 a	3.0 a
Gallery	2.5 a	3.0 a	3.0 a	3.0 a	3.0 a	3.0 a
Surflan	0.0 c	1.8 a	3.0 a	3.0 a	3.0 a	3.0 a
Pennant	1.8 ab	2.5 a	3.0 a	3.0 a	3.0 a	3.0 a
BroadStar	1.0 bc	2.0 a	3.0 a	3.0 a	3.0 a	3.0 a
Predict	0.5 c	2.5 a	3.0 a	3.0 a	3.0 a	3.0 a
UTC	0.3 c	2.8 a	3.0 a	3.0 a	3.0 a	3.0 a
LSD	1.03	1.15	0.0	0.0	0.0	0.0
Standard Deviation	0.71	0.79	0.00	0.00	0.00	0.00
	Temperature (C)					
	-12	-15	-18	-21	-24	-27
Trade name	**January 10, 2005 - Injury Rating[y]**					
Dimension	0.0 a	0.0 a	1.7 a	2.0 a	2.5 b	3.0 a
Gallery	0.0 a	0.0 a	0.0 c	1.5 b	2.3 b	3.0 a
Surflan	0.0 a	0.0 a	0.0 c	1.0 c	2.5 b	3.0 a
Pennant	0.0 a	0.0 a	1.5 a	2.0 a	3.0 a	3.0 a
BroadStar	0.0 a	0.0 a	1.5 a	1.5 b	3.0 a	3.0 a
Predict	0.0 a	0.0 a	0.0 c	2.0 a	3.0 a	3.0 a
UTC	0.0 a	0.0 a	0.5 b	1.5 b	3.0 a	3.0 a
LSD	0.00	0.00	0.48	0.42	0.41	0.00
Standard Deviation	0.00	0.00	0.41	0.36	0.35	0.00
	Temperature (C)					
	-12	-15	-18	-21	-24	-27
Trade name	**February 14, 2005 - Injury ratings[y]**					
Dimension	0.0 a	0.0 a	0.0 c	0.3 cd	0.8 d	3.0 a
Gallery	0.0 a	0.0 a	0.0 c	0.0 d	0.3 d	2.0 b
Surflan	0.0 a	0.0 a	0.0 c	1.4 a	2.0 ab	1.8 bc
Pennant	0.0 a	0.0 a	0.4 ab	0.8 bc	2.2 a	2.8 a
BroadStar	0.0 a	0.0 a	0.2 bc	0.9 ab	1.5 bc	1.6 bc
Predict	0.0 a	0.1 a	0.5 a	0.8 bc	2.3 a	2.8 a
UTC	0.0 a	0.0 a	0.1 c	0.3 cd	1.3 c	1.4 c
LSD	0.00	0.09	0.30	0.54	0.56	0.56
Standard Deviation	0.00	0.08	0.25	0.46	0.47	0.48

[z] Means within a column followed by the same letter are not significantly different at α = 0.05 as determined by Fisher's Least Significant test.

[y] Cold injury ratings on 0-3 scale, where 0 = no damaged and 3 = dead.

Table 3. Injury rating of *Rhododendron* x *hybrida* 'Tradition' stems sampled on December 10, 2004 (10 WAT), January 10, 2005 (10 WAT), February 14, 2005[z].

	Temperature (C)					
	-12	-15	-18	-21	-24	-27
Trade name	**December 10, 2004 - Injury Ratings[y]**					
Dimension	0.0 b	0.5 bc	1.0 b	2.0 a	2.0 b	3.0 a
Gallery	0.0 b	2.0 a	1.8 a	2.3 a	3.0 a	3.0 a
Surflan	0.8 a	1.0 b	1.0 b	1.3 bc	2.3 b	3.0 a
Pennant	0.0 b	1.0 b	1.3 ab	2.0 a	2.0 b	3.0 a
BroadStar	0.0 b	0.0 c	0.0 c	0.0 d	1.5 c	3.0 a
Predict	0.0 b	0.0 c	1.0 b	1.8 ab	2.0 b	3.0 a
UTC	0.0 b	1.0 b	1.0 b	1.0 c	2.0 b	2.0 b
LSD	0.26	0.53	0.57	0.63	0.40	0.00
Standard Deviation	0.18	0.36	0.39	0.43	0.28	0.00
	Temperature					
	-12	-15	-18	-21	-24	-27
Trade name	**January 10, 2005 - Injury Ratings[y]**					
Dimension	0.0 a	0.9 a	0.8 a	1.8 a	3.0 a	3.0 a
Gallery	0.0 a	0.0 a	0.0 a	0.0 b	0.0 b	0.0 c
Surflan	0.0 a	0.0 a	0.0 a	0.3 b	0.7 b	1.3 b
Pennant	0.0 a	0.0 a	0.0 a	0.3 b	0.3 b	0.4 c
BroadStar	0.0 a	0.0 a	0.0 a	0.0 b	0.4 b	0.3 c
Predict	0.0 a	0.0 a	0.0 a	0.1 b	0.1 b	0.6 c
UTC	0.0 a	0.0 a	0.0 a	0.1 b	0.2 b	0.3 c
LSD	0.00	0.09	0.19	0.35	0.67	0.70
Standard Deviation	0.00	0.08	0.16	0.29	0.57	0.60
	Temperature (C)					
	-12	-15	-18	-21	-24	-27
Trade name	**February 14, 2005 - Injury ratings[y]**					
Dimension	0.0 a	0.9 a	0.0 a	0.0 c	2.0 a	3.0 a
Gallery	0.0 a	0.0 a	0.0 a	0.0 c	0.0 d	2.5 ab
Surflan	0.0 a	0.0 a	0.0 a	0.4 b	0.8 bc	1.3 c
Pennant	0.0 a	0.0 a	0.0 a	0.0 c	0.2 d	0.5 d
BroadStar	0.0 a	0.0 a	0.4 a	0.3 bc	1.3 b	1.3 c
Predict	0.0 a	0.0 a	0.1 a	0.3 bc	0.7 c	1.4 c
UTC	0.0 a	0.0 a	0.3 a	0.8 a	1.8 a	2.3 b
LSD	0.00	0.09	0.36	0.41	0.43	0.57
Standard Deviation	0.00	0.08	0.30	0.35	0.37	0.49

[z] Means within a column followed by the same letter are not significantly different at α = 0.05 as determined by Fisher's Least Significant test.

[y] Cold injury ratings on 0-3 scale, where 0 = no damaged and 3 = dead

Halosulfuron and Sulfentrazone: Phytotoxicity and Weed Control in Container-Grown Woody Ornamentals

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Index Words: Sedge, Sandea 75DF, Spartan 4F, *Rhododendron* 'Fashion', *Hydrangea paniculata* 'Pink Diamond', *Juniperus horizontalis* 'Wiltonii', *Ilex crenata* 'Green Lustre', *Lagerstroemia* ‘Cheyenne'

Significance to Industry: Sedge infestations can be a major problem in ornamental plantings in Florida. Sedgehammer 75WDG (halosulfuron; formerly marketed as Manage) is currently labeled for sedge control in noncrop, ornamental plantings but no ornamentals are currently listed on the label as being tolerant, an issue that the IR-4 program is addressing. Sulfentrazone (Spartan 4F) is another herbicide that shows promise for sedge control in ornamentals. Under Florida conditions, well-rooted liners of containerized Fashion azalea, Pink Diamond hydrangea, Blue Rug juniper, Green Lustre holly, and Cheyenne crape myrtle were more tolerant of halosulfuron (applied as Sandea 75DF; halosulfuron product provided by Gowan) than Spartan 4F. Sandea 75DF caused no to minimal injury (chlorosis) to all species except Fashion azalea, which exhibited slight to moderate chlorosis. Neither product provided acceptable overall control of broadleaf and grass weeds.

Nature of Work: Sedges such as yellow nutsedge (*Cyperus esculentus*), purple nutsedge (*Cyperus rotundus*), and green kyllinga (*Kyllinga brevifolia*) can be troublesome weeds in landscape plantings as well as woody ornamental field nurseries. Sedgehammer 75WDG (halosulfuron, Gowan; formerly marketed as Manage by Monsanto) is labelled for use around established woody ornamentals in landscape beds for control of yellow and purple nutsedge and suppression of green kyllinga. Another sedge herbicide that shows promise for use around ornamentals is sulfentrazone (Spartan 4F). Both herbicides have been evaluated for weed control and/or phytotoxicity in ornamentals over the past 10 years (1, 3, 4) but Spartan 4F has yet to be labelled for use around ornamentals. We are not aware of any formal evaluation of either herbicide on ornamentals under Florida landscape bed or nursery conditions.

Liners of Fashion azalea (*Rhododendron* 'Fashion'), Pink Diamond hydrangea (*Hydrangea paniculata* 'Pink Diamond', Blue Rug juniper (*Juniperus horizontalis* 'Wiltonii'), Green Lustre holly (*Ilex crenata* 'Green Lustre'), and) Cheyenne crape myrtle (*Lagerstroemia* 'Cheyenne') were potted into 1-gal containers on 18 April

2005. The soilless mix was composed of pine bark:peat:sand, 3:1:1, by vol., and amended with 9 lb/yd^3 (6 lb/yd^3 for azalea) of Osmocote 18-6-12 (8-9 month) and 1.6 lb/yd^3 Micromax. Hydrangea and azalea were grown under 30% shade and the other species were grown under full sun. Halosulfuron (Sandea 75 DF; the Gowan halosulfuron product for row crops) and sulfentrazone (Spartan 4F) were applied over-the-top of all plants on May 26, 2005 (25 gal/acre; Table 1); nonsprayed plants served as controls and were not weeded except as noted below. There were four single pot replications per treatment. Pots were arranged in a completely randomized design within a species. The total amount of water applied via overhead irrigation (168 in) plus rain (29.2 in) from 26 May through 10 November was 197.2 in. Injury and weed control were evaluated at 2, 4, and 12 weeks after treatment (WAT) (2). Due to widespread, inadequate control of spurges (*Chamaesyce* spp.) and bittercress (*Cardamine* sp.) in late August, all containers were carefully hand weeded as needed so that we could continue to accurately assess phytotoxicity. Therefore, only injury was determined 24 WAT.

Results and Discussion: Tolerance to Spartan 4F varied substantially by species (Table 1). One day after application there were small necrotic spots on the terminal leaves of Fashion azalea, substantial necrosis on the terminal growth of Pink Diamond hydrangea, and some necrosis and defoliation on terminal growth of Cheyenne crape myrtle. Early detection of sulfentrazone injury also was observed on other ornamentals in another study (Jeff Derr, pers. comm.). By 24 WAT, Spartan 4F caused moderate to severe rate dependent injury to Pink Diamond hydrangea. Spartan 4F damage was slight to none on all other species by 24 WAT (Table 1). Sandea 75DF caused no to minimal damage (chlorosis) on all species except Fashion azalea, which exhibited slight to moderate chlorosis (Table 1). This level of injury contrasts with the results of Gilliam summarized by Palmer and Vea (4) and the recommendation that *Rhododendron* species be added to the Sedgehammer label as being tolerant to an over-the-top application (4). No Sandea 75DF injury was observed on Blue Rug juniper at any time (results not shown).

The primary weeds that occurred were woodsorrel (*Oxalis* sp.), bittercress (*Cardamine* sp.), hyssop and spotted spurge (*Chamaesyce hyssopifolia* and *C. maculata*, respectively), and crabgrass (*Digitaria* sp.). Neither product provided adequate overall weed control (Table 1). Weed control in pots containing Blue Rug juniper was excellent throughout the study, even in nonsprayed pots. Sandea 75DF and Sedgehammer 75WDG are not labelled for control of any the aforementioned species; Spartan 4F is labeled for control of several crabgrass species and partial control of spotted spurge.

In conclusion, halosulfuron (applied as Sandea 75DF) was less phytotoxic than sulfentrazone (Spartan 4F) when these herbicides were applied to well-rooted liners, a situation in which plants probably would be more sensitive to injury compared to more mature plants. Based on our results, halosulfuron (marketed as Sedgehammer 75WDG) would seem to be better positioned than Spartan 4F for sedge control in landscape beds and field nurseries in Florida, sites where sedges are most likely to occur in Florida. However, both products should be tank mixed with a preemergence herbicide to provide residual control of broadleaf weeds and grasses common in ornamental plantings.

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Table 1. Phytotoxicity and weed control of halosulfuron (Sandea 75DF) and sulfentrazone (Spartan 4F) in containerized woody ornamentals. Herbicides were applied on 26 May 2005.

	Phytotoxicity rating[z] (weeks after application)				Weed control rating[z] (weeks after application)		
Herbicide (lb ai/A)	2	4	12	24	2	4	12
Fashion azalea							
Control[y]	0	0	0	0	92 ± 2.0	92 ± 2.0	56 ± 7.5
Sandea 75DF 0.045	0	2 ± 2.0	10 ± 0	24 ± 16.7	100 ± 0	98 ± 2.0	78 ± 9.7
0.09	0	4 ± 4.0	18 ± 7.5	32 ± 20.5	100 ± 0	96 ± 2.4	56 ± 8.1
0.18	0	2 ± 0	23 ± 10.2	22 ± 8.4	100 ± 0	100 ± 0	70 ± 8.9
Spartan 4F 0.25	0	0	0	0	98 ± 2.0	96 ± 2.4	68 ± 11.4
0.5	12 ± 3.7	0	4 ± 4.0	4 ± 8.9	98 ± 2.0	94 ± 2.4	60 ± 9.5
1.0	16 ± 2.4	2 ± 2.0	4 ± 2.4	0	100 ± 0	96 ± 2.4	66 ± 10.3
Cheyenne crape myrtle							
Control[y]	0	0	0	0	98 ± 2.0	98 ± 2.0	76 ± 14.0
Sandea 75DF 0.045	4 ± 2.4	0	6 ± 4.0	12 ± 17.9	100 ± 0	98 ± 2.0	80 ± 8.4
0.09	0	0	6 ± 4.0	10 ± 17.3	100 ± 0	98 ± 2.0	74 ± 10.3
0.18	2 ± 2.0	0	4 ± 4.0	8 ± 11	100 ± 0	100 ± 0	60 ± 10.0
Spartan 4F 0.25	34 ± 2.4	30 ± 0	0	0	98 ± 2.0	98 ± 2.0	82 ± 8.0
0.5	36 ± 2.4	26 ± 2.4	2 ± 2.0	6 ± 13.4	100 ± 0	100 ± 0	70 ± 7.1
1.0	42 ± 2.0	34 ± 2.4	2 ± 2.0	2 ± 4.4	100 ± 0	96 ± 2.4	76 ± 9.2
Green Lustre holly							
Control[y]	0	0	0	2 ± 4.4	96 ± 2.4	96 ± 2.4	52 ± 11.6
Sandea 75DF 0.045	8 ± 4.9	6 ± 4.0	0	14 ± 20.7	100 ± 0	100 ± 0	68 ± 6.6
0.09	6 ± 2.4	6 ± 2.4	0	8 ± 11	100 ± 0	100 ± 0	66 ± 9.3
0.18	10 ± 0	6 ± 2.4	0	0	100 ± 0	98 ± 2.0	58 ± 13.6
Spartan 4F 0.25	4 ± 4.0	2 ± 2.0	0	4 ± 5.5	100 ± 0	100 ± 0	70 ± 3.2
0.5	4 ± 2.4	4 ± 4.0	0	2 ± 4.4	100 ± 0	98 ± 2.0	52 ± 13.2
1.0	4 ± 4.0	6 ± 2.4	0	4 ± 8.9	100 ± 0	100 ± 0	70 ± 5.5

Table 1. (cont.) Phytotoxicity and weed control of halosulfuron (Sandea 75DF) and sulfentrazone (Spartan 4F) in containerized woody ornamentals. Herbicides were applied on 26 May 2005.

		Pink Diamond hydrangea						
Control[y]		0	0	0	0	100 ± 0	100 ± 0	96 ± 2.4
Sandea 75DF	0.045	4 ± 2.4	0	0	0	100 ± 0	98 ± 2.0	88 ± 2.0
	0.09	6 ± 4.0	4 ± 2.4	0	0	100 ± 0	100 ± 0	90 ± 0
	0.18	0	0	0	0	100 ± 0	100 ± 0	92 ± 2.0
Spartan 4F	0.25	34 ± 2.4	30 ± 3.2	8 ± 8.0	10 ± 22.4	96 ± 2.4	96 ± 2.4	92 ± 3.7
	0.5	34 ± 2.4	34 ± 2.40	24 ± 10.3	26 ± 27.9	100 ± 0	98 ± 2.0	92 ± 3.8
	1.0	68 ± 13.5	82 ± 3.8	90 ± 6.3	70 ± 41.2	100 ± 0	96 ± 2.4	78 ± 5.8

[z] Ratings: Injury rated on a 0-100 scale (increments of 10), where 0=no injury and 100=dead; weed control rated on a 0-100 scale (increments of 10), where 0=no control and 100=100% control; means ± std. dev.

[y] Control plants – not sprayed, and not hand weeded.

Efficacy and Phytotoxicity of Sulfentrazone in Field-Grown Native Wildflowers

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Index Words: Weed management, seed production, Spartan 4F, *Coreopsis lanceolata*, *Gaillardia pulchella*, *Rudbeckia hirta*

Significance to Industry: Sulfentrazone (Spartan 4F) controlled nutsedges during establishment of blanketflower, black-eyed susan, and lanceleaf tickseed being grown for seed production. Overall weed control at 4 and 12 weeks after application (WAA) was excellent only in blanketflower plots treated with Spartan 4F, and less than adequate in all other species and treatments. Spartan 4F at 0.125, 0.25, or 0.375 lb ai/A per acre caused substantial short-term injury to all species, but if short-term injury to blanketflower and black-eyed susan can be tolerated, Spartan 4F at up to 0.25 lb ai/A (black-eyed susan) or 0.375 lb ai/A per acre (blanketflower) shows promise for nutsedge control during establishment since both species eventually flowered and set seed. Spartan 4F should not be used on lanceleaf tickseed because all plants treated with Spartan 4F exhibited substantial injury at 24 WAA.

Nature of Work: Seed production of locally or regionally specific ecotype seeds of native wildflowers for roadside plantings and ecological restoration has increased over the past 10-20 years in response to an ever-growing demand. In the southeastern U.S., this type of seed production is mainly in Florida, with very limited production in Alabama and North Carolina. The main pest encountered by growers, at least in Florida, is weeds. In Florida, nutsedges (*Cyperus* spp.) are of a particular concern, especially during establishment, because they are difficult to control and can quickly infest a planting.

Spartan 4F could potentially be used as part of an integrated weed program in native wildflower seed production fields because it controls a broad spectrum of weeds, including some *Cyperus* species (1, 3). Evaluation of injury in field-grown native wildflowers has been extremely limited (4), and we are not aware of any studies in which Spartan 4F has been evaluated during field establishment of transplanted wildflowers.

Liners of Florida ecotypes of black-eyed susan (*Rudbeckia hirta*), blanketflower (*Gaillardia pulchella*), and lanceleaf tickseed (*Coreopsis lanceolata*) were produced in a greenhouse in winter of 2005. On 5 April 2005, liners were transplanted to the field in 3-inch wide rows formed in between parallel strips of landscape fabric. This type of planting is common among Florida native wildflower seed producers. Liners were transplanted 6 inches (black-eyed susan and lanceleaf tickseed) or 12 inches (blanketflower) on center. Plots (replications) were 6 ft (black-eyed susan and tickseed) or 9 ft long (blanketflower). At the time of transplanting the average height and width (inches; ± std. dev.) of liners were: lanceleaf tickseed – 4.1 ± 1.0 and 7.5 ± 1.6; black-eyed susan – 1.9 ± 0.9 and 5.0 ± 0.7; blanketflower – 3.4 ± 0.8 and 5.5 ± 0.9. The soil was a Ruston loamy fine sand (pH 5.3; organic matter – 2.1%). Plants were fertilized with 15-9-12 (Osmocote Plus, 12-14 month Southern) at a rate of 3 lb/100 ft^2 on 5 April, and drip irrigated as needed. Total rainfall from April 28 through July 21 was 18.5 inches.

On 28 April 2005, Spartan 4F at 0.125, 0.25, or 0.375 lb ai/A was applied over-the-top of all plants (40 gallons per acre). Control (unsprayed) plots were included and were hand weeded. There were four replications per treatment. Phytotoxicity was evaluated at 1, 4, 12, and 24 weeks after application (WAA) and weed control at 4 and 12 WAA (2).

Results and Discussion: One week after application, Spartan 4F caused moderate to severe injury to black-eyed susan and severe injury to lanceleaf tickseed, but there was new growth on both species and they appeared to be recovering (Table 1). Blanketflower was more tolerant but still exhibited moderate injury 1 WAA (Table 1). All species continued to recover and by early to mid-summer all black-eyed susan and lanceleaf tickseed plants treated with the lower two rates were flowering and/or setting seed. Regardless of rate, blanketflower was flowering and setting seed. By mid-fall, little to no injury was observed on blanketflower, and many black-eyed susan had senesced (unrelated to herbicide treatment) (Table 1). In contrast, there was substantial Spartan-related decline of lanceleaf tickseed (Table 1).

Spartan 4F provided excellent control of all nutsedges through 12 WAA; the only *Cyperus* spp. were in the unsprayed plots. At 4 WAA, overall weed control was acceptable to excellent in all plots sprayed with Spartan 4F but weed control declined in lanceleaf tickseed and black-eyed susan plots by 12 WAA (Table 1). Spartan 4F did not seem to control crabgrass, bermudagrass, clover, or spurges. Competition from the wildflowers, especially blanketflower, facilitated weed control. In plots were wildflowers were small due to injury, weed control was poorer.

In conclusion, Spartan 4F shows promise as an option for nutsedge control when blanketflower and black-eyed susan are being established for seed production and if some short-term injury can be tolerated. Inadequate overall weed control in black-eyed susan plots can be overcome by tank mixing Spartan 4F with a preemergence herbicide to control broadleaves and grasses.

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Table 1. Phytotoxicity and weed control during establishment of black-eyed susan, blanketflower, and lanceleaf tickseed that were transplanted on April 5, 2005 and sprayed with Spartan 4F on April 28, 2005.

	Phytotoxicity rating[z] (weeks after application)				Weed control rating[z] (weeks after application)	
Spartan 4F (lb ai/A)	1	4	12	24	4	12
Black-eyed susan						
0[y]	0	0	0	---[x]	42 ± 22	55 ± 24
0.125	48 ± 9	18 ± 5	10 ± 8	---	85 ± 6	55 ± 17
0.25	72 ± 9	30 ± 14	18 ± 9	---	90 ± 0	72 ± 9
0.375	88 ± 5	48 ± 13	45 ± 17	---	92 ± 5	62 ± 10
Blanketflower						
0	0	0	0	0 ± 0	48 ± 15	85 ± 10
0.125	30 ± 0	10 ± 8	0 ± 0	0 ± 0	88 ± 5	92 ± 5
0.25	38 ± 5	25 ± 6	8 ± 5	0 ± 0	90 ± 0	95 ± 6
0.375	45 ± 6	35 ± 6	13 ± 10	10 ± 0	85 ± 6	95 ± 6
Lanceleaf tickseed						
0	0	0	0	---[x]	60 ± 8	38 ± 13
0.125	65 ± 6	25 ± 6	18 ± 5	---	72 ± 9	50 ± 16
0.25	85 ± 6	70 ± 0	55 ± 6	---	72 ± 17	22 ± 9
0.375	90 ± 0	80 ± 14	70 ± 18	---	80 ± 8	30 ± 28

[z] Ratings (2): Injury rated on a 0-100 scale (increments of 10), where 0=no injury and 100=dead; weed control rated on a 0-100 scale (increments of 10), where 0=no control and 100=100% control; means ± std. dev.

[y] Control plots were hand weeded after weed control was evaluated on May 26 (4 WAA).

[x] Plant were not evaluated because too many plants has senesced.

Use of Lightweight Aggregate 'Hydrocks'™ as a Weed Barrier

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Index Words: Light Expanded Clay Aggregate, Oxalis.

Significance to Industry: There is an increasing need for non-herbicide weed control strategies in container production of nursery plants. Previous studies have evaluated a number of materials as weed barriers. The results of this study indicate that Hydrocks™ applied 1 inch thick controls oxalis already present on the substrate surface and provides partial control over subsequent infestations of seed when applied at a depth of ½ inch.

Nature of Work: Due to the growing concern of environmental and ecological impact, there is an increasing interest in non-herbicide weed control strategies in container production. Application of pre-emergent herbicide to large containers is not cost effective with spacing practices associated with large plant material. Chemical applications to containers with wide spacing result in a considerable amount of non-target loss. In addition to non-target loss, labor involved with hand weeding has lead growers to search for more economical alternatives (2). Furthermore there are no pre-emergent herbicides available for use in covered structures such as greenhouses. Previous studies have evaluated hair-mat disks, recycled newsprint pellets, ground rubber tires, geo-textile disks, and large pine bark nuggets as weed barriers. Pine bark nuggets applied as surface mulch in combination with a single pre-emergent application has been shown to provide excellent weed suppression 180 days after treatment (2).

Weed barriers should be made of course materials that dry out quickly, contain little nutrients, and be resistant to decomposition (1). Hydrocks™, a light weight fired clay, used as a mulch layer to freshly potted plants could create an unfavorable environment for weed seed germination and establishment. Physical properties of Hydrocks™ prevent aggregates from breaking down and thus require only a single application at potting. Because Hydrocks™ is resistant to breaking down it could be utilized in planters or when growing plant materials that require extended production times. Hydrocks™ is very flowable, such that automatic application at potting could easily be mechanized. The highly automated German nursery industry is already mechanically applying mulches for weed prevention in container production (1). Hydrocks™ applied as mulch to containerized plants may provide an economical and environmentally safe substitute to current weed control measures.

The objective of this study was to evaluate the use of Hydrocks™ as a weed barrier when compared to conventional pre-emergent herbicides. The study was conducted in Auburn, Alabama in the spring of 2007. On December 18, 2006, 3.5 inch liners of crapemyrtle (*Lagerstroemia indica* 'Tuscarora'), azalea (*Rhododendron* x 'Midnight Flare'), and nandina (*Nandina domestica nana* 'Firepower') were potted into 1 gallon containers (7.5 inch diameter). A 6:1 pine bark:sand (v:v) substrate was used and amended with 16.7 lbs of Polyon 18-6-12, 5 lbs of dolimitic lime, and 1.5 lbs of Micromax. Plants were potted approximately 1.5 inches below the top of the pot. Twenty-five oxalis seeds were applied to the surface of each container before application of the following treatments: granular pre-emergent herbicide application (Broadstar 0.25G at a rate of 150 lbs per acre), Hydrocks™ mulch at 0.5 or 1.0 inch depth, and no mulch or herbicide. Two treatments consisted of applying 25 oxalis seeds to the surface of each container after application of Hydrocks™ mulch at 0.5 or 1.0 inch depth. One treatment consisted of no oxalis seed application, no mulch and no herbicide. Hydrocks aggregates were removed by screening to include only particles less than 0.25 inches. All treatments were irrigated prior to mulch and herbicide application. Each treatment consisted of 10 single pot replications for crapemyrtle and azalea and 6 single pot replications for nandina. On April 11, 2007, oxalis seedlings were counted. Data were analyzed using the GLM procedure with mean separation by Waller-Duncan K-ratio test (SAS 9.1).

Results and Discussion: With data pooled across species, there was no difference 120 days after planting (DAP) between the herbicide treatment and the 1 inch thick Hydrocks™ treatment with oxalis seeds applied before mulching (Table 1). There was no significant difference between Hydrocks™ mulch treatments of 0.5 inch and 1.0 inch with oxalis seeds applied post mulch application and Hydrocks™ mulch treatments of 0.5 inch with oxalis seeds applied pre mulch application. This study shows that Hydrocks™, when used as surface mulch at 1" deep, can provide successful weed control for oxalis seeds already present on substrates. This study also suggests that Hydrocks™ can provide limited control of oxalis seeds that are introduced post-mulch application. Chemical pre-emergent herbicides provide excellent weed prevention with exception of the disturbance of the chemical barrier at the surface of the substrate. Container mulches similar to Hydrocks™ would greatly reduce the problems associated with the disruption of chemical barriers. Hydrocks™ resistance to decomposition could provide a reusable tool for weed prevention in container production. Further testing could provide a better understanding of what weed species Hydrocks™ could control when used as mulch in container production.

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Table 1. Comparison of Hydrocks™ mulch and pre-emergent herbicides on establishment of *Oxalis stricta.*

				Oxalis Weed Count[Z]			
Treatment	Seeded[Y]	Herbicide[X]	Mulch Depth[W]	Azalea	Crapemyrtle	Nandina	Pooled
1	None	None	0	3.0 C[V]	7.8 B	1.2 CD	4.4 C
2	Before	None	0	9.6 A	11.7 A	6.5 A	9.7 A
3	Before	Yes	0	0.1 D	0.2 D	0.7 D	0.3 D
4	Before	None	0.5	3.2 C	5.6 BC	2.8 BC	4.0 C
5	Before	None	1	0.5 D	0.9 D	0.0 D	0.5 D
6	After	None	0.5	5.6 B	7.0 B	4.2 B	5.8 B
7	After	None	1	6.5 B	3.7 C	3.5 B	4.7 BC

[Z]25 seeds were sown per pot, count made 120 days after planting, highest counts equal greatest number of weeds.

[Y]Seeds were sown before or after application depending on treatment.

[X]Broadstar 2.5 G was applied at a rate of 150 lbs per acre.

[W]Mulch depth in inches.

[V]Means within column followed by the same letter are not significantly different (Waller-Duncan K-ratio t test < = 0.05).

Field Evaluation of Various Herbicide Formulations Combined With Mulches

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Index words: weed control, herbicide safety

Significance to Industry: Chemical control is the most commonly used method for controlling weeds in the nursery and landscape industry. Multiple applications per year are often needed. Some of the problems associated with the use of herbicides are phytotoxicity, leaching, spray drift, runoff, and herbicide resistance. Herbicide treated mulches can be a potential approach to control weeds for a longer period of time, while reducing the weed control costs and herbicides in the environment. The results of this experiment have shown that the mulches and herbicides should be combined to control weeds effectively for longer period of time.

Nature of Work: Weeds not only compete for resources like nutrients, light and space etc., but also reduce the aesthetics of plants and landscape. Different weed control strategies have been implemented but none of them alone is effective. Herbicide treated mulch is an integrated weed management approach in which two or more weed control methods are combined in order to control weeds effectively. Previous studies demonstrated that herbicide treated mulches work effectively in controlling weeds. Fretz (2), and Fretz and Dunham (3) reported higher weed control efficiency with herbicide impregnated mulches. Case and Mathers (1) found that pine nuggets combined with various herbicides provided weed control for one year in field. Mathers (4) obtained higher weed control efficacy with herbicide treated bark nuggets in containers. The objective of this study was to evaluate previously untested granular herbicides and mulch combinations at various depths of mulching compared to liquid formulations of herbicides combined with mulches. In addition, two new granular + mulch combinations were evaluated in which one is currently commercially available.

Two types of mulches, hardwood and pine nuggets, were tried alone at different depths (1, 2.5, and 5 inches) and in combination with Snapshot 2.5TG [isoxaben + trifluralin at 1.0 lb ai/ac + 4 lb ai/ac respectively (Dow AgroSciences, Indianapolis, IN)] or a liquid formulation consisting of Treflan HFP (Dow AgroSciences) + Gallery (Dow AgroSciences) at 1.0 lb ai/ac + 4 lb ai/ac, respectively. The three mulching depths represent the recommended depth (2.5 in), the depth previously evaluated (1 in) and a depth closer approximating what is used in industry (5 in). Snapshot was directly applied on top of the mulch in the field. The liquid formulation was applied below or above the mulch at each depth and was used to pretreat the mulches. There were a total of 35 treatments including untreated mulches at three depths, herbicides applied alone, two commercially available herbicide treated mulches, and untreated control. Mulches were pretreated with herbicides by placing the mulch on a plastic sheet at the depths described above and herbicide was sprayed evenly on top of the mulch and allowed to dry for 48 hours before applying them to field. An experiment was conducted in September, 2006 at The Ohio State University's Waterman Agricultural and Natural Resources Laboratory, Columbus, Ohio with randomized complete block design replicated five times. Visual readings were taken at 30, 90, 180 and 210 days after treatment (DAT). Visual readings were based on a scale of 0 (no control) to 10 (complete control), with 7 and above commercially acceptable. Differences between treatment means were analyzed using Proc Mixed in SAS (SAS, Institute, Cary NC) with the LSMeans statement.

Results and Discussion: Weed pressures were low 30 and 90 DAT due to very low temperatures (data not presented). The average maximum, mean, minimum temperatures for three months period (till 90 DAT) were 55^{o} F, 46^{o} F, and 37^{o} F, respectively. The most dominant weed in both the experiments was Canada thistle (*Cirsium arvense*). Canada thistle was considered as one of the weeds when taking the visual ratings. However, it is a perennial weed and pre-emergent herbicides alone can not control it once established, and is the reason for the low visual ratings.

***Results at 180 DAT*:** The visual ratings of twenty-eight treatments were seven or above at 180 DAT (Table.1). The other seven treatments which have visual readings less than commercially acceptable level are Snapshot, Snapshot over PN @ 1 inch depth, Treflan + Gallery under pine nuggets @ 1 inch depth, Treflan + Gallery over hardwood @ 1 inch depth, Treflan + Gallery treated hardwood @ 1 inch, untreated hard wood @ 1 inch, and control. The best treatments at 180 DAT were Snapshot over pine nuggets @ 2.5 inch depth (9.4), Snapshot over pine nuggets @ 5.0 inch depth (10), Treflan + Gallery under pine nuggets @ 5.0 inches depth (10), and Treflan + Gallery under hard wood @ 5.0 inches depth (9.4).

Results at 210 DAT: Twenty treatments were found to be at or above commercially acceptable level. All of those commercially acceptable except three are mulch and herbicide combined treatments. The best treatments were Snapshot over pine nuggets @ 5.0 inches (9.2), and Treflan + Gallery under pine nuggets @ 5.0 inches depth.

The results indicated that to get effective long-term weed control herbicides and mulches have to be applied together at least 2.5 inches thick or mulches alone can be applied at 5.0 inches depth, which is an expensive practice. The slow releasing ability of the herbicide from mulches explains their ability to control weeds for a longer period of time versus herbicides applied alone (4). This practice could reduce weed control costs while keeping the environment healthy.

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Table.1: Influence of various weed control treatments on visual ratings (weed control efficacy) at 180 and 210 days after treatment (DAT).

Treatments	**180 DAT**	**210 DAT**
Snapshot	6.8	5.6
Snapshot over pine nuggets (PN) @ 1 inch depth	5.8	5.6
Snapshot over pine nuggets @ 2.5 inches depth	9.4	8.2
Snapshot over pine nuggets @ 5.0 inches depth	10.0	9.2
Snapshot over Hard wood (HW) @ 1 inch depth	7.2	6.4
Snapshot over Hard wood @ 2.5 inches depth	7.2	7.2
Snapshot over Hard wood @ 5.0 inches depth	7.2	7.4
Treflan + Gallery	7.4	6.2
Treflan + Gallery over pine nuggets @ 1 inch	7.8	6.4
Treflan + Gallery over pine nuggets @ 2.5 inches	7.8	6.0
Treflan + Gallery over pine nuggets @ 5.0 inches	9.0	8.4
Treflan + Gallery under pine nuggets @ 1 inch	6.8	6.6
Treflan + Gallery under pine nuggets @ 2.5 inch	8.8	7.4
Treflan + Gallery under pine nuggets @ 5.0 inch	10.0	9.4
Treflan + Gallery over HW @ 1 inch	6.25	6.4
Treflan + Gallery over HW @ 2.5 inch	7.8	7.2
Treflan + Gallery over HW @ 5.0 inch	8.8	8.0
Treflan + Gallery under HW @ 1 inch	8.4	7.2
Treflan + Gallery under HW @ 2.5 inch	7.4	7.6
Treflan + Gallery under HW @ 5.0 inch	9.4	9.0
Treflan + Gallery treated PN @ 1 inch	8.0	7.0
Treflan + Gallery treated PN @ 2.5 inches	8.0	7.2
Treflan + Gallery treated PN @ 5.0 inches	9.2	8.6
Treflan + Gallery treated HW @ 1 inches	6.0	6.2
Treflan + Gallery treated HW @ 2.5 inches	9.0	8.6
Treflan + Gallery treated HW @ 5.0 inches	7.8	7.6
Untreated PN @ 1.0 inch	7.6	6.0
Untreated PN @ 2.5 inch	7.2	7.2
Untreated PN @ 5.0 inch	8.6	8.2
Untreated HW @ 1.0 inch	6.8	5.8
Untreated HW @ 2.5 inches	7.0	6.4
Untreated HW @ 5.0 inches	8.8	7.8
Weedstop at 2.5 inches depth	8.8	7.6
Mulch with snapshot at 2.5 inches depth	8.75	7.6
Untreated Control	0	0
LS Means (0.05%)	2.4	1.7