SECTION 9

Weed Control

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Section 1 and Section 13 may contain related titles.

Control of Spanishneedles with Preemergent Herbicides

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Nature of Work: Spanishneedles (*Bidens bipinnata* L.) is primarily considered - warm season weed which can infest ornamental nurseries and landscapes. Its range is from Rhode Island to Florida and westward to Kansas and even Mexico (2). There are two preemergent herbicides, Casoron (dichlobenil) and Princep (simazine), labeled for use in nurseries (1,4). In order to reduce the risk to the crop, either one or both of these herbicides have application restrictions on plant age, timing, and soil type. For example, dichlobenil should not be used during the summer in the lower south because of its volatility. Both herbicides also have a somewhat limited list of other weed species on the label.

A study to evaluate five other preemergent herbicides (Table 1) for efficacy on spanishneedles was undertaken in 1993 at the North Florida Research and Education Center in Monticello. These herbicides were chosen in part because they were generally less phytotoxic (i.e., greater number of tolerant ornamentals) and had less application restrictions than either Casoron or Princep.

In June of 1993, 0.75 gal containers were filled with a substrate (3:1:1 by vol) of pine bark:sand:Canadian sphagnum peat amended with Osmocote 18-6-12, Micromax, triple superphosphate, and dolomite. On June 16, sprayable herbicides were applied to the substrate using a backpack sprayer with a single 8002VS tip that delivered 40 GPA at 25 psi. Granular herbicides were manually applied in separate aliquots to each container. A nontreated control was included. After the applications, herbicides were incorporated with V of water; 20 spanishneedle seeds were then placed on the substrate. Five replications per treatment were arranged in a completely randomized block design on a black polyethylene bed in full sun. Daily overhead irrigation of 0.5" was supplied. Twelve weeks after treatment, the number of spanishneedle plants and the percent of the substrate covered were recorded.

Results and Discussion: Predict, both Snapshot DF treatments, and Snapshot TG provided equivalent control of spanishneedles for twelve weeks. These treatments resulted in percent substrate coverage of 4 to 20% compared to 98% coverage for nontreated controls; number of weeds per container ranged from 0.3 to 2.3 for these treatmenta compared to 6.3 for nontreated controls. The Barricade and Derby treatments were not statistically different than the nontreated control. Although Predict is restricted to use in field nurseries, Snapshot TG and the

components of Snapshot DF (isoxaben and oryzalin) are labeled for container, field, and landscape use (3).

Significance to Industry: Twelve weeks of preemergent control of spanishneedles was achieved with Predict at 3.8 lb product/A, Snapshot TG 160 lba product/A, or Snapshot DF 3.8 lb product/A (Snapshot DF is no longer manufactured but a tank mix of oryzalin and isoxaben would probably be effective).

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Table 1. Effect of five preemergent herbicides on the control of spanishneedles in containers at Monticello, FL twelve weeks after treatment.[z]

Treatment /Formulation	Rate lb. ai/A	Rate lb. prod/A	Labeled sitey	Percent coveragex	No. weeds/ container
Nontreated control	-	-	-	98aw	6.3ab
Barricade 65WG	2	3.1	L	98a	6.8ab
Barricade 65WG	3	4.6	L	95a	7.3a
Barricade 65WG	4	6.2	L	88a	8.Oa
Derby 5G	4	80.0	C,F,LC	93a	4.0bc
Predict 80DF	3	3.8	F	20b	0.3d
Snapshot 80DF	3	3.8	C,F,L	16b	2.3cd
Snapshot 80DF	4	5.0	C,F,L	7b	0.8d
Snapshot 2.5G	4	160.0	C,F,L	4b	1.5cd

[z]Containers were overseeded with 20 spanishneedle seeds per container O days after application. Treatments were replicated five times.

[Y]C = container, F = field, L - landscape, LC = commercial landscape only.

[X]Statistical analysis performed after arcaine transformation; untransformed means are presented.

[W]Means within columns followed by the same letter are not significantly different by Duncan's multiple range test ($P \leq 0.05$).

Preemergent Herbicides for Control of Prostrate Spurge in Containers

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Nature of Work: Prostrate spurge (*Euphorbia humistrata* Engelm. ex Gray) is one of the most difficult weeds to control in container-grown plants (3). One prostrate spurge plant per container limited the growth of azaleas (1). Ronstar (oxadiazon) is a commonly used herbicide in container-plant production, but does not effectively control prostrate spurge (2, personal observation). Combinations of Ronstar with other herbicides increased the control of several weed species (2,4,5). Ronstar and Goal (oxyfluorfen) and Ronstar and prodiamine combinations provided adequate control of prostrate spurge for a 10 to 12 week period (5). The purpose of this study was to evaluate the effects of different granular herbicide combinations (Goal + Ronstar, Ronstar + Factor (prodiamine)) or Factor alone on the control of prostrate spurge in containers.

Research was conducted at Wight Nurseries in Cairo, Ga. On August 1, 1996, prostrate spurge seeds (~40/pot) were broadcast over #1 black plastic containers filled with a mixture of milled pine bark and river sand (4:1 by vol) amended with micronutrients and dolomitic limestone. Liquid fertilizer was provided with each irrigation. The following herbicides (Table 1) were applied on August 1, 1996: Regal O-O (oxyfluorfen + oxadiazon) at 100 and 200 lbs./A; RegalKade 50 (prodiamine) at 150 and 200 lbs./A; and RegalStar II (oxadiazon + prodiamine) at 200 and 300 lbs./A. The granular herbicides were broadcast over the containers using pre-weighed herbicide aliquots and a hand-held shaker jar. All treatments were replicated six times in a completely randomized block design.

Visual ratings for percent weed coverage (1 = 0 to 20% weed coverage; 2 = 21 to 40%; 3 = 41 to 60%; 4 = 61 to 80%, and 5 = 81 to 100%) were performed at 30 and 60 days after treatment (DAT). Number of plants per container were counted 30 and 60 DAT and individual plants were harvested on 10/2/96 for dry weights. Data was subjected to analysis of variance using SAS. Chi-square analysis was used for percent coverage data. Means _ standard error are shown.

Results and Discussion: Herbicide had no effect on percent coverage 30 DAT (Table 2). At 60 DAT, RegalKade and RegalStar II reduced percent coverage of prostrate spurge compared to Regal O-O. The high rate of each herbicide reduced the percent coverage to a greater extent than the medium rate at 30 DAT. At 60 DAT, there were no differences in percent coverage between the medium and high rates.

Number of prostrate spurge plants per container was only influenced by rate at 30 DAT (Table 3). Controls had 24 plants/container, compared to 13 plants/container at the medium rate and 7 plants/container at the high rate. Number of plants/container 60 DAT was influenced by an interaction between herbicide treatment and rate (Table 3). At the medium and high rates, RegalKade and RegalStar II had fewer plants/container compared to Regal 0-0.

At the medium rate of application, plant dry weight was reduced the most by RegalStar II (Table 3). RegalKade reduced plant dry weight to a greater degree than Regal O-O. At the high rate, there were no differences between RegalKade and RegalStar II for plant dry weight. Dry weight per plant was not influenced by herbicide treatment, only rate. Dry weights per plant were 0.23 ± 0.01, 0.42 ± 0.05, and 0.37 ± 0.05, respectively; for control, medium, and high rates. Increases in dry weight per plant may have been due to RegalKade having a potassium fertilizer carrier and RegalStar II having a 38-0-0 carrier.

Significance to Industry: Based on the results presented in this study and observations of the staff at Wight Nurseries, RegalKade at the high rate and RegalStar II at the medium and high rates provided acceptable control of prostrate spurge 60 DAT. Regal O-O is not recommended for summer control of prostrate spurge but may be useful for fall and early spring weed control programs.

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

Trade name	Common name	Percent active ingredients
Regal 0-0	Oxyfluorfen + Oxadiazon	2.0 + 1.0
RegalKade 50	Prodiamine	0.5
RegalStar II	Oxadiazon + Prodiamine	1.0 + 0.2

Table 2. Influence of herbicide treatment and rate of application on percent coverage of container surface with prostrate spurge. Means + SE are shown.

	Percent coverage[z] (30 DAT)	Percent coverage (60 DAT)
Treatment		
Regal 0-0	2.3 + 0.2	4.9 +0.1
RegalKade	2.4 + 0.2	4.1 + 0.3
RegalStar II	2.4 + 0.2	3.6 + 0.3
Significance[y]	NS	*
Rate		
Control	3.0 + 0.2	5.0 + 0.0
Medium	2.3 + 0.2	4.0 + 0.3
High	1.8 + 0.1	3.8 + 0.3
Significance	**	**

[z]Percent weed coverage (1 = 0 to 20% weed coverage; 2 = 21 to 40%, 3 = 41 to 60%, 4 = 61 to 80%, and 5 = 81-100%).

[y]NS, *, ** Nonsignificant or significant at $P \leq 0.05$, or 0.01, respectively.

Table 3. Influence of herbicide treatment and rate of application on number of plants per container and final plant dry weight.

Treatment	Rate (lbs/A)	--Number of plants-- (30 DAT)	(60 DAT)	Plant dry weight (g)
Regal 0-0	0	22 + 1.4	23 + 2.2	5.5 + 0.2
	100	16 + 1.4	16 + 0.9	5.8 + 0.6
	200	8 + 1.6	7 + 1.5	2.8 + 0.4
RegalKade 50	0	22 + 2.6	22 + 2.0	5.5 + 0.5
	150	10 + 3.3	7 + 1.8	2.3 + 0.6
	200	10 + 2.1	4 + 0.9	1.2 + 0.2
RegalStar II	0	27 + 4.5	21 + 2.7	5.3 + 0.2
	200	12 + 3.3	3 + 0.7	1.0 + 0.1
	300	5 + 1.1	4 + 0.7	1.3 + 0.2
Significance[z]				
Treatment		NS	**	**
Rate		**	**	**
Treatment & Rate		NS	**	**

[z]NS, ** Nonsignificant or significant at $P \leq 0.01$.

Effects of Preemergence-Applied Herbicides on Container-Grown Perennials

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Nature of Work: Herbaceous perennials are increasing in popularity as landscape plants. Many of them are low maintenance, tolerant of diverse environmental conditions, and dynamic year after year in the landscape. Response of perennials to the preemergent herbicides typically used in nursery production is species, and many times even cultivar or variety dependent (1,2,3,4,5). Diversity of perennials in production increases yearly while the preemergent herbicides labeled for weed control in them does not. Screening studies for phytotoxicity must be conducted regularly for the purpose of label expansion.

An evaluation of preemergent herbicides applied over-the-top of container-grown perennials was initiated March 27, 1997. Plants were in 1 gallon containers with a pine bark and sand (4:1 v/v) mix. Nitrogen fertilizer was applied at 80 ppm through the overhead irrigation system. The study consisted of 4 herbicide treatments each at 1X, 2X, and 4X rates and an untreated control. The treatments were: Gallery 75 DF at .66, 1.32 and 2.64 lb/A; Surflan 4AS at 2, 4 and 8 qt/A; Factor 65 WG at 1, 2 and 4 lb/A; Pendulum 3.3 EC at 2.4, 4.8 and 9.6 qt/A. Treatments were applied with a CO_2 pressurized backpack sprayer at 25 GPA using 8003 nozzles and 30 PSI at the boom. The species were: Astilbe (*Astilbe x ardensi* 'Fanal'), threadleaf coreopsis (*Coreopsis verticillata* 'Moonbeam'), delosperma (*Delosperma cooperi*), cottage pink (*Dianthus plumaris* 'Mountain Mist'), purple cone flower (*Echinacea purpurea*), blanket flower (*Gallardia x grandiflora* 'Goblin'), coral bells (*Heuchera micrantha* 'Palace Purple'), plantain lily or hosta (*Hosta fortunei* 'Francee'), iris (*Iris siberica* 'Caesar'), black-eyed Susan (*Rudbeckia fulgida* 'Goldstrum'), stonecrop (*Sedum spectilbe* 'Autumn Joy'), verbena (*Verbena canadensis* 'Homestead Purple'). Plots were arranged in a randomized complete block design with six replications.

Plots were rated visually for herbicide phytotoxicity using a 0 - 100% scale with 0 and 100 representing no injury and plant kill respectively. Data were collected weekly for 6 weeks after treatment (WAT). Data were analyzed using analysis of variance and means were separated at the 0.05 level of significance.

Results and Discussion: The following species were not adversely affected by herbicide treatments in this study: coreopsis, delosperma, dianthus, iris, sedum, and hosta.

Echinacea showed injury at 2 WAT from all herbicides. At 4 WAT injury ratings peaked from Pendulum at the 2X rate (32%), Factor at the 2X (37%) and 4X (28%) rates, Surflan at the 2X (35%) and 4X (30%) rates, and Gallery at the 1X (30%) and 4X (25%) rates. Leaf petiole twisting and interveinal wrinkling were the predominant injury symptoms observed. By 6 WAT injury levels were insignificant, and new uninjured foliage had covered most of the earlier abnormalities.

Gallardia showed injury at 4 WAT from Pendulum at the 4X (15%) rate and from Gallery at all three rates (10-18%). Injury from both Pendulum and Gallery persisted through 6 WAT but decreased to <10%. The predominant symptoms observed were leaf chlorosis and marginal necrosis.

Rudbeckia showed injury 3 WAT from Gallery at the 4X (<10%) rate. At 4 WAT injury was observed from Gallery at all three rates (10-27%) with a decrease in ratings to <10% again by 5 WAT. Rudbeckia also showed injury 4 WAT from all three rates of Surflan (13-23%) with a subsequent ratings decrease to <10% by 5 WAT. Leaf chlorosis, interveinal wrinkling, and reduced plant growth were the predominant injury symptoms. In most cases new foliage covered the abnormalities by 6 WAT.

Verbena showed injury 3 WAT from Gallery at the 4X (15%) rate. Injury symptoms persisted through 5 WAT (22%). Verbena also showed injury 5 WAT from Surflan and Pendulum (10% and 15% respectively). The predominant injury symptom was necrotic spots on the leaves. New plant growth appeared normal at 6 WAT.

Astilbe showed no tissue damage injury symptoms from the applied herbicides, however, all rates of Pendulum caused up to 50% stunting of the plants.

Heuchera showed injury 2 WAT from Gallery at the 2X (10%) and 4X (12%) rates. Injury increased in severity, peaked 4 WAT at 2X (27%) and 4X (35%) rates, and persisted through 6 WAT. Heuchera also showed injury from Pendulum at the 4X (15%) rate 6 WAT. Predominant injury symptoms included stunting, necrotic spots on leaves, and abnormal cupping of leaves.

Significance to Industry: Data indicate that commercial production of container-grown perennials using preemergent herbicides for weed control can be safely accomplished. Response of perennials to preemergent herbicides and herbicide rates varies greatly, however, and therefore screening of perennials, particularly new cultivars and varieties, needs to be conducted so that product labels can reflect industry production trends.

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Tolerance of Seedlings to Preemergence Herbicides

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Nature of Work: Several nurseries in Middle Tennessee grow a variety of woody ornamental species from seed, primarily in seed rows. Many of the seedlings may become landscape plants but many are used as rootstocks for budded or grafted selections. Growers began producing seedlings in rows prior to the practice of fumigation and continued due to the ease of cultivation and the convenience of budding in the row. Weeds are primarily controlled by cultivation due to the lack of labeled preemergence herbicides for use in deciduous woody ornamental seedbeds or seed rows. The objective of this study was to evaluate the tolerance of seedlings to preemergence herbicides.

On 5 June 1995, *Acer rubrum*, red maple, *Quercus phellos*, willow oak, and *Ulmus pumila*, Siberian elm seedlings were treated with preemergence herbicides at a nursery in middle Tennessee. Seedlings were about 2-3" tall with at least four sets of true leaves. Red maple and willow oak were on a two year production cycle and were retreated on 20 May 1996.

Also on 20 May 1996, *Cornus florida*, white flowering dogwood, *Elaeagnus spp.*, autumn olive, *Koelreuteria paniculata*, golden raintree, *Pyrus calleryana*, callery pear and *Quercus palustris*, pin oak seedlings were treated with preemergence herbicides at another location. Seedlings were about 2-3" tall with at least four sets of true leaves. Both nurseries have a silt loam soil. The experimental area was 5 linear feet in the row with a two foot over-the-top bandwidth with 4 replications. Plots were treated with a CO_2 pressurized plot sprayer delivering 25 gallons of water per acre. Granular materials were applied with a hand held shaker. Seedlings were evaluated at 15, 30, 60, 90, and 120 days after treatment (DAT) (15 and 120 DAT data not shown).

Results and Discussion: In 1995, there were some visual growth differences with red maple seedlings (Table 1). Seedlings treated with Factor, Gallery, Princep and Surflan appeared stunted at 30 DAT. By the 90 DAT, all seedlings were uniform in plant growth with no discernible differences in size. Willow oak seedlings exhibited some leaf strapping with all preemergence herbicide treatments at 30 DAT (Table 2). At 90 DAT, all seedlings had no foliar symptoms of herbicide damage.

Siberian elm seedlings had foliar phytotoxicity from Rout herbicide (Table 3). At 30 DAT, foliage was distorted and plants were stunted. At the end

of the growing season, seedlings treated with the 2x and 4x rate (6 and 12 lbs. ai/A) were still stunted with some foliage distortion.
In 1996, the two year old red maple and willow oak seedlings were treated with the same herbicides and rates as 1995. There was no discernible differences among the treatments at 15, 30, 60 and 90 DAT (data not shown). The authors observed no foliar phytotoxicity on dogwood, golden raintree, callery pear, elaeagnus and pin oak seedlings in 1996.

Significance to Industry: This research indicates that some preemergence herbicides can be safely used as an over-the-top application on some seedling species. More research is needed to determine which herbicides and rates are safe over a broad range of species.

Table 1. *Acer rubrum*, red maple seedlings response to preemergence herbicide applications (1995).

Herbicide Treatment	Rate lbs. ai/A	30 DAT	60 DAT	90 DAT
Devrinol 50 DF	4.0	1.0b	1.0 a	1.0a
Devrinol 50 DF	8.0	1.0b	1.0 a	1.0a
Devrinol50DF	16.0	1.0b	1.0 a	1.0a
Factor/Gallery	1.5 + 0.25	1.0b	1.0 a	1.0a
Factor/Gallery	1.5 + 0.50	2.0a	1.5 a	1.0a
Factor/Princep	1.5 + 0.2	52.0a	1.0 a	1.0a
Factor/Princep	1.5 + 0.50	2.0a	1.25a	1.0a
Surflan/Gallery	2.0 + 0.25	2.0a	1.25a	1.0a
Surflan/Gallery	2.0 + 0.50	2.0a	1.0a	1.0a
Surflan/Princep	2.0 + 0.50	2.0a	1.25a	1.0a
Control		1.0b	1.0 a	1.0a

Phytotoxicity rating: 1=healthy, 2= slight stunting, distortion on new foliage, 3= moderate stunting, distortion on new foliage, 4= severe stunting, distortion on new foliage, 5= dead.

Table 2. *Quercus phellos*, willow oak seedlings response to preemergence herbicide applications (1995).

Herbicide Treatment	Rate lbs. ai/A	30 DAT	60 DAT	90 DAT
Devrinol 50 DF	4.0	1.25b	1.0a	1.0a
Devrinol 50 DF	8.0	1.25b	1.0a	1.0a
Devrinol 50 DF	16.0	1.25b	1.5a	1.0a
Devrinol 5 G	4.0	1.25b	1.0a	1.0a
Devrinol 5 G	8.0	1.25b	1.0a	1.0a
Devrinol 5 G	16.0	1.0 b	1.0a	1.0a
Factor/Gallery	1.5 + 0.25	1.5 a	1.5a	1.0a
Factor/Gallery	1.5 + 0.50	1.5 a	1.5a	1.0a
Factor/Princep	1.5 + 0.25	1.5 a	1.0a	1.0a
Factor/Princep	1.5 + 0.50	1.5 a	1.0a	1.0a
Surflan/Gallery	2.0 + 0.25	1.5 a	1.5a	1.0a
Surflan/Gallery	2.0 + 0.50	1.5 a	1.5a	1.0a
Surflan/Princep	2.0 + 0.25	1.5 a	1.0a	1.0a
Surflan/Princep	2.0 + 0.50	1.5 a	1.0a	1.0a
Control		1.0 b	1.0a	1.0a

Phytotoxicity rating: 1=healthy,2= slight stunting, distortion on new foliage, 3= moderate stunting, distortion on new foliage, 4= severe stunting, distortion on new foliage, 5= dead.

Table 3. *Ulmus pumila*, Siberian elm seedlings response to preemergence herbicide applications (1995).

Herbicide Treatment	Rate lbs. ai/A	30 DAT	60 DAT	90 DAT
Devrinol 50 DF	4.0	1.9b	1.9ab	1.0b
Devrinol 50 DF	8.0	1.8b	1.5b	1.0b
Devrinol 50 DF	16.0	1.8b	1.9ab	1.2b
Devrinol 5G	4.0	1.8b	1.2c	1.0b
Devrinol 5G	8.0	1.2b	1.2c	1.0b
Devrinol 5G	16.0	1.4b	1.5b	1.0b
Rout 2G	3.0	1.6b	1.4b	1.0b
Rout 2G	6.0	2.4a	2.3a	2.5a
Rout 2G	12.0	3.3a	3.2a	2.7a
Control		1.0b	1.0c	1.0b

Phytotoxicity rating: 1 =healthy, 2= slight stunting, distortion on new foliage, 3= moderate

Table 4. Preemergence herbicides applied to white flowering dogwood, autumn olive, golden raintree, callery pear and pin oak seedlings (1996).

Herbicide Treatment	Rate lbs. ai/A
Pendulum 60 WDG	2.0
Factor 65 WDG	0.5
Sufflan 4AS	2.0
Gallery 75DF	0.25
Princep 4L	0.50
Pendulum + Gallery	2.0 + 0.25
Pendulum + Gallery	2.0 + 0.5
Pendulum + Princep	2.0 + 0.5
Factor + Gallery	0.5 + 0.25
Factor + Gallery	1.0 + 0.25
Factor + Princep	0.5 + 0.5
Factor + Princep	1.0 + 0.5
Surflan + Gallery	2.0 + 0.25
Sufflan + Gallery	2.0 + 0.5
Surflan + Princep	2.0 + 0.5
Control	

Seedling Kyllinga Management in Nursery Crops

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Nature of the Work: Green Kyllinga (*Kyllinga brevifolia*) is a warm season herbaceous perennial weed which inhabits excessively moist environments. It can invade sites through both seeds and rhizomes. Postemergence herbicides will suppress Kyllinga populations but re-growth from rhizomes will occur (Whitwell and Smith 1997). Previous research indicated that Manage and sulfentrazone suppressed perennial populations (with rhizomes) but preemergence control of seed emergence and emerged seedlings were not considered (Whitwell and Smith 1996). It is very important to control a weedy species before it becomes established as a perennial population. The objectives of our research were to evaluate preemergence and postemergence herbicides for control of seedling (non-perennialized) green Kyllinga in Ophiopogon.

Greenhouse experiments were initiaited in the spring of 1997. *Ophiopogon japonicus* (4 inch liners) was transplanted into 1 qt. pots containing a 80% pine bark 20% sand fertilizer amended media on December 3, 1996. Preemergence treatments included Gallery (1.0 lb ai/A), Factor (1.5 lb ai/A), Pendulum (3.0 lb ai/A), Pennant (3.0 lb ai/A) and Sulfentrazone (0.5 lb ai/A). Treatments were applied on March 11, 1997 and 100 green Kyllinga seeds were placed into each pot on April 8, 1997.

In the postemergence study, Ophiopogon was clipped to a 2 inch height and 100 green Kyllinga seeds were placed into each pot on January 3, 1997. Treatments were applied on March 11, 1997 with a CO_2 backpack sprayer calibrated at 30 gal./A. Postemergence treatments included Manage (0.063 lb ai/ A), Image (0.5 lb ai/A), Basagran (1.0 lb ai/A), Sulfentrazone (0.25 lb ai/A) and MSMA (2.0 lb ai/A). Optima surfactant (0.5% v/v) was added to Manage, Image, Basagran and sulfentrazone spray mixes.

Preemergence Kyllinga control was rated on a 0 to 100% scale where percent control was based on the average of emerged seedlings in untreated pots. Weekly postemergence green Kyllinga control and Ophiopogon injury was rated visually on a 0 to 100% scale, where 0 = no control and 100% = plant death.

The experimental design of the study was a randomized complete block with 5 repetitions. Analysis of variance was conducted on the data utilizing an LSD of $P = 0.05$.

Results and Discussion: In both studies only sulfentrazone caused unacceptable Ophiopogon injury. Bleached lesions on the leaves were observed until the leaves were clipped at 2 weeks after treatment (WAT). Sulfentrazone is quite volatile and injury may occur on other crops if treated within an enclosed space.

Pennant provided the greatest preemergence Kyllinga control (>85%) throughout the entire study (Table 1). Pendulum, Sulfentrazone and Factor provided less control (>70, >70, >65%, respectively). Gallery provided unacceptable preemergence control (<45%).

Sulfentrazone provided the greatest postemergence Kyllinga control (>98%) throughout the entire study with no regrowth occurring (Table 2). No new plants emerged from seeds or other plant material by 12 WAT. Manage also provided excellent control throughout the study and by 12 WAT was still providing 83% control; however, new plants had emerged by 12 WAT. Image provided 75% control at 12 WAT; whereas, Basagran and MSMA provided unacceptable control throughout the entire study (<40, <10%, respectively).

Significance to Industry: Preventing an infestation of Kyllinga before it perennializes is the key to managing this species. Pennant applied preemergence was effective in controlling green Kyllinga from seed. Postemergence seedling Kyllinga was effectively controlled with Manage. Minimum injury was noted from either of these treatments on *Ophiopogon japonicus*. Sulfentrazone was also effective but caused unacceptable injury to Ophiopogon.

Literature Cited

1. Whitwell, Ted and Russell Smith. 1996. Perennial Kyllinga control in Ophiopogon production. Proceedings of SNA Research Conference 41: 262-264.

2. Whitwell, Ted and Russell Smith. 1997. Perennial Kyllinga control in nursery crops.WSSA Abstracts 37:28.

Table 1. Preemergence Green Kyllinga control in Ophiopogon.

	Green Kyllinga Control(%)[a]			
Herbicide (lb ai/A)	6 WAT	8 WAT	10 WAT	12 WAT
Pennant (3.0)	89 a	85 a	94 a	86 a
Pendulum (3.0)	94 ab	80 a	77 ab	77 a
Sulfentrazone (0.5)	77 a	65 a	70 ab	70 a
Factor (1.5)	71 ab	61 ab	61 b	61 a
Gallery (1.0)	41 b	33 b	30 c	30 b
UNTREATED	0c	0c	0 d	0c

[a]Green Kyllinga control is a percentage based on the average emerged seedlings in untreated pots. Pots were seeded 4 weeks after treatments (WAT) with green Kyllinga seeds and seedlings began to emerge in untreated pots at 6 WAT. [b] Means followed by the same letter within a column are significantly different according to LSD (*P* = 0.05).

Table 2. Postemergence seedling green Kyllinga control in Ophiopogon.

	Green Kyllinga Control(%)[a]					
Herbicide (lb ai/A)	2 WAT	4 WAT	6 WAT	8 WAT	10 WAT	12 WAT
Sulfentrazone (0.25)[c]	90 a[b]	80a	98 a	lOOa	lOOa	98a
Manage (0.063)	62b	90a	92a	93a	93a	83 ab
Image (0.5)	54b	66a	70b	73b	83b	75b
Basagran (1.0)	38c	24b	lOc	3c	l5c	l5c
MSMA (2.0)	Od	Ob	Oc	Oc	Od	Oc
UNTREATED	Od	Ob	Oc	Oc	Od	Oc

[a]Green Kyllinga control rated visually on a 0- 100% scale with O=no control and 100%=plant death. Treatments were applied to 2 month-old seedling Kyllinga (without rhizomes).

[b] Means followed by the same letter within a column are sign)ficantly different according to LSD (*P* = 0.05).

[c]Optima surfactant (0.5 % v/v) was added to Sulfentrazone, Manage, Image and Basagran treatments.

Tolerance of Herbaceous Perennials to Gallery, Factor, Pendulum, and Rout Herbicides

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Nature of Work: Increased production of flowering species that provide year long color in the landscape require more information about maintaining weed free plant material. A limited number of herbaceous perennial crops are included on herbicide labels. Additionally, labor costs continue to increase and hand weeding is not a viable option for most nurseries producing large quantities of these plants. Porter (1) found that certain herbaceous species were sensitive to Gallery and Snapshot DF, however Snapshot TG was less injurious to all species tested. Also, there is little information available concerning the tolerance of perennials to other preemergence herbicides.

Clemson University's research center at Carolina Nurseries was the site for a study to evaluate the preemergence herbicides Gallery WG at 2 lbs ai/A, Pendulum WG at 4 lbs ai/A, Factor WG at 2 lbs ai/A, and Rout G at 6 lbs ai/A on fall potted herbaceous perennials. Eight perennial species (Table 1.) were potted in the fall of 1996. Perennial plugs were established in one-gallon pots in a fertilizer/lime amended media (20% sand and 80% pine bark). Experimental design was a randomized block for each species with 5 single plant replications. Herbicides were applied twice the labeled rate to determine tolerance. The sprayable treatments were applied using a CO_2 backpack boom sprayer with 8006 flat fan nozzles. Pre-measured granular formulations were distributed with a hand-held shaker. A single 2x rate of each herbicide was applied on 11/14/96 and the same pots were retreated with the same rate on 5/14/97. Visual ratings were taken on a scale of 0 = no injury to 100 = complete kill. Growth index was measured by taking height + width /2. Data was subjected to analysis of variance and means were separated by LSD at $P = 0.05$.

Results and Discussion: Pendulum caused minimum visual injury to all species except *Scabosia* (Table 1). Foliar injury (>35%) and stunting was observed on Scabosia at 6 months after initial treatment (MAIT) and growth was also reduced compared to the untreated plants. *Veronica* growth index was also reduced. Factor caused minimal visual injury (<16%) and did not reduce the growth index of the selected perennials in this study (data not shown). Gallery was phytotoxic to *Chrysongonium*, *Scabosia, Stachys*, and *Veronica* with injury ratings ranging from 16 to 54% (Table 3). Injury ratings were lower at the 6 MAIT evaluation for these species with the exception of *Stachys*. The growth index of

Stachys was reduced compared to the untreated. Rout (Table 3.) caused severe foliar injury to most species except Scabosia, however, growth index was reduced only for *Filipendula.*

Significance to Industry: Controlling weeds with preemergence herbicides in herbaceous perennial production is challenging because there are few labeled herbicides. Factor caused minimal injury to the eight species in this study and Rout was the most injurious. Herbicides should be continually evaluated for safety to perennial species.

Literature Cited

1. Porter, W.C. 1996. Isoxaben and isoxaben combinations for weed control in container-grown herbaceous flowering perennials. J. Environ. Hort. 14:27-30.

Table 1. Visual injury and growth index of perennials from premergence applications of Pendulum at 4 lbs ai/A.

	% Injury[a]		Growth Index[b]	
Chrys. "Allen Bush'	4	8	22 a	21 a
Coreopsis 'Moonbeam'	0	0	24 a	24 a
Coreopsis 'Zareb'	0	0	24a	22 a
Filipendula hexapetals	0	0	30 a	33 a
Scabosia "Butterfly Blue"	6	38	14 b	17 a
Sedum sp. 'Matrona'	14	0	24 a	23 a
Stachys 'Big Ears'	0	0	36 a	36 a
Veronica 'Red Fox'	16	10	18 b	23 a

[a]Visual injury is presented on a scale 0 to 100 with 0= no injury and 100 = complete kill. The 2 MAIT rating was made after the first application and the 6 MAIT rating was made after the sedcond application.

[b]Growht index was determined by measuring the plant height + plant width /2 reported in cm.

6 MAIT. (UNT) = growth index of untreated plants 6 months after initial treatment. Means followed by same letter in a row are not significantly different according to LSD @ P = 0.05.

[c] MAIT = Months after initial treatment date.

Table 2. Visual injury and growth index of perennials from preemergence applications of GAllery WG at 2 lbs ai/A.

	% Injury[a]		Growth Index[b]	
Plants	2 MAIT[c]	6 MAIT	6 MAIT	6 MAIT
Chrys. 'Allen Bush'	20	24	18 a	21 a
Coreopsis 'Moonbeam"	0	0	24 a	18 a
Coreopsis "Zareb'	0	11	16 a	22 a
Filipendula hexapetals	0	2	26 a	33 a
Scabosia "Butterfly Blue"	38	0	15 a	17 a
Sedum sp. 'Matrona'	4	0	23 a	23 a
Stachys 'Big Ears'	16	48	24 b	36 a
Vernonica 'Red Fox'	54	22	21 a	23 a

[a] Visual injury is presented on a scale 0 to 100 with 0 = no injury and 100 = complete kill. The 2 MAIT rating was make after the first application and the 6 MAIT rating was made after the second application.

[b] Growth index was determined by measuring the plant height + plant width/2 reported in cm.

6 MAIT. (UNT) = growth index of untreated plants 6 months after initial treatment. Means followed by same letter in a row are not significantly different according to LSD @ P =0.05.

[c] MAIT = Months after initial treatment date.

Table 3. Visual injury and growth index of perennials from preemergence applications of Rout at 6 lbs ai/A.

	% Injury[a]		Growth Index[b]	
Plants	2 MAITc	6 MAIT	6 MAIT	6 MAIT
Chrys. 'Allen Bush'	14	14	21 a	21 a
Coreopsis 'Moonbeam'	0	32	23 a	18 a
Coreopsis 'Zareb'	0	16	19 a	22 a
Filipendula hexapetals	20	54	21 b	31 a
Scabosia 'Butterfly Blue'	10	0	16 a	17 a
Sedum sp. 'Matrona'	25	44	23 a	23 a
Stachys 'Big Ears'	-	34	33 a	36 a
Vernonica 'Red Fox'	24	42	21 a	23 a

a Visual injury ispresented on a scale 0 to 100 with 0 = no injury and 100 = complete kill. The 2 MAIT rating was made after the first application and the 6 MAIT rating was made after the second application.

b Growth index was determined by measuring the plant height + plant width /2 reported in cm.

6 MAIT. (UNT) = growth index of untreated plants 6 months after initial treatment. Means followed by same letter in a row are not dignificantly different according to LSD @ P = 0.05.

c MAIT = Months after initial treatment date.

Dinitroanaline Herbicide Comparison on Container-Grown Herbaceous Perennials

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Nature of the Work: Preemergent herbicides remain the safest and most cost-efficient means of controlling annual weeds in container-grown nursery stock. Unfortunately, the more effective herbicides used in woody plant production have injured many herbaceous species (1). Of the preemergent herbicides registered for use in container nurseries, dinitroanaline herbicides offer a good balance between weed control and safety on a wide number of ornamental plants. However, injury has also been reported on a number of herbaceous ornamentals treated with dinitroanaline herbicides (1, 2). Consequently, more information on herbicide safety to herbaceous perennials is needed. In this test, the safety of dinitroanaline herbicides was evaluated on 21 species of herbaceous perennials. The species evaluated are listed in Table 1. Liners obtained from commercial sources were potted within two weeks prior to the day of treatment into a pine bark + sand substrate provided by the cooperating grower, Zelenka Nursery, Inc. of Sims, NC. The experiment was conducted in a randomized complete block design with four replicates and three plants per species per plot. Herbicides evaluated in the study are listed in Table 2. Plants were treated on April 27, 1997. Granular herbicides were applied with a hand-held shaker jar. Spray treatments were applied with a CO_2 pressurized sprayer at 30 gallons per acre. Percent injury was visually evaluated periodically for 10 weeks, by which time the cooperating grower would have shipped all plants. Eight weeks after treatment, incidence of stem breakage was also evaluated on Salvia by brushing the plants gently n four directions (north, south, east & west) then counting the numba of broken stems which resulted.

Results and Discussion: No injury was observed on painted daisy, coreopsis, rudbeckia, heuchera, artemisia, liatris, yarrow, gaillardia, or foxglove. Neither Factor at 0.75 and 1.5 lb ai/A nor Treflan injured any species tested. All other treatments produced moderate to severe injury on one or more species. The most injurious product was Pendulum 60WDG, followed in decreasing order of severity by Surflan, Pendulum 2G and Factor at 3 lb ai/A. Injury symptoms differed between species and products, and included foliar burn, distorted foliage, stunting and girdled stems (resulting in brittle stems and breakage at the soil line). Of the species tested, phlox 'Davidii' was the most sensitive.

Nine days after treatment phlox 'Davidii' was significantly injured by Factor @ 3 lb/A, and each rate of Pendulum 2G, Pendulum 60WDG, and

Surflan (data not presented). Pendulum 60DG produced foliar burn and distorted young leaves on phlox 'Davidii', bearded tongue and evening primrose. Pendulum 2G severely injured shasta daisy producing necrotic growing points, foliar burn and distorted leaves. By 15 days after treatment much of the initial foliar burn was not apparent since most damaged leaves had fallan off(data not presented). By 10 weeks after treatmant Pandulum 60WDG had produced moderate to severe injury on sedum, lavanda, salvia, phlox (both species), and Russian sage (Table 3). Additionally, Factor at 3 lb/A injured both species of phlox, and Pendulum 2G had severely injured shasta daisy and moderately injured phlox 'Davidii'. Surflan injured coneflower, sedum, salvia, bearded tongue, phlox 'Davidii', and Russian sage. The high rate of Factor, both Pendulum formulations, and Surflan caused stem girdling and breakage in salvia (data not shown).

Significance to the Industry: These data show that many of our commonly used nursery herbicides have the potential to injure certain habaceous perennials. Only Treflan 5G and the two lower rates of Factor (0.75 and 1.5 lb ai/A) were safe on all plants tested. Growers of habaceous perennials should avoid using Pandulum WDG, Surflan, or Pendulum 2G unless they are sure of the crop tolerance.

Literature Cited

1. Derr, J. F. 1994. Weed control in container-grown herbaceous perennials. HortScience 29(2):95-97

2. Senesac, A. F., I. Tsontakis-Bradley, and D. Gilrein. 1995. Evaluation of Preemergent herbicides for container grown pernnials. Proc. Northeast. Weed Sci. Soc. 49:64

Table 1. Plant species tested and growth stages at the time of herbicide application.

Artemisia 'Silver mound' (*Artemisia schmidtiana*)
Bearded tongue 'Rhondo' (*Penstemon barbatus*)
Coneflower 'Purple Magnus' (*Echinacea purpurea*)
Coreopsis 'Moon beam' (*Coreopsis verticilata*)
Eveningprimrose 'Missouri' (*Oenothera missouriensis*)
Foxglove 'Strawberry' (*Digitalis mertonensis*)
Heuchera 'Palace purple' (*Heuchera micrantha*)
Lavender 'Hidecote blue' (*Lavendula angustifolia*)
Painted daisy 'Robinson' (*Chrysanthemum coccineum*)
Shasta daisy 'White knight' (*Lecanthemum x superbum*)
Vaonica 'Sunny border blue' (*Veronica spicata*)
Gaillardia 'Goblin' (*Gaillardia x 'Goblin'*)
Geranium 'Bloody' (*Geranium sp.*)
Liatris 'Kobold' (*Liatris spicata*)
Phlox 'Davidii' (*Phlox paniculata*)
Phlox 'Chatahoochee' (*Phlox divaricata x*)
Rudbeckia 'Goldsturm' (*Rudbeckia fulgida*)
Russian sage (*Perovskia atriplicifolia*)
Salvia ‘East Friesland’(*Salvia nemorosa*)
Sedum ‘Autumn Joy’(*Sedum sp*)
Yarrow ‘Paprika’(*Achillea millefolium*)

Table 2. Herbicides evaluated in this test.

Trade Name	Formulation	Common name	Rates (lb ai /A)
Factor	65 WDG	prodiamine	0.75, 1.5 and 3.0
Pendulum	60 WDG and 2G	pendimethalin	2 and 4
Surflan	4 AS	oryzalin	2 and4
Treflan	5 G	trifluralin	2 and 4

Table 3. Herbicide injury ten weeks after treatment. Herbicides and plants not listed displayed no injury at this rating date.

		% injury, by species								
Herbicide	Rate lb ai/A	Cone-flower	Sedum	Lavender	Salvia	Bearded tongue	Phlox 'Chata.'	Shasta daisy	Phlox 'Davidii'	Russian sage
Factor	0.75	5	5	8	3	7	0	5	2	0
	1.5	8	0	3	8	10	8	8	10	2
	3	5	8	5	5	0	25*	3	20*	0
Pendulum G	2	3	5	8	8	2	0	40**	12	0
	4	8	5	3	5	0	3	58**	20*	0
Pendulum WDG	2	8	3	25*	0	7	55**	8	65**	25*
	4	5	18*	50**	18*	12	53**	5	77**	40**
Surflan	2	13	5	3	20*	17	5	13	30*	5
	4	20*	10*	3	35**	30*	13	13	50**	18*

*, ** denote means significantly different from zero at the 5% and 1% levels, respectively.