Auburn University
Southern Forest Nursery
Management Cooperative

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HERBICIDE TRIALS WITH FLORASULAM, PENOXSULAM, TRIFLOXYSULFURON AND SULFENTRAZONE IN LOBLOLLY AND SLASH PINE SEEDBEDS

by
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INTRODUCTION

At its inception in 1972, the Southern Forest Nursery Management Cooperative was tasked by its members to develop effective weed control practices due to the considerable production problems caused by weed infestations. Since that time, trials have been conducted with numerous preemergent herbicides. Several of these proved to be effective in their control of targeted weeds emerging in the early months of the bareroot nursery growing season with no damage to germinating seedlings. The inclusion of these preemergent herbicides into operational weed control regimes by cooperative member nurseries has been a positive result of these SFNMC trials. Even as fewer weed problems appear early in the growing season, later-season weed growth continues after the herbicidal effectiveness of the preemergents has diminished. The reduction or elimination of the need to hand-weed nursery beds or containers would be a considerable boost to seedling production and a reduction in expense for nurseries employing the practice. Depending on the weed involved, removal by hand-weeding may actually increase its spread if rhizomes are left since new plants can sprout at each stem node.

The need for selective postemergent herbicides has been evident in SFNMC member nurseries since 1972, as noted in one of the first herbicide trials conducted to identify a postemergent herbicide that could control nutsedge (*Cyperus spp.*). Since that time, many selective postemergent herbicides have been tested with minimal success when applied in over-the-top applications. The herbicides tested were chosen for their control of targeted weeds and were typically 'borrowed' from the agricultural, turf or ornamental sectors but usually did not include conifer nurseries on the labelled list of acceptable application sites.

Simply put, the forest nursery footprint is not large enough to warrant new chemistries solely for use on seedlings. Like previous years, we reached into the Agricultural and Turf toolboxes and selected four herbicides for testing over the top of pine seedlings. These compounds were chosen after a survey was conducted of SFNMC member nurseries in order to identify problematic later-season weeds. Potential postemergent herbicides were identified as control agents of these weeds by faculty of the Department of Crop, Soil and Environmental Sciences in College of Agriculture at Auburn University. These herbicides are florasulam, penoxsulam, trifloxysulfuron and sulfentrazone.

Florasulam (used as Defendor™) is a triazolopyrimidine chemical which acts as an ALS inhibitor to disrupt production of amino acids, thereby stopping biological function. Activity in the plant is seen as chlorosis, growth inhibition and reddening of veins, resulting in necrosis in 1-4 weeks.

Florasulam is a broadleaf herbicide, and is produced by Dow AgroSciences as Defendor™ in a suspension concentrate formulation for turf applications in the U.S. It is foliar and soil active and is used primarily in postemergent applications due to its short half-life in soil.

Penoxsulam (used as Grasp® SC) is also a triazolopyrimidine chemical and ALS inhibitor. It is used for control of specific sedges, grasses and broadleaf plants. Penoxsulam is produced by Dow AgroSciences as Grasp® SC and Granite® SC in a suspension concentrate formulation for rice crops and as LockUp® and Sapphire® in turf applications. It is also sold as a postemergent herbicide for control of annual grass and broadleaf weeds in winter wheat and triticale under the trade name PowerFlex®.

Trifloxysulfuron (used as Envoke®) is a sulfonylurea chemical and ALS inhibitor. It is used for control of certain sedges, grasses and broadleaf plants. Trifloxysulfuron is produced by Syngenta as Envoke® in a water dispersible granular formulation for cotton and sugarcane crops and as Monument® in turf.

Sulfentrazone (used as Dismiss®) is a phenyltriazoles chemical which acts as a PPO inhibitor to block chlorophyll production and break down cell membranes, resulting in plant death. PPO inhibitors can be applied in preemergent or postemergent applications. In preemergent uses, targeted plants die after emergence from treated soil and exposure to light. In postemergent uses, good foliar coverage is essential due to limited translocation of sulfentrazone. It is used for control of specific broadleaf plants, sedges and goosegrass. Sulfentrazone is produced by FMC as Dismiss® in a suspension concentrate formulation for turf and ornamentals and as Spartan® for tobacco, sunflower and soybean crops as well as certain vegetable and oil crops. This herbicide was selected for a postemergent application trial to identify an acceptable chemical capable of controlling goosegrass *(Eleusine indica)* in a SFNMC member nursery reporting severe goosegrass problems in previous years.

The objectives of these trials were to 1) determine tolerance of bareroot loblolly and slash pine seedlings to preemergent and postemergent applications of the 4 herbicides, and 2) evaluate herbicidal effectiveness on later-season weeds.

METHODOLOGY

Trials were established in April and June of 2016 in four SFNMC member bareroot nurseries: ArborGen Selma Nursery (AL), Georgia Forestry Commission Flint River Nursery (GA), K & L Forest Nursery (GA) and Weyerhaeuser (now IFCO) Pine Hill Nursery (AL). Each of the **florasulam**, **penoxsulam** and **trifloxysulfuron** trials were sprayed at sowing, at 8, 13 and 16 weeks post-sowing. Loblolly and slash pine were included at the Pine Hill and Flint River nurseries, with loblolly pine at the Selma and K & L nurseries. The **sulfentrazone** trial was installed at the Weyerhaeuser (now IFCO) Pine Hill Nursery (AL) in single sprays at 8, 13 and 16 weeks post-sowing, with an additional double application made at 8 and 13 weeks. Loblolly and slash pine were included in this trial.

Studies were constructed in a randomized block design and each treatment was one seedling bed wide by 10 feet in length and replicated 5 times. All trials contained 4 treatments and a non-treated control. Each of the herbicides was tested at its lowest labelled rate: **florasulam** (Defendor™) at 4 oz/ac, **penoxsulam** (Grasp® SC) at 2 oz/ac, **trifloxysulfuron** (Envoke®) at 0.1 oz/ac and **sulfentrazone** (Dismiss®) at 4 oz/ac. Herbicide applications were made by SFNMC personnel with a CO_2 hand sprayer calibrated to broadcast spray 25 gallons per acre.

In an attempt to quantify weed control, estimates of weed coverage and identification of weeds were made in all installations in September 2016. At the end of the growing season, all seedlings within a counting frame placed in each plot in each installation were collected and transported to the SFNMC laboratory for evaluation. Seedling counts for density were made, then all seedlings from within rows 2, 4 and 6 of the

beds were measured for shoot height, root collar diameter, shoot dry weight and root dry weight. Measurements of treated seedlings were compared to those of non-treated control seedlings to determine tolerance to applications of the herbicide. Data was analyzed using Analysis of Variance (ANOVA) and treatment means were compared at alpha=0.05. Significant differences in treatments were noted if p-values fell below 0.05.

RESULTS AND DISCUSSION

The application of **florasulam** (Defendor™) on loblolly and slash pine seedlings had no negative effects on seedling densities, shoot heights, root collar diameters, shoot weights or root weights (Tables 1 and 2).

Penoxsulam (Grasp® SC) applications on loblolly pine at the time of sowing resulted in significantly lower seedling densities, shoot heights, root collar diameters and shoot weights (Table 3). Applications at other times had no effect on these characteristics. Loblolly root weights were not negatively affected at any time of application. Similarly, slash pine densities, shoot heights and shoot weights were negatively affected by at-sowing applications of penoxsulam (Table 4). Root collar diameters and root weights were not affected.

The use of **trifloxysulfuron** (Envoke®) in loblolly pine at the time of sowing significantly lowered seedling density in one nursery and shoot height, root collar diameter and shoot weight in one of four nurseries involved in the study (Table 5). As with the other herbicides, root weights were not negatively affected. Slash pine plots also had lower seedling densities and shoot heights when trifloxysulfuron was sprayed at sowing (Table 6). However, seedling root collar diameters, root weights and shoot weights were not affected at any time of application.

The applications of **sulfentrazone** (Dismiss®) were all made post-sowing on loblolly and slash pine seedlings with no negative effects on seedling densities, shoot heights, root collar diameters, root weights or shoot weights (Table 7).

Weed control as measured by appearance of weeds is difficult to assess due to the non-normal distribution of weeds. Thus, like previous studies, estimates of weed coverage are not reported due to the high variability of weed populations in treatment plots. As new herbicides are tested by the SFNMC, it is assumed that each will control or suppress those weeds listed on individual labels. During the course of these trials, varying quantities of eclipta, annual sedge, prostrate spurge, crabgrass, sicklepod, morning glory, black willow, Florida beggarweed, crowsfoot grass, horseweed and ragweed were observed in beds included in these studies. The presence of this range of broadleaf weeds, sedges and grasses highlights the need for safe and effective selective postemergent herbicides in bareroot pine seedling nurseries.

MANAGEMENT IMPLICATIONS

- Because of negative effects observed on loblolly and slash pine, penoxsulam and trifloxysulfuron are not safe to be used at the time of sowing. However, all four of the herbicides included in these trials are typically applied in postemergent treatments after problem weeds have emerged weeks after pine seedlings have germinated. The at-sowing time of application would not be a suggested use of these herbicides by their manufacturers.
- Additional trials of these and other selective postemergent herbicides should be conducted in order to identify currently available products for possible revision of labels or special local needs label registration.

REFERENCES

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Table 1. Bareroot loblolly pine seedling characteristics treated with florasulam (Defendor™).

Nursery[1]	Time of Application	Density/ft^2	Shoot Height (cm)	RCD (mm)		Root Weight (g)		Shoot Weight (g)	
A	control	30.8	27.8	4.27		0.58		2.96	
	at sowing	27.4	26.5	4.21		0.61		2.85	
	8 wks	27.4	26.8	3.97		0.52		2.68	
	13 wks	31.2	27.2	4.20		0.57		2.94	
	16 wks	29.9	27.9	4.21		0.56		2.88	
B	control	26.1	15.9	2.59	c	0.24	b	0.56	b
	at sowing	26.5	18.3	3.14	ab	0.35	ab	1.07	a
	8 wks	23.8	18.9	3.34	a	0.39	a	1.22	a
	13 wks	25.3	17.8	2.97	abc	0.30	ab	0.84	ab
	16 wks	23.9	16.0	2.84	bc	0.28	ab	0.68	ab
C	control	26.9	32.7	4.69		0.57		3.41	
	at sowing	25.6	32.6	4.69		0.64		3.43	
	8 wks	24.5	32.0	4.69		0.65		3.57	
	13 wks	26.2	33.3	4.87		0.62		3.66	
	16 wks	26.8	32.5	4.65		0.57		3.46	

Different letters (a, b) within a seedling characteristic column indicate significant treatment difference in rates according to Duncan's Multiple Range test at alpha = 0.05. Underlined means within a seedling characteristic indicate significant treatment difference from that of the non-treated Control at that rate according to Dunnett's T-test at alpha = 0.05.
[1]One nursery was eliminated from this trial due to insufficient replications available for sampling.

Table 2. Bareroot slash pine seedling characteristics treated with florasulam (Defendor™).

Nursery[1]	Time of Application	Density/ft^2		Shoot Height (cm)	RCD (mm)		Root Weight (g)		Shoot Weight (g)	
A	control	29.3	ab	18.8	2.66	c	0.18	b	0.98	c
	at sowing	26.7	b	21.1	3.44	a	0.36	a	2.01	a
	8 wks	30.1	a	20.8	3.18	ab	0.26	b	1.58	b
	13 wks	29.9	a	20.0	2.82	bc	0.19	b	0.95	c
	16 wks	28.6	ab	20.0	2.97	bc	0.25	b	1.13	c

Different letters (a, b) within a seedling characteristic column indicate significant treatment difference in rates according to Duncan's Multiple Range test at alpha = 0.05. Underlined means within a seedling characteristic indicate significant treatment difference from that of the non-treated Control at that rate according to Dunnett's T-test at alpha = 0.05.
[1]One nursery was omitted from this trial due to insufficient replications available for sampling.

Table 3. Bareroot loblolly pine seedling characteristics treated with penoxsulam (Grasp® SC).

Nursery	Time of Application	Density/ft^2		Shoot Height (cm)		RCD (mm)		Root Weight (g)		Shoot Weight (g)	
A	control	32.8	a	27.8	a	4.21	a	0.55		2.78	a
	at sowing	25.4	b	16.9	b	3.32	b	0.60		1.61	b
	8 wks	30.0	a	27.6	a	4.29	a	0.64		2.99	a
	13 wks	31.5	a	27.6	a	4.08	a	0.57		2.73	a
	16 wks	30.1	a	27.5	a	4.25	a	0.62		2.89	a
B	control	25.3	a	19.4	ab	3.00		0.32		1.19	
	at sowing	18.3	b	17.6	b	3.14		0.42		1.44	
	8 wks	28.1	a	22.6	a	3.29		0.37		1.73	
	13 wks	26.1	a	19.2	ab	3.21		0.39		1.42	
	16 wks	25.8	a	19.8	ab	3.09		0.34		1.38	
C	control	31.8	a	22.7	a	3.27	ab	0.73	ab	1.79	a
	at sowing	26.3	b	13.8	b	2.69	b	0.60	b	0.86	b
	8 wks	29.1	ab	21.4	a	3.53	a	0.82	ab	1.78	a
	13 wks	31.7	a	21.5	a	3.38	a	0.72	ab	1.83	a
	16 wks	32.7	a	25.6	a	3.73	a	0.88	a	2.35	a
D	control	26.5		32.2	a	4.64	a	0.61	bc	3.55	a
	at sowing	24.6		27.0	b	4.17	b	0.75	a	2.75	b
	8 wks	25.8		31.3	a	4.62	a	0.68	ab	3.66	a
	13 wks	26.7		32.7	a	4.49	a	0.56	c	3.32	a
	16 wks	28.6		32.2	a	4.51	a	0.59	bc	3.26	a

Different letters (a, b) within a seedling characteristic column indicate significant treatment difference in rates according to Duncan's Multiple Range test at alpha = 0.05. Underlined means within a seedling characteristic indicate significant treatment difference from that of the non-treated Control at that rate according to Dunnett's T-test at alpha = 0.05.

Table 4. Bareroot slash pine seedling characteristics treated with penoxsulam (Grasp® SC).

Nursery	Time of Application	Density/ft^2		Shoot Height (cm)		RCD (mm)		Root Weight (g)		Shoot Weight (g)	
A	control	21.7	a	20.6	a	3.22		0.31	b	1.70	
	at sowing	14.3	b	<u>16.5</u>	b	3.78		<u>0.51</u>	a	2.09	
	8 wks	22.7	a	22.8	a	3.78		0.40	ab	2.45	
	13 wks	23.3	a	21.1	a	3.63		0.40	ab	1.80	
	16 wks	23.2	a	22.2	a	3.46		0.36	ab	1.76	
B	control	31.8	a	22.7	a	3.27	ab	0.73	ab	1.79	a
	at sowing	<u>26.3</u>	b	<u>13.8</u>	b	2.69	b	0.60	b	<u>0.86</u>	b
	8 wks	29.1	ab	21.4	a	3.53	a	0.82	ab	1.78	a
	13 wks	31.7	a	21.5	a	3.38	a	0.72	ab	1.83	a
	16 wks	32.7	a	25.6	a	3.73	a	0.88	a	2.35	a

Different letters (a, b) within a seedling characteristic column indicate significant treatment difference in rates according to Duncan's Multiple Range test at alpha = 0.05. Underlined <u>means</u> within a seedling characteristic indicate significant treatment difference from that of the non-treated Control at that rate according to Dunnett's T-test at alpha = 0.05.

Table 5. Bareroot loblolly pine seedling characteristics treated with trifloxysulfuron (Envoke®).

Nursery	Time of Application	Density/ft²		Shoot Height (cm)		RCD (mm)		Root Weight (g)	Shoot Weight (g)	
A	control	30.3	ab	27.7		4.18		0.56	2.75	ab
	at sowing	25.8	c	27.4		4.08		0.56	2.55	b
	8 wks	30.5	a	27.7		4.20		0.58	2.98	a
	13 wks	27.8	bc	28.2		4.28		0.58	3.00	a
	16 wks	30.8	a	27.4		4.00		0.57	2.84	ab
B	control	27.1		25.6	a	3.81	a	0.55	2.36	a
	at sowing	26.5		19.7	b	3.34	b	0.47	1.55	b
	8 wks	27.5		26.7	a	3.87	a	0.59	2.46	a
	13 wks	26.7		25.7	a	3.69	ab	0.52	2.23	a
	16 wks	25.9		25.5	a	3.85	a	0.57	2.33	a
C	control	32.7		21.8		3.39		0.64	1.71	
	at sowing[1]	.		.		.		.	.	
	8 wks	33.0		22.5		3.61		0.71	1.88	
	13 wks	30.9		21.3		3.33		0.62	1.64	
	16 wks	34.3		22.5		3.40		0.65	1.79	
D	control	26.1		32.1		4.63		0.58	3.20	
	at sowing	23.8		32.2		4.70		0.68	3.46	
	8 wks	28.1		32.3		4.71		0.63	3.52	
	13 wks	25.2		32.4		4.68		0.62	3.34	
	16 wks	27.6		31.8		4.59		0.58	3.23	

Different letters (a, b) within a seedling characteristic column indicate significant treatment difference in rates according to Duncan's Multiple Range test at alpha = 0.05. Underlined means within a seedling characteristic indicate significant treatment difference from that of the non-treated Control at that rate according to Dunnett's T-test at alpha = 0.05.

[1] This application was omitted from this trial due to insufficient replications available for sampling.

Table 6. Bareroot slash pine seedling characteristics treated with trifloxysulfuron (Envoke®).

Nursery	Time of Application	Density/ft²		Shoot Height (cm)		RCD (mm)	Root Weight (g)	Shoot Weight (g)
A	control	21.5	a	26.6	a	4.39	0.67	3.86
	at sowing	14.0	b	19.3	b	4.69	0.81	3.41
	8 wks	19.6	ab	27.2	a	4.67	0.74	4.28
	13 wks	17.1	ab	27.4	a	5.02	0.82	4.79
	16 wks	20.2	ab	25.4	a	4.31	0.62	3.31

Different letters (a, b) within a seedling characteristic column indicate significant treatment difference in rates according to Duncan's Multiple Range test at alpha = 0.05. Underlined means within a seedling characteristic indicate significant treatment difference from that of the non-treated Control at that rate according to Dunnett's T-test at alpha = 0.05.

Table 7. Bareroot loblolly and slash pine seedling characteristics treated with sulfentrazone (Dismiss®) at one nursery.

Pine Species	Time of Application	Density/ft^2	Shoot Height (cm)		RCD (mm)	Root Weigh t (g)	Shoot Weight (g)
Loblolly	control	24.3	28.2		4.22	0.77	2.84
	8 wks	25.4	26.5		3.97	0.66	2.63
	13 wks	21.3	27.5		4.43	0.85	3.13
	16 wks	24.5	26.8		4.13	0.71	2.61
	8 and 13 wks	26.2	26.1		3.99	0.65	2.72
Slash	control	23.4	26.3	b	4.62	0.82	4.03
	8 wks	21.1	25.4	b	4.52	0.77	4.21
	13 wks	22.8	28.5	a	4.70	0.72	4.19
	16 wks	25.9	26.7	ab	4.23	0.60	3.45
	8 and 13 wks	24.1	26.5	b	4.34	0.67	3.84

Different letters (a, b) within a seedling characteristic column indicate significant treatment difference in rates according to Duncan's Multiple Range test at alpha = 0.05. Underlined means within a seedling characteristic indicate significant treatment difference from that of the non-treated Control at that rate according to Dunnett's T-test at alpha = 0.05.

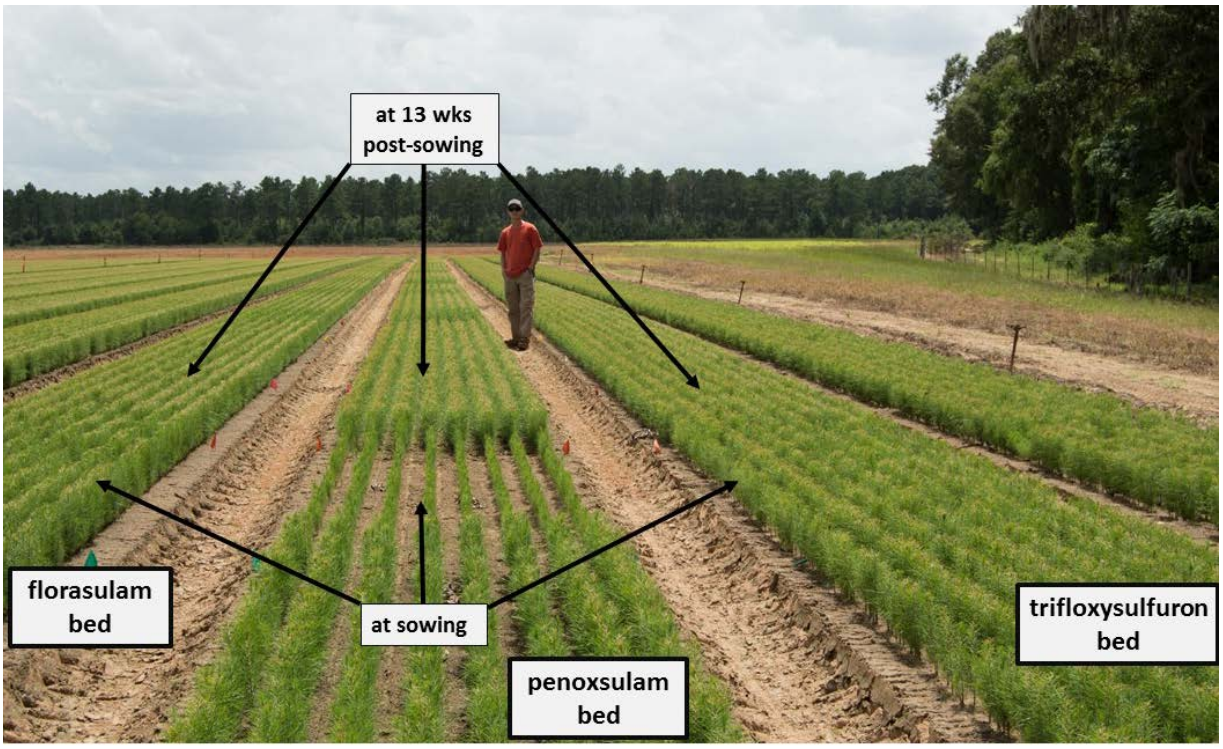

Figure 1. Loblolly pine seedlings treated with florsulam, penoxsulam and trifloxysulfuron over the growing season. Application of Penoxsulam, center bed, at time of sowing resulted in stunting of seedlings.