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RONSTAR®FLO (OXADIAZON) ON LOBLOLLY, LONGLEAF, SHORTLEAF AND SLASH PINE IN CONTAINER-GROWN AND BAREROOT NURSERIES

by
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INTRODUCTION

Control of annual sedge (*Cyperus compressus*) in bareroot and container nurseries is problematic as the weed generally appears mid-summer when pine seedlings are actively growing. The availability of herbicides to safely spray over-the-top of pine seedlings is limited, and even more so when selecting herbicides that target sedges. One herbicide that controls annual sedge is oxadiazon. Packaged as Ronstar® in several formulations, annual sedge is listed as a controlled weed on its label. The Southern Forest Nursery Management Cooperative (SFNMC) began testing oxadiazon in a water-soluble packet (WSP) formulation in the late 1990s. Results of a 1999 SFNMC study (Research Report 00-08) found that this formulation did not injure pine seedlings when applied at four to six weeks post-sowing. Further studies in 2012 and 2013 tested Ronstar®Flo (liquid formulation of oxadiazon) in preemergent applications alone and in tank mix combinations with Pendulum® AquaCap™ and Goal®2XL. Results of these trials (Research Reports 13-04 and 14-06) showed good loblolly pine tolerance and sedge control. A recommendation from the 2013 trial was to test Ronstar®Flo at nursery sites of varying soil types.

Just as annual sedge competes with bareroot pine seedlings for nutrients and water, its presence in containerized growing systems is also detrimental to seedling growth. A larger weed problem in containers, however, is black willow (*Salix nigra*). Due to its seeding patterns, population prediction and control is difficult. Hand-weeding willow seedlings from container trays is currently the only reliable method of removal, resulting in considerable labor costs. This expense may be reduced or eliminated by the application of an appropriate selective herbicide chosen for its tolerance by pine and effectiveness in controlling black willow. Although black willow is not listed as a controlled weed on the Ronstar®Flo label, neither is it listed as tolerant to the herbicide. Oxadiazon has not been tested by the SFNMC in a containerized growing system, so was selected for use in this study for its labelled control of annual sedge and potential control of black willow in containers.

In order to provide additional herbicide options, continued testing of oxadiazon was warranted. The objectives of this study were: 1) to assess the tolerance of bareroot loblolly pine and containerized loblolly, longleaf, shortleaf and slash pine to Ronstar®Flo, and 2) evaluate the effectiveness of Ronstar®Flo in controlling black willow populations in a containerized growing system.

METHODOLOGY

Bareroot Seedling Studies

Trials were established in April 2017 at four SFNMC member nurseries: the South Carolina Forestry Commission Nursery in Trenton, South Carolina, the K & L Forest Nursery in Buena Vista, Georgia, the ArborGen SuperTree Nursery in Blenheim, South Carolina and the ArborGen SuperTree Nursery in Shellman, Georgia. Each trial contained replicated treatments with rates of 0.0 oz./ac., 40 oz./ac, 80 oz./ac and 122 oz./ac applied. In previous SFNMC Ronstar®Flo studies, two rates were tested: one-half of the lowest label rate (40 oz./ac) and the lowest label rate of 80 oz./ac. The highest label rate of Ronstar®Flo (122 oz./ac) was added to this study. Five replications of treatments one seedling bed wide by 10 feet in length were established for each rate, utilizing 200 feet of bed space. Applications of Ronstar®Flo were made either the day of sowing or one day after sowing. The herbicide was applied prior to bark spreading at those nurseries using pine bark mulch. Each nursery made their specific operational herbicide applications to the study areas, and Ronstar®Flo was applied by SFNMC staff using a CO_2 hand sprayer calibrated to broadcast spray 25 gallons per gallon.

In October and November 2017, seedling density measurements were made within a counting frame placed in each treatment plot. Seedling samples were removed from each plot and transported to the SFNMC laboratory for evaluation of tolerance to Ronstar®Flo. A sample size of 25 seedlings per treatment plot was used to measure seedling height, root collar diameter, stem swelling, root dry weight and shoot dry weight. Data from treated seedlings were compared to those of seedlings with no Ronstar®Flo applications with analysis using Duncan's Multiple Range test, Dunnett's T-test and Wilcoxon Method for Nonparametric Comparisons, all at alpha = 0.05.

Container Seedling Studies

Weekly applications of Ronstar®Flo were made over newly-sown trays of loblolly, longleaf, shortleaf and slash pine at the International Forest Company Nursery in Moultrie, Georgia. Beginning on March 23, 2017, prior to black willow seed dispersal, capped trays were sprayed either the day of sowing or one day after sowing. A five-week period was required to capture optimal black willow seed dispersal and pine species availability. Trays received one of four treatments; 0.0 oz./ac, 40 oz./ac, 80 oz./ac and 122 oz./ac, representing the control, one-half the lowest label rate, the lowest label rate and the highest label rate, respectively. All applications were made by SFNMC personnel using a CO_2 hand sprayer calibrated to broadcast spray 25 gallons per gallon.

Each treatment was one container tray, replicated 15 times for each rate. At the end of the growing season, the week with the highest willow population within the control trays was selected for herbicide evaluation. In December 2017, the number of pine seedlings, the number of willow and the number of other weeds species were recorded. A total of 240 trays were used in this study (4 treatments x 15 trays per treatment x 4 species). Random samples of 10 seedlings from each treatment in each species were removed and evaluated at the SFNMC laboratory for tolerance to the herbicide. Measurements of shoot height, root collar diameter, stem swelling, plug dry weight and shoot dry weight were made and compared to those from seedlings in non-treated trays. Statistical analyses using Duncan's Multiple Range test, Dunnett's T-test and Wilcoxon Method for Nonparametric Comparisons, all at alpha = 0.05, were examined on data collected.

RESULTS AND DISCUSSION

Bareroot Seedling Studies

In this study, bareroot loblolly pine tolerance to Ronstar®Flo varied by nursery. At two nurseries (A and D in Table 1), seedling density reported as number of seedlings per square foot was negatively affected by Ronstar®Flo. At one nursery (D), seedling density, height and root collar diameter were negatively affected by all rates of the herbicide. When damage to seedlings was quantified, the highest label rate (122 oz./ac) had similar results to seedlings treated with the lowest label rate (80 oz./ac). These results of lower seedling densities in plots treated with Ronstar®Flo are in contrast to results reported in Research Reports 13-04 and 14-06. However, none of the four nurseries included in this 2017 trial were included in earlier trials summarized in those reports. This underscores the effect of nursery site characteristics on herbicide activity. Components of soil texture, soil and irrigation water pH, geography, rainfall, weather, and operational treatments play a part in determining how herbicides interact with a targeted or non-targeted plant species. If targeted weeds such as annual sedge listed on the Ronstar®Flo label continue to appear in nursery beds, this herbicide may be an option to consider as a pre-emergent herbicide AFTER TESTING the product in a small area.

Container Seedling Studies

The effect of Ronstar®Flo in a pre-emergent application on containerized pine was dependent on species. However, none of the four species in this trial exhibited negative effects of herbicide applications except at the highest rates. Loblolly pine trays treated with the highest label rate (122 oz./ac) had significantly lower survival than those trays treated with 0, 40 or 80 oz./acre of the product. Slash pine trays sprayed with either 80 oz./acre or 122 oz./ac had seedlings with significantly shorter height than those with no treatment or with 40 oz./acre applied. All other seedling characteristics had no differences from non-treated control trays (Table 2).

Seedling trays sprayed with Ronstar®Flo at sowing had significantly fewer black willow seedlings at the end of the growing season (Table 3) than non-treated trays. For the two pine species placed on pivots at this nursery during willow seed dispersal, loblolly and longleaf, decreases of 87% to 100% in willow populations were quantified when compared to untreated control trays.

Oxadiazon is used in the ornamental horticulture industry and studied for its phytotoxicity to various plants grown in large containers. Information dating to the 1970's can be found on the interaction of this herbicide with plants grown in organic media of different mixtures. Although the various mixtures of peat moss, compost, sand, sawdust, muck, and bark used in these studies is not identical to the media used in this trial, some correlations can be made. It has been reported that oxadiazon was more persistent in and leached less than 4 centimeters from the soil surface in media with high organic content.

MANAGEMENT IMPLICATIONS

- In bareroot nurseries, the effects of Ronstar®Flo on loblolly pine seedlings was dependent on nursery site. Because negative effects on seedling bed density, seedling height and root collar diameters were found in most nurseries cooperating in the study, this compound

should not be used until it has been thoroughly tested at a specific nursery in a small trial area.

- In containerized growing systems, the two pine species most likely to be exposed to black willow infestations are longleaf and loblolly pine due to their time of sowing and willow seed dispersal. Ronstar®Flo sprayed at 40 oz./ac and 80 oz./ac resulted in no negative effects to either species. The highest rate applied, 122 oz./ac, reduced survival in loblolly pine but had no negative effect to longleaf pine. Populations of black willow were significantly reduced by all applications of Ronstar®Flo on longleaf and loblolly pine trays.

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Table 1. Bareroot loblolly pine seedling characteristics treated with Ronstar®Flo at four nurseries.

Nursery	Rate	Density/ft^2	Shoot Height (cm)	RCD (mm)	Shoot Weight (g)	Root Weight (g)
A	0 oz./ac	26.0	23.2	4.11 a	2.53	0.60 a
	40 oz./ac	24.7	23.3	4.16 ab	2.57	0.59 a
	80 oz./ac	20.5	23.3	4.31 b	2.91	0.66 ab
	122 oz./ac	16.0	23.5	4.53 c	3.27	0.72 b
B	0 oz./ac	25.1	29.7	4.98	3.35	0.65
	40 oz./ac	25.2	29.0	4.92	3.20	0.61
	80 oz./ac	24.9	29.2	4.80	3.28	0.62
	122 oz./ac	23.8	29.9	4.90	3.39	0.59
C	0 oz./ac	17.3	31.0	4.62	4.13	0.46
	40 oz./ac	18.7	30.6	4.38	3.53	0.39
	80 oz./ac	16.7	30.9	4.46	3.59	0.41
	122 oz./ac	18.3	30.9	4.27	3.50	0.37
D	0 oz./ac	24.3 a	27.4	4.40	3.23	0.40
	40 oz./ac	24.3 a	24.3	3.90	2.51	0.39
	80 oz./ac	12.8 b	21.1	3.90	2.68	0.45
	122 oz./ac	11.1 b	17.4	3.90	2.24	0.44

Different letters (a, b) within a seedling characteristic column indicate significant treatment differences in rates according to Duncan's Multiple Range test at alpha = 0.05.

Single 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.

Double underlined means within a seedling characteristic indicate a significant treatment difference from that of the non-treated control at that rate according to nonparametric Wilcoxon test at alpha = 0.05.

Table 2. Container pine seedling characteristics treated with Ronstar®Flo in four species, IFCO Nursery, Moultrie, GA.

Species	Rate	Survival[1] (% Fill)	Shoot Height (cm)	RCD (mm)	Shoot Weight (g)	Plug Weight[2] (g)
Loblolly	0 oz./ac	92.7 a	26.2	3.72	2.05	11.38
	40 oz./ac	93.2 a	26.6	3.75	2.09	11.52
	80 oz./ac	90.2 a	26.7	3.78	2.12	11.69
	122 oz./ac	86.5 b	26.1	3.78	2.07	11.81
Longleaf	0 oz./ac	83.4	26.6	8.10	3.12	13.73
	40 oz./ac	82.9	26.4	8.18	3.08	13.77
	80 oz./ac	83.7	26.1	8.18	3.10	13.69
	122 oz./ac	79.8	26.3	8.30	3.18	13.89
Shortleaf	0 oz./ac	88.0	21.5	3.99	1.86	11.22
	40 oz./ac	89.1	21.8	3.92	1.90	11.37
	80 oz./ac	86.7	21.9	3.98	1.92	11.38
	122 oz./ac	88.0	22.0	3.98	1.90	11.36
Slash	0 oz./ac	93.5	28.7	4.22	2.77	12.61
	40 oz./ac	92.5	28.4	4.21	2.66	12.77
	80 oz./ac	89.9	27.8	4.14	2.61	12.78
	122 oz./ac	90.2	27.6	4.18	2.64	12.62

Different letters (a, b) within a seedling characteristic column indicate significant treatment differences in rates according to Duncan's Multiple Range test at alpha = 0.05.

Single 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.

Double underlined means within a seedling characteristic indicate a significant treatment difference from that of the non-treated control at that rate according to nonparametric Wilcoxon test at alpha = 0.05.

[1] Percent survival based on tray seedling count made in December compared to total number of cells initially sown.
[2] Plug weight includes both media and root dry weight.

Table 3. Percent likelihood of no willow or other weed populations in containers treated with Ronstar®Flo in four species, IFCO Nursery, Moultrie, GA.

Species	Rate	% likelihood of 0 willows present in 1 container tray	% likelihood of 0 other weeds present in 1 container tray
Loblolly	0.0 oz./ac	20.0	80.0
	40 oz./ac	**86.7**	100.0
	80 oz./ac	**100.0**	86.7
	122 oz./ac	**93.3**	100.0
Longleaf	0.0 oz./ac	53.3	86.7
	40 oz./ac	**100.0**	100.0
	80 oz./ac	**100.0**	100.0
	122 oz./ac	**100.0**	100.0
Shortleaf	0.0 oz./ac	*	*
	40 oz./ac	*	*
	80 oz./ac	*	*
	122 oz./ac	*	*
Slash	0.0 oz./ac	*	66.7
	40 oz./ac	*	**100.0**
	80 oz./ac	*	**100.0**
	122 oz./ac	*	**93.3**

Bold underlined means within a column indicate a significant treatment difference from that of the non-treated control at that rate according to Chi-square test at alpha = 0.05.

*indicates no willow or other weed populations present