Southern Forest Nursery Management Cooperative

RESEARCH REPORT 20-02

APPLICATION OF RONSTAR®FLO (OXADIAZON) FOR WILLOW CONTROL IN CONTAINERIZED GROWING SYSTEMS: A SUMMARY OF THREE YEARS OF TRIALS

by
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INTRODUCTION

As the quantity of pine seedlings grown for reforestation steadily increases annually, the percentage increase in the number of containerized seedlings produced in the southern U.S. has outpaced those grown in bareroot nurseries. Between 2012 and 2018, the number of bareroot seedlings grown in 13 southern states has increased by 12%. In contrast, the number of container seedlings has increased by 19% in the same 6-year time period (Harper et al 2013, Haase et al 2019).

As production increases, so does the need for information and technologies developed specifically for the management of containerized growing systems, including weed control products suitable for these nurseries. Few of the herbicides currently used operationally in bareroot nurseries have been tested in, or are labeled for use in container nurseries. In the southern U.S., one unwanted plant that continually presents a problem in containers is black willow (*Salix nigra*) (Starkey et al 2015). The presence of a black willow seedling growing within a pine seedling container plug diminishes the pine seedling's value and decreases its viability (Starkey 2014). The current method of controlling black willow infestations in containers is primarily their removal by hand, which is a costly, labor-intensive operation further compounded by the potential shortage of available workers to perform this nursery sanitation task (Starkey et al 2015).

The Southern Forest Nursery Management Cooperative (SFNMC) has tested potential herbicides for use in controlling black willow in containerized growing systems since 2014. Multiple testing trials are required prior to operational use as herbicidal active ingredients interact differently in container growing media than in bareroot growing systems. One herbicide tested was Marengo® (indaziflam) (Bayer CropScience, North Carolina), which was tested in 2014, 2016 and 2017. A second herbicide tested was Pendulum®AquaCap™ (pendimethalin) (BASF, North Carolina) in 2015, 2016, and 2017. Both Marengo® and Pendulum®AquaCap™ were found to be unacceptable for use in containerized nurseries due to decreased plug weights in treated seedlings and inconsistencies in effects on most seedling characteristics (Enebak et al 2015, Payne et al 2016a, b, 2017a, b and 2018). The selection of Ronstar®Flo (oxadiazon) (Bayer CropScience, North Carolina) for testing was a result of its successful testing in 2012 and 2013 in bareroot nurseries (Enebak et al 2013 and 2014). The product is labeled for use in conifer nurseries in pre-emergent applications or as a directed spray to the soil in postemergent

applications. The four pine species typically included in container studies are not included in the label's list of tolerant plants suitable for over-the-top postemergent applications.

This report summarizes the methods used and results of three years of testing of Ronstar®Flo (oxadiazon) on four pine species grown in containers. The objectives of each trial were: 1) to assess the tolerance of containerized longleaf, loblolly, slash, and shortleaf pine to applications of the herbicide, and 2) to evaluate the effectiveness of the herbicide in controlling black willow in the same growing containers.

METHODOLOGY

2017

The initial testing of Ronstar®Flo (oxadiazon) was conducted over a 10-week period in March, April, and May of 2017 at the IFCO Moultrie, Georgia container nursery. As seedling trays were sown, capped and transported to benches, 60 trays were pulled for each test. Each installation included four treatments of 15 trays per treatment:

0 ounces per acre (control)
40 ounces per acre (0.5 x lowest labeled rate)
80 ounces per acre (1 x lowest labeled rate)
122 ounces per acre (1 x highest labeled rate)

The following pine species were included in the 2017 trial:

Longleaf pine
Loblolly pine
Slash pine
Shortleaf pine

Applications of Ronstar®Flo were made using one species per installation based on availability of species. Herbicide applications were made on the day of sowing or one day post-sowing. SFNMC personnel labeled trays and sprayed respective treatments using a CO_2 hand sprayer calibrated to spray 25 gallons per acre, then randomly placed trays in a designated bench space.

In order to quantify seedling tolerance and willow control, the 60 trays from each species' installation were removed from benches in December 2017 for inventory and sample retrieval. Counts of pine seedlings per tray compared to initial tray cell count (assuming 100% sow rate) were used to quantify survival/percent fill of trays. The number of willow and other weeds (with weed identifications made) were recorded for each tray. Random samples of 10 seedlings per tray (600 seedlings per species, 2400 seedlings total) were removed, bagged, and transported to the SFNMC lab in Auburn, Alabama, for measurements of seedling height, root collar diameter, and dry weights of plugs and shoots. Counts and measurements of seedlings from treated trays were compared to those of the non-treated control trays and analyzed for statistical differences using Duncan's Multiple Range test, Dunnett's T-test, and Wilcoxon Method for Nonparametric Comparisons at alpha = 0.5, with results included in a 2018 report (Payne et al 2018).

2018

The second round of testing of Ronstar®Flo (oxadiazon) in container seedling trays was made weekly over a four-week period in March and April of 2018. The same method of spray application and tray utilization was used as in 2017, with the following three treatments of 15 trays each:

0 ounces per acre (control)
40 ounces per acre (0.5 x lowest labeled rate)
80 ounces per acre (1 x lowest labeled rate)

The highest rate tested in 2017 (122 ounces per acre) was not used in 2018 due to its negative effect on loblolly pine seedling density in the 2017 study (Payne et al 2018).

The following pine species were included in the 2018 trial:

Longleaf pine
Loblolly pine

These two species were selected due to the coinciding of their sowing dates with expected black willow seed emergence at this nursery location. In the 2017 study, no willow were present in slash or shortleaf pine trays (Payne et al 2018).

Assessment of seedling tolerance and willow control was made as in 2017, with 45 trays per week and 90 trays per species used. A total of 900 longleaf pine seedlings and 900 loblolly pine seedlings were measured. Analyses of seedling measurements and counts made of seedlings, willow, and other weeds were made as in the 2017 study. Results of the 2018 study are included (Payne et al 2019).

2019

To provide a significantly larger data set on seedling tolerance and willow control, increased samples sizes and an additional nursery site were included in the 2019 study. This third round of testing was conducted from March 11 through May 9, 2019 at the IFCO Moultrie, Georgia nursery and on April 11 and 17, 2019 at the Westervelt nursery in Eutaw, Alabama. The same method of spray application and tray utilization was used as in 2017 and 2018, with the following treatments used:

IFCO Nursery:
2 treatments of 50 trays each: 0 ounces per acre (control)
40 ounces per acre (0.5 x lowest labeled rate)

Westervelt Nursery:
2 treatments of 50 trays each: 0 ounces per acre (control)
40 ounces per acre (0.5 x lowest labeled rate)

The 1X lowest labeled rate tested in 2018 (80 ounces per acre) was not used in 2019 in order to adequately quantify the lowest rate previously tested and maintain manageable sample sizes.

The following pine species were included in the 2019 trial:

IFCO Nursery:	Longleaf pine
	Loblolly pine
	Slash pine
	Shortleaf pine
Westervelt Nursery:	Loblolly pine

The inclusion of slash and shortleaf pine at the IFCO site was made in order to obtain additional data on these species' tolerance to the herbicide. Loblolly pine was the only pine species grown at the Westervelt site at the time of the 2019 study.

The procedures for quantifying seedling tolerance and willow control were the same as those used in 2017 and 2018, with the use of significantly larger sample sizes. At IFCO, seedling and willow (plus weed) counts were made in all 50 treated trays from each week of spray application. Seedling counts were made in 10 non-treated (control) trays while willow and weed counts were made in all 50 non-treated (control) trays. Random samples of 10 seedlings from 50 treated trays and 10 seedlings from 10 non-treated (control) trays from each week of spray application (600 seedlings per week) were bagged and transported to the SFNMC lab in Auburn, Alabama, for measurements. A total of 1200 longleaf pine, 1200 loblolly pine, 600 slash pine and 600 shortleaf pine seedlings (3600 total) were used in this 2019 IFCO trial. Similar procedures for data collection were used at the Westervelt Nursery, with seedling and willow (plus weed) counts being made in all 50 treated trays, seedling counts in 10 non-treated (control) trays and willow (plus weed) counts in all 50 non-treated (control) trays. Random samples were collected as at the IFCO Nursery, with 600 seedlings each week (1200 total) measured for seedling quality characteristics. Analyses of all data involving seedling and willow (plus weed) counts and pine seedling measurements were made as in the 2017 and 2018 studies, and are reported in Tables 1 - 10.

RESULTS AND DISCUSSION

Tables of results of three years of testing Ronstar®Flo (oxadiazon) in containerized growing systems are reported by **species**, and are included in the following:

Table 1 (Longleaf pine)
Table 2 (Loblolly pine at IFCO Nursery)
Table 3 (Loblolly pine at Westervelt Nursery)
Table 4 (Slash pine)
Table 5 (Shortleaf pine)
Table 6 (Willow and weed control in longleaf pine)
Table 7 (Willow and weed control in loblolly pine at IFCO Nursery)
Table 8 (Willow and weed control in loblolly pine at Westervelt Nursery)
Table 9 (Willow and weed control in slash pine)
Table 10 (Willow and weed control in shortleaf pine)

Longleaf Pine

The 2017 and 2018 trials in longleaf pine produced similar results of no measured herbicidal effect on shoot height, root collar diameter, and plug weights (Table 1). However, inconclusive results were seen in survival and shoot weight in 2018 when compared to 2017 results. These results demonstrated the necessity for an additional round of testing. Two installations were made in longleaf pine in 2019. The first installation of the Ronstar®Flo (oxadiazon) study on March 11, 2019, resulted in no statistically significant negative effects on the seedlings. The second installation (March 18, 2019) showed similar results on survival, root collar diameter, and plug weight. Shoot height of treated seedlings was statistically lower than non-treated control seedlings, although the actual measured quantity was 1.0 centimeter shorter. Because these seedlings are top-clipped during the growing season, this height differential should not be attributed solely to herbicidal effect. Shoot weights of treated seedlings were 0.47 grams less than those of non-treated control seedlings but were statistically lower. It follows that shorter seedlings (treated) would generally weigh less than taller seedlings (non-treated).

It should be noted that in five trials installed in longleaf pine, applications of Ronstar®Flo resulted in no negative effects on the plug weights of treated seedlings when compared to non-treated seedlings. Maintaining consistent plug weights and structural integrity of plugs of container-grown seedlings are of high importance when implementing the operational use of any new herbicide into these growing systems.

Loblolly Pine

For purposes of this summary report, reviews were made only of those measurements from non-treated control seedlings and the 40 ounce per acre rate applied to treated seedlings each year (Tables 2 and 3). It should be noted that an overall trend toward lower measurements on treated loblolly seedlings in the 4/2/19 installation at IFCO was seen. This trend was not found in other installations.

Of seven studies done over the 3-year period, survival was negatively affected in two of these, as noted in the following chart:

Nursery	Trial date	Percent lower survival of treated trays	No. of seedlings represented
IFCO	4/2/19	-7.8%	10 seedlings per tray
Westervelt	4/11/19	-1.8%	4 seedlings per tray

Shoot height was unaffected in four of the seven installations. Of the three studies in which significantly lower shoot heights of treated seedlings were measured when compared to non-treated control seedlings, the actual numerical differences between non-treated and treated seedlings ranged from 0.7 centimeters to 1.3 centimeters (IFCO 4/2/19, IFCO 4/15/19, and Westervelt 4/17/19). Because these seedlings are top-clipped during the growing season, this relatively small lower amount should not be attributed solely to herbicidal effect on seedling height.

Of the 7 studies installed in loblolly pine, no statistical differences between the size of root collar diameters of treated and non-treated seedlings were seen.

Dry weights of shoots and plugs were measured on all samples from the 7 studies in loblolly pine. Only one installation (IFCO 4/2/19) had lower shoot weights of treated seedlings when compared to non-treated seedlings. However, this amount was only 0.08 grams lower, and was in the installation showing a trend of lower quantities for most seedling characteristics. Applications of Ronstar®Flo negatively affected plug weights in three of the seven installations (IFCO 4/10/18, IFCO 4/2/19, and IFCO 4/15/19). In these three IFCO installations, actual numerical quantities ranged from 0.22 grams to 0.56 grams lower of treated seedlings than of plugs from non-treated seedlings, representing approximately 2% to 5% lower plug weights. No differences between treated and non-treated plug weights were quantified in seedlings from the Westervelt nursery.

Slash Pine

This species was included in only two of the three years of study, as the dates of its sowing generally did not overlap with the dissemination of black willow seed. In these two installations, comparisons of seedling characteristics of non-treated and treated (40 ounces per acre) seedlings resulted in no differences, except in plug weights in the 2019 study (Table 4). Slash pine seedlings treated on 4/30/19 at the 40 ounce per acre rate were 0.18 grams less in weight than non-treated seedlings. However, this represents less than 2% of the plug weight of these seedlings.

Shortleaf Pine

As was the case with slash pine, shortleaf pine was included in only two years of this study, with similar results as slash pine. Only one seedling characteristic measured over the two years showed a lower value in treated (40 ounces per acre) seedlings compared to non-treated seedlings (Table 5). Lower shoot heights were measured in treated sample seedlings in the 5/9/19 installation, with treated seedlings averaging 1.6 centimeters shorter than non-treated control seedlings. As was mentioned in the loblolly pine discussion, this relatively small lower height should not be attributed solely to herbicidal effect since these seedlings are top-clipped during the growing season.

Black Willow Control

Both longleaf and loblolly pine trays sprayed with Ronstar®Flo (oxadiazon) at sowing had significantly fewer black willow seedlings at the end of the growing season (Tables 6, 7, and 8) than non-treated trays. These pine species are typically sown during the time of willow seed dispersal, and should demonstrate the greatest amount of willow control should it occur. In the five longleaf pine installations over three years, four showed significantly fewer willows in treated trays when compared to untreated trays (Table 6). The loblolly pine installations had similar results in that 7 out of 7 installations over three years in two nurseries had significantly fewer willow present in treated trays (Tables 7 and 8).

Black willow generally does not pose as severe a weed problem in slash and shortleaf pine trays due to their later sowing dates. However, when willow did seed into slash pine trays in 2019,

treated trays had significantly fewer willow seedlings than non-treated trays (Table 9). Willow was not present in any of the shortleaf pine trays used in this study in 2017 and 2019 (Table 10).

Weed Control (other than Black Willow)

Another result of this study was the significant amount of weed control (other than black willow) that Ronstar®Flo (oxadiazon) provided. Those pine species sown later in the season (slash pine and shortleaf pine) had the greatest amount of weed control other than black willow (Tables 9 and 10). This may be due to the seeding and germination timing of these plants occurring later in the spring (May) than in early March and April when longleaf and loblolly are typically sown. Weeds present in trays included crabgrass, flathead sedge, annual sedge, prostrate spurge, and other broadleaf and grass weeds. The Ronstar®Flo label lists 25 annual broadleaf weeds, 9 annual grasses, and annual sedge as weeds it is effective in controlling.

MANAGEMENT IMPLICATIONS

- After 3 years of trials, the application of 40 ounces per acre of Ronstar®Flo (oxadiazon) on newly-sown containerized seedling trays was shown to be effective in controlling **black willow** germination and establishment in those pine species sown early in the growing season.

- Containerized nursery managers should consider the treatment of each species with Ronstar®Flo (oxadiazon) as a separate operation. Each of the four species tested had slightly varied tolerance levels to the herbicide. As with any new herbicide used in nurseries, a small test area in each species should be utilized prior to larger-scale operational use.

- In five installations over 3 years, the same applications (40 ounce per acre rate) showed that the tolerance of **longleaf pine** to the herbicide was shown to be good in most seedling characteristics with no differences between plug weights of treated and non-treated seedlings. Of the seedling characteristics negatively affected, shoot weights (2 of 5) were lower (less than 0.5 grams), shoot height (1 of 5) was shorter (by 1 centimeter), and survival (1 of 5) was less (by a percentage representing 6 seedlings per tray).

- Tolerance of **loblolly pine** to 40 ounces per acre of Ronstar®Flo (oxadiazon) in 7 installations over 3 years was measured with mixed results. Most importantly to container seedling quality, seedlings in 3 of the 7 installations had lower plug weights in treated than non-treated seedlings (ranging from 0.22 grams to 0.56 grams less). Lower survival (1.8%, 7.8%), shoot height (0.7 to 1.3 centimeters), and lower shoot weights (0.08 grams) were also measured when comparing treated to non-treated seedlings.

- **Slash pine** was studied in 2 installations in 2 years. No negative effects of the 40 ounce per acre rate of Ronstar®Flo application were quantified in either of the 2 slash pine sites, with the exception of lower plug weights of treated seedlings in 1 of the 2 installations (0.18 grams less).

- **Shortleaf pine** was also limited to 2 installations in 2 years. The only negative effect of the herbicide was measured in lower shoot height of treated seedlings in 1 of the 2 installations (1.6 centimeters shorter). All other seedling characteristics measured were unaffected by the use of the herbicide.

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Table 1. Container longleaf pine seedling characteristics treated with Ronstar®Flo in three years of study, IFCO Nursery, Moultrie, GA.

Year	Application Date	Rate	Survival[1] (% Fill)	Shoot Height (cm)	RCD (mm)	Shoot Weight (g)	Plug Weight[2] (g)
2017	3/23/17	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
2018	3/21/18	0 oz./ac	85.0	29.6	8.86 a	4.10 a	13.74 a
		40 oz./ac	83.1	29.6	8.49 b	3.71 b	13.61 a
		80 oz./ac	84.2	29.9	8.83 ab	4.11 a	14.08 b
	3/28/18	0 oz./ac	88.1 a	28.8	7.66 ab	3.50	12.07
		40 oz./ac	83.5 b	28.6	7.95 a	3.54	11.83
		80 oz./ac	87.0 a	29.3	7.45 b	3.58	11.81
2019	3/11/19	0 oz./ac	83.2	28.0	9.55	3.40	12.04
		40 oz./ac	78.8	29.1	9.48	4.08	12.33
	3/18/19	0 oz./ac	83.3	31.1	9.40	3.92	12.32
		40 oz./ac	86.5	30.1	9.19	3.45	12.13

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 fill based on tray seedling count made in November or December each year compared to total number of cells initially sown.

[2] Plug weight includes both media and root dry weight.

Table 2. Container loblolly pine seedling characteristics treated with Ronstar®Flo in three years of study, IFCO Nursery, Moultrie, GA.

Year	Application Date	Rate	Survival[1] (% Fill)	Shoot Height (cm)	RCD (mm)	Shoot Weight (g)	Plug Weight[2] (g)
2017	4/10/17	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
2018	4/2/18	0 oz./ac	97.8	30.1	3.65 a	2.00	10.39
		40 oz./ac	98.0	30.3	3.72 ab	1.99	10.29
		80 oz./ac	95.3	30.3	3.78 b	1.95	10.39
	4/10/18	0 oz./ac	98.2	31.5	3.94	2.35 a	11.77 a
		40 oz./ac	97.4	31.2	3.89	2.25 a	11.21 b
		80 oz./ac	97.4	31.2	3.85	2.10 b	11.23 b
2019	4/2/19	0 oz./ac	94.9	25.7	3.71	1.54	10.19
		40 oz./ac	87.1	24.4	3.70	1.46	9.96
	4/15/19	0 oz./ac	96.8	33.6	3.98	2.72	10.61
		40 oz./ac	97.1	32.9	3.87	2.60	10.39

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 fill based on tray seedling count made in November or December each year compared to total number of cells initially sown.

[2] Plug weight includes both media and root dry weight.

Table 3. Container loblolly pine seedling characteristics treated with Ronstar®Flo in one year of study, Westervelt Nursery, Eutaw, AL.

Year	Application Date	Rate	Survival[1] (% Fill)	Shoot Height (cm)	RCD (mm)	Shoot Weight (g)	Plug Weight[2] (g)
2019	4/11/19	0 oz./ac	95.8	38.9	3.70	2.14	7.01
		40 oz./ac	94.0	38.5	3.77	2.18	6.91
	4/17/19	0 oz./ac	92.4	32.2	3.66	1.86	6.95
		40 oz./ac	92.8	31.5	3.70	1.82	6.94

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 fill based on tray seedling count made in December 2019 compared to total number of cells initially sown.

[2] Plug weight includes both media and root dry weight.

Table 4. Container slash pine seedling characteristics treated with Ronstar®Flo in two years of study, IFCO Nursery, Moultrie, GA.

Year	Application Date	Rate	Survival[1] (% Fill)	Shoot Height (cm)	RCD (mm)	Shoot Weight (g)	Plug Weight[2] (g)
2017	4/21/17	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
2019	4/30/19	0 oz./ac	79.6	27.2	3.85	2.37	10.98
		40 oz./ac	81.7	28.5	3.88	2.39	10.80

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 fill based on tray seedling count made in November or December each year compared to total number of cells initially sown.

[2] Plug weight includes both media and root dry weight.

Table 5. Container shortleaf pine seedling characteristics treated with Ronstar®Flo in two years of study, IFCO Nursery, Moultrie, GA.

Year	Application Date	Rate	Survival[1] (% Fill)	Shoot Height (cm)	RCD (mm)	Shoot Weight (g)	Plug Weight[2] (g)
2017	4/20/17	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
2019	5/9/19	0 oz./ac	75.9	21.5	3.71	1.56	8.85
		40 oz./ac	76.5	19.9	3.70	1.51	9.02

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 fill based on tray seedling count made in November or December each year compared to total number of cells initially sown.

[2] Plug weight includes both media and root dry weight.

Table 6. Percent likelihood of no willow or other weed populations in longleaf pine containers treated with Ronstar®Flo in three years of study, IFCO Nursery, Moultrie, GA.

Year	Species	Application Date	Rate	% likelihood of 0 willows present in 1 container tray	% likelihood of 0 other weeds present in 1 container tray
2017	Longleaf	3/23/17	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
2018	Longleaf	3/21/18	0 oz./ac	86.7	93.3
			40 oz./ac	100.0	100.0
			80 oz./ac	100.0	92.3
	Longleaf	3/28/18	0 oz./ac	73.3	80.0
			40 oz./ac	**100.0**	**100.0**
			80 oz./ac	**100.0**	**100.0**
2019	Longleaf	3/11/19	0 oz./ac	22.0	78.0
			40 oz./ac	**90.0**	**96.0**
	Longleaf	3/18/19	0 oz./ac	34.0	90.0
			40 oz./ac	**98.0**	98.0

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.

Table 7. Percent likelihood of no willow or other weed populations in loblolly pine containers treated with Ronstar®Flo in three years of study, IFCO Nursery, Moultrie, GA.

Year	Species	Application Date	Rate	% likelihood of 0 willows present in 1 container tray	% likelihood of 0 other weeds present in 1 container tray
2017	Loblolly	4/10/17	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
2018	Loblolly	4/2/18[1]	0 oz./ac	13.3	40.0
			40 oz./ac	100.0	73.3
			80 oz./ac	100.0	73.3
	Loblolly	4/10/18	0 oz./ac	26.7	73.3
			40 oz./ac	73.3	100.0
			80 oz./ac	46.7	100.0
2019	Loblolly	4/2/19[1]	0 oz./ac	25.0	97.9
			40 oz./ac	100.0	96.0
	Loblolly	4/15/19[1]	0 oz./ac	84.0	98.0
			40 oz./ac	100.0	100.0

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.

[1] Trays in this application date had no shadecloth used after placement on pivot.

Table 8. Percent likelihood of no willow or other weed populations in loblolly pine containers treated with Ronstar®Flo in one year of study, Westervelt Nursery, Eutaw, AL.

Year	Species	Application Date	Rate	% likelihood of 0 willows present in 1 container tray	% likelihood of 0 other weeds present in 1 container tray
2019	Loblolly	4/11/19	0 oz./ac	62.0	100.0
			40 oz./ac	**100.0**	100.0
	Loblolly	4/17/19	0 oz./ac	22.0	96.0
			40 oz./ac	**94.0**	100.0

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.

Table 9. Percent likelihood of no willow or other weed populations in slash pine containers treated with Ronstar®Flo in two years of study, IFCO Nursery, Moultrie, GA.

Year	Species	Application Date	Rate	% likelihood of 0 willows present in 1 container tray	% likelihood of 0 other weeds present in 1 container tray
2017	Slash	4/21/17	0 oz./ac	*	66.7
			40 oz./ac	*	**100.0**
			80 oz./ac	*	**100.0**
			122 oz./ac	*	**93.3**
2019	Slash	4/30/19	0 oz./ac	83.3	83.3
			40 oz./ac	**100.0**	**100.0**

*Asterisk indicates no willow present in trays at conclusion of study.

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.

Table 10. Percent likelihood of no willow or other weed populations in shortleaf pine containers treated with Ronstar®Flo in two years of study, IFCO Nursery, Moultrie, GA.

Year	Species	Application Date	Rate	% likelihood of 0 willows present in 1 container tray	% likelihood of 0 other weeds present in 1 container tray	% likelihood of grass present in 1 container tray[1]	% of tray area with sedge present in 1 container tray[1]
2017	Shortleaf	4/20/17	0 oz./ac	*	*		
			40 oz./ac	*	*		
			80 oz./ac	*	*		
			122 oz./ac	*	*		
2019	Shortleaf	5/9/19	0 oz./ac	*		98.0	32.0
			40 oz./ac	*		94.0	5.0

*Asterisk indicates no willow or other weeds present in trays at conclusion of study.

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.

[1] Grass and sedge populations were quantified separately in 2019 shortleaf pine installation due to high populations of both in these trays.