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Evaluation of Selected Herbicides on Field-Grown Woody Ornamentals¹

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Abstract

Six herbicides and selected combinations were evaluated on four field-grown woody landscape crops: live oak, 'Mary Nell' holly, 'Chesapeake' viburnum, and 'Acoma' crapemyrtle. All herbicide treatments provided excellent control of goosegrass (*Eleusine indica* (L.) Gaertn.). Treatments with Predict (norflurazon) provided adequate sicklepod (*Cassia obtusifolia* L.) control. Only Goal (oxyfluorfen)-containing treatments controlled cutleaf eveningprimrose (*Oenothera laciniata* Hill). Predict and Predict treatment-combinations bleached older foliage of crapemyrtle and viburnum when applied in the first year after planting; however, growth was not affected. Holly was not injured by any herbicide treatments. Pendulum (pendamethalin) and Surflan (oryzalin) had similar weed control activity and plant growth with no plant injury.

Index words: weed control, nursery crops.

Herbicides used in this study: Predict (norflurazon), 4-chloro-5-(methylamino)-2-(3-(trifluoromethyl)phenyl)-3(2H)-pyridazinone; Pendulum (pendimethalin), N-(1-ethylpropyl)-3, 4-dimethyl-2, 6-dinitrobenzenamine; surflan (oryzalin), 4-(dipropylamino)-3, 5-dinitrobenzenesulfonamide; Goal (oxyfluorfen), 2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene; Gallery (isoxaben), N-[3-(1-ethyl-1-methylpropyl)-5-isoxazolyl]-2, 6-dimethoxybenzamide; Princep (simazine), 6-chloro-N, N'-diethyl-1, 3,5-triazine-2,4-diamine.

Species used in this study: live oak (*Quercus virginiana* Mill.); 'Mary Nell' holly [(*Ilex cornuta* 'Burfordii' x *I. pernyi* 'Red Delight') x *I. latifolia*]; 'Chesapeake' viburnum (*Viburnum x utile* 'Chesapeake' Hemsl.); and 'Acoma' crapemyrtle (*Lagerstroemia fauriei* x *indica* 'Acoma').

Significance to the Nursery Industry

Two recently registered herbicides, Pendulum (pendimethalin) and Predict (norflurazon), were generally safe on field-grown nursery crops. Predict and its combination treatments provided superior control of sicklepod compared to Surflan and Pendulum. Slight to moderate injury occurred with Predict; however, plants generally grew past injury symptoms by 60 days after treatment (DAT). No injury was observed by 90 DAT or during the second year with either of the two treatment applications. Pendulum provided weed control similar to Surflan and may be considered as an alternative herbicide when rotating chemicals.

Introduction

In field-grown nursery crops, weed control is more difficult than container production due to a greater diversity of difficult-to-control broadleaf weeds and crop sensitivity to herbicides that control those weeds. For many years, the two most widely used broadleaf active herbicides for field-grown plants were Goal (oxyfluorfen) and Princep (simazine) (12). However both of these herbicides can be injurious to certain landscape species (1, 2, 4, 6, 11).

In 1990, Gallery (isoxaben) was added to the list of herbicides available for broadleaf weed control in field-grown nursery crops. Combining Gallery 75DF with Surflan (oryzalin) 4AS at 3.4 or 6.7 kg ai/ha (3.0 or 6.0 lb ai/A) provided weed control comparable to that obtained with traditional herbicide programs of Surflan in combination with

Princep or Goal (7). Neal and Senesac (9) reported Gallery 75WDG at 1.1 or 2.2 kg ai/ha (1.0 or 2.0 lb ai/A) and Gallery 1G at 1.1 kg ai/ha (1.0 lb ai/A) to be non-injurious when applied over the top of ten species of woody plants. Of the ten, only common lilac (*Syringa vulgaris* L.) demonstrated any sensitivity to Gallery. They also reported the combination of Gallery 75DF at 0.56 kg ai/ha (0.5 lb ai/A) and Surflan AS at 1.7 kg ai/ha (1.5 lb ai/A) provided an expanded spectrum of weed control, with excellent safety on most container and field-grown nursery crops (10).

Two herbicides, Predict (norflurazon) and Pendulum (pendimethalin), were recently registered for use in field-grown nursery crops. Prior to this registration, norflurazon use was limited to cotton, cranberries, and various fruit and nut tree crops. Predict controls various annual weeds, including goosegrass (*Eleusine indica* L.), crabgrass (*Digitaria sanguinalis* L.), dogfennel (*Eupatorium capillifolium* (Lam.) Small), Carolina geranium (*Geranium carolinianum* L.), and prostrate spurge (*Euphorbia maculata* L.) (3).

Pendimethalin has been available for use in container nursery crops for several years as Southern Weedgrass Control, in granular formulation. Pendimethalin and Surflan (oryzalin), both dinitroaniline herbicides, control annual grasses and small-seeded broadleaf weeds. The activity of pendimethalin (Prowl 4L) and oryzalin was similar (5); however, the recently-registered formulation of pendimethalin is a water dispersible granule (Pendulum 60 WDG).

The objective of this test was to evaluate Predict, Pendulum and Surflan applied alone and in combination with other currently-registered broadleaf-active herbicides for weed control and crop safety in field-grown nursery crops.

Materials and Methods

Liners of 'Acoma' crapemyrtle, 'Chesapeake' viburnum, live oak, and 'Mary Nell' holly were planted on April 12,

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1991, at the E.V. Smith Research Center in Shorter, AL. The soil type was a Wickman fine sandy loam (fine-loamy, mixed, thermic, Typic hapludults) with a pH of 6.3 and organic matter content of 1.0%. Granular fertilizer [13N-5P-11K (13-13-13)] was applied preplant [58 kg N/ha (52 lb N/A)], and annually thereafter at 134.5 kg N/ha (120 lb/A). Irrigation was provided as needed with Chapin twin-wall IV irrigation hoses containing holes every 30 cm (1 ft). Plots were 3.7 × 4.9 m (12 × 16 ft) with plants spaced 0.9 × 1.1 m (3.0 × 3.6 ft).

One week after planting, herbicides were applied with a CO₂ backpack sprayer equipped with a 8004 flat fan nozzle at 28 psi, in a spray volume of 187 liter/ha (20 gpa). Pendulum 60 WDG, Predict 80 DF, and Surflan AS were applied at 3.4 kg ai/ha (3.0 lb ai/A) or in combination with either Gallery, Goal, or Princep at 1.1 kg ai/ha (1.0 lb ai/A). Herbicides were applied on April 17 and July 22, 1991, and March 17 and June 23, 1992. Weeded and nonweeded control plots were maintained. The test area was overseeded with sicklepod (*Cassia obtusifolia* L.) and goosegrass. The test area contained an erratic population of yellow nutsedge (*Cyperus esculentus* L.), consequently, the entire area was treated with Pennant (metolachlor) 7.8E at 2.2 kg ai/ha (2.0 lb ai/A) prior to the other treatments to suppress yellow nutsedge as a confounding variable. In the spring of 1992, an infestation of cutleaf eveningprimrose (*Oenothera laciniata* Hill) developed in the study area. Uniformity of population across the entire study area indicated limited residual herbicide activity from the previous application in July. Control ratings for this species were taken after the March 17 (first) application. The experimental design was a randomized complete block design with 4 replications of 4 plants each.

Data collected included plant injury at 30, 60, and 90 days after treatment (DAT) rated on a scale of 0 (no plant injury) to 100 (dead plants); percent sicklepod control rated at 30, 60, and 90 DAT on a scale of 0 (no weed control) to 100 (complete weed control); percent primrose control in

May 1992 (same scale as sicklepod); primrose fresh weight (May 1992); and growth indices of woody plants [(height + width at widest point + width perpendicular to widest point)/3] in October 1991 and 1992. Data were analyzed using ANOVA and treatment means compared using Duncan's Multiple Range Test, $p = 0.05$.

Results and Discussion

Crapemyrtle. Injury following the first application in 1991 was influenced primarily by Goal. Goal in combination with other herbicides produced 92 and 86% injury 30 and 60 DAT, respectively (Table 1); injury was restricted to new growth. These data concur with previous work reporting injury from application of Goal (4, 6, 8). In our study, crapemyrtle recovered and no visual injury was present 90 DAT (data not shown). Rapid vegetative growth from mature stems occurred with the Goal treated crapemyrtle after 60 DAT. Crapemyrtle was not visually injured by Goal treatments in the second application. This concurs with previous reports where over-the-top, midsummer applications of Goal to *Ilex* (7) were not injurious.

There was no crapemyrtle injury from application of Pendulum, Predict, or Surflan. After the first application, only Predict or Predict combinations caused crapemyrtle injury. The injury, which dissipated by 90 DAT, was characterized by bleaching of the older foliage. There was no injury in 1992 (data not shown).

Crapemyrtle growth indices in 1991 were numerically smaller when Goal was applied (61 averaged across all Goal treatments) compared to 74 average for all other treatments. By October 1992, Goal-treated crapemyrtle were similar in size to plants in other herbicide combinations. In both years, the numerically greatest plant growth occurred with the following treatments: Surflan + Gallery, Pendulum, and Surflan. By October 1992, all herbicide treated plants were similar in size to the handweeded plants.

Table 1. Effects of selected herbicides on injury and growth of field-grown 'Acoma' crapemyrtle.

Treatment	Rate kg/ha	1991				GI* (cm)	1992 GI (cm)
		Injury (%) ^a					
		April 17 ^b		July 22			
30	60	30	60				
Predict	3.4	13bc ^w	13bc	0b	0c	69bc	101ab
Predict + Princep	3.4 + 1.1	29b	29bc	37a	25a	73abc	102ab
Predict + Goal	3.4 + 1.1	95a	93a	0b	19ab	65cde	93abc
Predict + Gallery	3.4 + 1.1	8c	6bc	0b	28a	71bc	99ab
Surflan	3.4	5c	6bc	6b	0c	77abc	102ab
Surflan + Princep	3.4 + 1.1	0c	0c	5b	5bc	63cd	101ab
Surflan + Goal	3.4 + 1.1	94a	88ac	0b	0c	66bcd	93abc
Surflan + Gallery	3.4 + 1.1	13bc	13bc	0b	0c	89a	111a
Pendulum	3.4	0c	0c	0b	0c	80ab	102ab
Pendulum + Princep	3.4 + 1.1	38b	38b	0b	0c	75abc	86bc
Pendulum + Goal	3.4 + 1.1	88a	78a	5b	5c	51de	91bc
Pendulum + Gallery	3.4 + 1.1	18bc	23bc	0b	0c	73abc	88bc
Weeded	—	15bc	13bc	0b	0c	73abc	99ab
Unweeded	—	0c	8bc	0b	0c	46e	80c

^aInjury rating scale, 0 = no injury, 100 = death.

^bApplications were made April 17 and July 22, 1991 and March 17 and June 23, 1992. Ratings were made 30 and 60 DAT.

*GI = growth indices [(height + width₁ + width₂) ÷ 3]; measured in October 1991 and 1992.

^wNumbers followed by the same letter are not significantly different according to Duncan's Multiple Range Test, $p = 0.05$.

Table 2. Effects of selected herbicides on injury and growth of field-grown 'Chesapeake' viburnum.

Treatment	Rate kg/ha	1991				GI [†] (cm)	1992 GI (cm)
		Injury (%) [‡]					
		April 17 [‡]		July 22			
		30	60	30	60		
Predict	3.4	38a ^w	8a	29ab	10b	49a	108ab
Predict + Princep	3.4 + 1.1	20b	0c	30a	18a	40cdef	115a
Predict + Goal	3.4 + 1.1	8c	5abc	23b	5b	47abc	91abc
Predict + Gallery	3.4 + 1.1	28b	10a	25ab	8b	38defg	76cd
Surflan	3.4	0c	0c	0c	0c	36efg	76cd
Surflan + Princep	3.4 + 1.1	0c	0c	0c	0c	43abcd	78cd
Surflan + Goal	3.4 + 1.1	0c	0c	6c	0c	47abc	87bc
Surflan + Gallery	3.4 + 1.1	0c	0c	0c	0c	41bcde	63cd
Pendulum	3.4	6c	0c	0c	0c	32g	65cd
Pendulum + Princep	3.4 + 1.1	0c	5abc	0c	0c	42bcde	78c
Pendulum + Goal	3.4 + 1.1	0c	3bc	5c	0c	40bcdef	84bc
Pendulum + Gallery	3.4 + 1.1	0c	3bc	0c	0c	40bcdef	78c
Weeded	—	0c	0c	0c	0c	24d	50e
Unweeded	—	0c	0c	0c	0c	21e	36f

[†]Injury rating scale, 0 = no injury, 100 = death.

[‡]Applications were made April 17 and July 22, 1991 and March 17 and June 23, 1992. Ratings were made 30 and 60 DAT.

[‡]GI = growth indices [(height + width₁ + width₂) ÷ 3]; measured in October 1991 and 1992.

*Numbers followed by the same letter are not significantly different according to Duncan's Multiple Range Test, p = 0.05.

Viburnum. Both applications of Predict alone and its combination treatments caused bleaching of 'Chesapeake' foliage 30 DAT in 1991 (Table 2). Injury symptoms were similar to those observed on crapemyrtle, i.e. temporary bleaching of the older foliage, which dissipated by 90 DAT (data not shown). There was no observed bleaching from 1992 applications of Predict (data not shown).

Generally, the Predict-induced injury was not reflected in growth indices, reflecting the temporary nature of this injury. Inspection of the data reveals that by the end of the 1992 growing season, the largest plants (numerically) were

treated with Predict. Predict + Princep treated plants were similar in size to plants treated with Predict alone and Predict + Goal and were larger than all other plants in the study. All herbicide treated plants were larger than the handweeded control plants.

Live Oak. Maximum herbicide injury occurred at 30 DAT in 1991 with all herbicide treatments (Table 3). Difficulty in distinguishing between transplant shock after field planting and herbicide injury attributed to these data. Evidence of post-transplant shock was noted by 29% injury to the

Table 3. Influence of selected herbicides on injury and growth of live oak over a two year period.

Treatment	Rate kg/ha	1991				GI [†] (cm)	1992 GI (cm)
		Injury (%) [‡]					
		April 17 [‡]		July 22			
		30	60	30	60		
Predict	3.4	45abc ^w	33ab	24ab	25a	34abc	99abc
Predict + Princep	3.4 + 1.1	23cd	16bcd	25a	13ab	37abc	112ab
Predict + Goal	3.4 + 1.1	48abc	43a	10abcd	19ab	40ab	117a
Predict + Gallery	3.4 + 1.1	25bcd	15bcd	23abc	28a	34abc	99abc
Surflan	3.4	40abc	15bcd	6d	0c	32abc	89bc
Surflan + Princep	3.4 + 1.1	48abc	33ab	9bcd	5c	26bc	83c
Surflan + Goal	3.4 + 1.1	34abcd	25abcd	5d	0c	36abc	118a
Surflan + Gallery	3.4 + 1.1	25bcd	8cd	0d	0c	31bc	84c
Pendulum	3.4	23cd	3d	3d	0c	50a	107abc
Pendulum + Princep	3.4 + 1.1	53a	29abc	8cd	0c	29b	97abc
Pendulum + Goal	3.4 + 1.1	50ab	37ab	10abcd	9bc	35abc	119a
Pendulum + Gallery	3.4 + 1.1	35abcd	25abcd	5d	0c	41ab	118a
Weeded	—	13d	3d	9bcd	0c	31abc	96abc
Unweeded	—	29abcd	18bcd	0d	0c	19c	43d

[†]Injury rating scale, 0 = no injury, 100 = death.

[‡]Applications were made April 17 and July 22, 1991 and March 17 and June 23, 1992. Ratings were made 30 and 60 DAT.

[‡]GI = growth indices [(height + width₁ + width₂) ÷ 3]; measured in October 1991 and 1992.

*Numbers followed by the same letter are not significantly different according to Duncan's Multiple Range Test, p = 0.05.

Table 4. Effects of selected herbicides on sicklepod control.

Treatment	Rate kg/ha	Sicklepod control (%)											
		April 17 ^a			Fresh wt. (kg/plot)	July 22			Fresh wt. (kg/plot)	June 23			Fresh wt (kg/plot)
		30	60	90		30	60	90		30	60	90	
Predict	3.4	75abc ^y	78abc	58bcd	2c	96ab	81ab	89a	2c	98a	96a	93a	0e
Predict + Princep	3.4 + 1.1	90ab	81abc	86ab	1c	99a	90a	94a	0c	71ab	99a	93a	0e
Predict + Goal	3.4 + 1.1	98a	96a	91a	0c	98ab	89a	90a	1c	96a	96a	94a	0e
Predict + Gallery	3.4 + 1.1	83ab	83abc	71abc	1c	98ab	90a	90a	1c	91a	93a	95a	0e
Surflan	3.4	48cd	43de	13f	5ab	70e	35c	28bc	13ab	48b	18d	25cd	22a
Surflan + Princep	3.4 + 1.1	53cd	33de	28def	7a	86abcd	38c	33b	9ab	70ab	45c	40c	14bc
Surflan + Goal	3.4 + 1.1	75abc	95a	48cde	0c	74de	38c	30bc	14ab	80a	60bc	30cd	18ab
Surflan + Gallery	3.4 + 1.1	63bcd	60bcd	25ef	3bc	78cde	55bc	35b	11abc	83a	53bc	38c	10cd
Pendulum	3.4	40de	58cde	30def	1c	90abc	48c	50b	6bc	78a	65bc	50c	8cde
Pendulum + Princep	3.4 + 1.1	43de	60bcd	28def	2bc	88abc	43c	40b	8bc	70ab	43c	28cd	15abcd
Pendulum + Goal	3.4 + 1.1	70bc	88ab	53cde	0c	88abc	55bc	38b	7bc	86a	79ab	55c	8cde
Pendulum + Gallery	3.4 + 1.1	63bcd	73abc	66abc	1c	84bcd	33c	25bc	11abc	83a	73ab	58bc	5de
Weeded	—	25e	30e	8f	44a	63e	25cd	93a	0c	71ab	93a	88ab	0g
Unweeded	—	23e	0f	0f	46a	0f	0d	0c	20a	0c	0d	0d	29a

^aApplications were made April 17 and July 22, 1991 and March 17 and June 23, 1992. Sicklepod control was not rated following the March 17, 1992 application due to limited germination. Control ratings were made 30, 60, and 90 DAT.

^yNumbers followed by the same letter are not significantly different according to Duncan's Multiple Range Test, p = 0.05.

nonweeded plants at 30 DAT when limited weed growth had occurred. By 90 DAT, plants had generally grown past injury symptoms or transplant shock (data not shown). With the July, 1991 application, plant injury was generally greatest when Predict or Predict combinations were applied. Predict symptoms were similar to those observed on crapemyrtle and viburnum (bleaching of older foliage).

Growth indices of live oak in all herbicide treatments were similar to the handweeded plants both years. Pendulum, Predict, and Surflan resulted in comparable growth indices in both years.

'Mary Nell' holly. None of the herbicide treatments resulted in visible plant injury in excess of 10% (data not shown). Injury was restricted to Predict (i.e. temporary discoloration of the older foliage). Growth indices were not influenced by any herbicide treatment (data not shown).

Weed control. Control of sicklepod, a major weed pest in field grown nursery crops in the Southeast, was consistently enhanced when Predict was applied. Sicklepod control ranged from about 75% to 95% when Predict was applied, with the exception of 90 DAT with the first application (Table 4). From the second application in July 1991 until the study was terminated, Predict and its combinations generally provided about 90% control of sicklepod. Pendulum and Surflan applied alone provided similar sicklepod control (50% or less by 90 DAT) after the first two applications. Thereafter, Pendulum provided greater sicklepod control than Surflan except at 90 DAT. Surflan + Princep was among the herbicide treatments providing the least sicklepod control 90 DAT for all dates (33%). This is one of the primary herbicide combinations used in field production in the Southeast and may explain why sicklepod is often a troublesome weed.

In 1992, Predict treatments provided almost total sicklepod control with fresh weed weights averaging less than 1.5 kg (3.3 lb)/plot. In comparison, Surflan and Pendulum treated plots averaged 15.8 kg (34.8 lb) and 8.9 kg (19.6 lb)/plot, respectively.

Goosegrass fresh weight was similar among all herbicide treatments in 1991 (data not shown). A lack of significance between Pendulum, Predict, and Surflan was a reflection of the acceptable (> 77%) and equivalent control these herbicides provided. Other reports have indicated similar activity of pendimethalin and oryzalin (5).

Cutleaf eveningprimrose control was influenced by herbicide application (Table 5). These data reflect residual control provided from the second application in 1991 (July 22) since primrose seedlings had emerged before the March 17 application. Maximum primrose control was achieved when Goal or Princep was tank mixed with either Pendulum, Predict, or Surflan. Pendulum, Predict, or Surflan applied alone provided negligible primrose control 60 DAT (May 27). These data demonstrate the benefits of tank mixing herbicides for extended broadleaf control.

Table 5. Effects of selected herbicides on cutleaf eveningprimrose control in the spring of 1992.

Treatment	Rate kg/ha	Primrose control (%) ^a		Fresh wt kg/plot
		May 6	May 27	
Predict	3.4	33ef ^y	5e	24abcd
Predict + Princep	3.4 + 1.1	60cd	55cd	15de
Predict + Goal	3.4 + 1.1	68bc	53cd	16cde
Predict + Gallery	3.4 + 1.1	43de	15e	19cde
Surflan	3.4	18fg	0e	27abc
Surflan + Princep	3.4 + 1.1	60cd	45d	12ef
Surflan + Goal	3.4 + 1.1	80b	73bc	12ef
Surflan + Gallery	3.4 + 1.1	13g	0e	33a
Pendulum	3.4	8g	0e	30ab
Pendulum + Princep	3.4 + 1.1	35ef	15e	25abc
Pendulum + Goal	3.4 + 1.1	81b	81ab	4fg
Pendulum + Gallery	3.4 + 1.1	5g	0e	32a
Weeded	—	100a	100a	0c
Unweeded	—	0g	0e	14abc

^aPercent weed control, 0 = no control, 100 = complete control.

^yNumbers followed by the same letter are not significantly different according to Duncan's Multiple Range Test, p = 0.05.

These data show that Pendulum is safe on field-grown woody plants and provides weed control similar to existing programs. Predict caused foliar injury characterized by marginal chlorosis to complete bleaching of the leaf. Most of the injury with Predict occurred with the first application after planting. Current registration recommends delaying Predict application until one full growing season after planting. Our data support this recommendation; however, plants generally grew past Predict injury symptoms within 60 DAT.

(*Ed. note:* This paper reports the results of research only and does not imply registration of a pesticide under amended FIFRA. Before using any of the products mentioned in this research paper, be certain of their registration by appropriate state and/or federal authorities).

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