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RESEARCH REPORT 18-02

BLACK WILLOW AND WEED CONTROL USING PENDULUM® AQUACAP™ (PENDIMETHALIN) ON LOBLOLLY, LONGLEAF, SHORTLEAF AND SLASH PINE IN CONTAINER-GROWN AND BAREROOT NURSERIES

by
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INTRODUCTION

Applications of Pendulum® AquaCap™ (PAC) at sowing on bareroot nursery beds resulted in populations of prostrate spurge (*Chamaesyce maculata*) and other weeds to decrease. The extent and frequency of populations of black willow in containerized growing systems is unpredictable year to year and the high moisture content and full sunlight of containerized growing systems provide excellent grounds for its germination. In those years with heavy black willow infestations, considerable labor and expense is expended for removal of black willow in containers, so the option of herbicidal control is desirable.

In contrast to container systems, the control of weeds in nursery beds early in the growing season may be accomplished through the use of preemergent herbicides such as Goal® (oxyfluorfen), PAC and Reflex® (fomesafen). For longer season weed control, options are limited as fewer post-emergent selective herbicides are available to the forest seedling nursery market. Longer-term weed control may be possible with higher application rates of PAC than have previously been tested by the SFNMC, as the product label lists use of 136 ounces per acre for 6 to 8 months of control of listed weeds.

Although SFNMC trials of PAC in 2015 and 2016 showed promising results of black willow control in containers, measures of pine seedling tolerance have been found to be species-dependent and inconsistent. Therefore, the objectives of this study were: 1) to further evaluate the effect of PAC applied at sowing in controlling weeds in containerized loblolly, longleaf, shortleaf and slash pine, and 2) to assess the tolerance of bareroot loblolly pine and containerized loblolly, longleaf, shortleaf and slash pine to the highest label rate of PAC.

METHODOLOGY

Bareroot Seedling Studies

Four installations of this study were made on loblolly pine seedbeds at ArborGen SuperTree Nurseries in Blenheim, South Carolina and Shellman, Georgia, at K & L Forest Nursery in Buena Vista, Georgia, and at the South Carolina Forestry Commission Nursery in Trenton, South Carolina.

All herbicide applications were made either the day of sowing or one day after sowing. Three rates were included in this study: a nursery operational rate ranging from 32 oz./acre to 68 oz./acre, 68 oz./acre (the lowest recommended label rate/if not used operationally) and 136 oz./acre (the highest label rate). Because these nurseries use PAC operationally at different rates, adjustments were made to the trial design to accommodate variations in PAC rates applied prior to study installation.

Each treatment was one seedling bed wide by 10 feet in length, replicated five times, with the exception of Shellman with only three replications due to limited space availability. SFNMC personnel sprayed PAC with a CO_2 hand sprayer calibrated to broadcast spray 25 gallons per acre. In October and November 2017, seedling density measurements were made in each plot at each location. Samples of seedlings from each treatment plot were removed and evaluated at the SFNMC laboratory for tolerance to the herbicide. Measurements of shoot height, root collar diameter, stem swelling, root dry weight and shoot dry weight were made and compared to those from seedlings in operationally treated plots. 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.

Container Seedling Studies

This study was installed on newly-sown containers of loblolly, longleaf, shortleaf and slash pine at the International Forest Company Nursery in Moultrie, Georgia. Trays were sprayed either on the day of sowing or one day after sowing, with capping material in place prior to the herbicide applications. Beginning on March 23, 2017, weekly applications were scheduled to coincide with black willow seed dispersal. Sprays continued once per week over a 5-week period to include the four pine species. Trays of each weekly application were placed on different pivot locations within the nursery to maximize exposure to willow seed. Trays received 4 treatments: 0.0 oz./ac, 34 oz.ac, 68 oz./ac and 136 oz./ac. that represented control, ½, 1 and 2 times the lowest label rate, respectively. SFNMC personnel sprayed PAC with a CO_2 hand sprayer calibrated to broadcast spray 25 gallons per acre.

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

There were no significant differences in seedling density or characteristics of shoot height, root collar diameter, stem swelling, root dry weight or shoot dry weight when compared to non-treated

control seedlings at the 34 oz./acre and 68 oz./acre rates. At the highest labelled rate of 136 oz./acre, one installation recorded a negative effect in one characteristic, seedling shoot height. No other installation showed any differences from the non-treated control at this highest rate in any of the aforementioned seedling characteristics (Table 1). Numerically, only four stem galls/swellings were noted out of all 1,175 treated seedlings sampled; however, all of these galls occurred in the highest rate plots. This number was statistically insignificant but should be noted as herbicide-induced galls reduce seedling quality. Previous studies showed that galls may form when PAC is applied between sowing and 12 weeks post-sowing, as reported in Research Report 14-03.

If weed pressure in bareroot seedling beds is such that preemergent herbicide applications are not providing control later into the summer, it may be possible to use 136 oz./acre for longer-lasting control. This higher rate may also be considered as an option to specific areas of the nursery if heavy weed infestations persist through the summer, although the PAC label states that beds should be weed-free prior to PAC applications. Use of large-scale applications of 136 oz./acre of PAC should be preceded by its use in smaller test areas, as variations in soil type and texture, as well as water chemistry, nursery location, temperature and weather patterns affect herbicide activity.

Container Seedling Studies

The effect of PAC on container pine seedlings grown in organic media were similar to those found in the SFNMC 2016 study (Research Report 17-03) in that seedling survival was negatively affected by the 68 oz./acre rate (Table 2). The 136 oz./acre rate also reduced loblolly seedling survival. In the 2015 study, root collar diameters of loblolly pine were smaller in those trays treated with 68 oz./acre than those in non-treated trays. In containerized slash pine, PAC studies in 2015 resulted in lower plug weights at both 34 and 68 oz./acre, while studies in 2016 and this trial showed no negative effects on slash seedling characteristics. Therefore, the variation in and inconsistency of seedling characteristics after three years of PAC trials on four pine species demonstrates that the effect of PAC on pine seedlings grown in organic media is uncertain.

Final counts of black willow in treated trays of loblolly pine showed markedly reduced willow populations when compared to non-treated trays (Table 3). Although the number of willow in treated longleaf pine trays were numerically smaller, they were not statistically different than trays with no herbicide applications. Neither shortleaf pine nor slash pine trays, treated or non-treated, contained willow seedlings at the end of this trial. Predicting willow seed dispersal is not an exact science, but dispersal generally occurs at this nursery when sowing of longleaf pine trays is concluding and loblolly pine sowing operations begin. Shortleaf pine and slash pine trays are sown later in the spring than longleaf and loblolly at this nursery, and willow seed has typically dispersed by the time these two species are sown and trays are placed on the pivots.

MANAGEMENT IMPLICATIONS

- Pendulum® AquaCap™ continues to be an option for preemergent herbicide use in bareroot loblolly pine seedling nurseries for control of weeds such as prostrate spurge, when applied **at the time of sowing**. The use of rates higher than 68 oz./acre may be an option for longer-season weed control but should be tested in a small area of the nursery prior to large scale applications, and monitoring of the seedling crop for herbicide gall formation is necessary.

- Although applications of PAC at 34 oz./acre, 68 oz./acre and 136 oz./acre to containerized loblolly pine **at the time of sowing** have shown to provide good willow control in three trials, the uncertainty of negative effects on seedling quality with this herbicide may outweigh any positive gains to be made by reducing black willow populations.

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Table 1. Bareroot loblolly pine seedling characteristics treated with Pendulum® AquaCap™ at four nurseries.

Nursery	Rate	Density/ft^2	Shoot Height (cm)	RCD (mm)	Shoot Weight (g)	Root Weight (g)
A	34 oz./ac	25.9	23.0	4.55 a	2.58	0.64
	68 oz./ac	27.0	22.9	4.39 b	2.36	0.62
	136 oz./ac	25.7	23.2	4.60 a	2.58	0.66
B	34 oz./ac	24.7	30.3	4.80	3.21	0.56
	68 oz./ac	25.6	27.4	4.64	3.14	0.56
	136 oz./ac	25.2	27.5	4.73	3.12	0.51
C	32 oz./ac	16.2	30.8	4.27	3.11	0.38
	66 oz./ac	18.4	31.2	4.18	3.04	0.36
	134 oz./ac	19.1	31.0	4.37	3.02	0.39
D	68 oz./ac	29.8	26.5	4.06	2.67	0.35
	136 oz./ac	27.5	24.5	4.00	2.55	0.34

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 Pendulum® AquaCap™ 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	0.0 oz./ac	94.0	27.0	3.82	2.26	12.23 ab
	34 oz./ac	91.3	27.0	3.84	2.28	12.17 b
	68 oz./ac	90.4	27.1	3.90	2.34	12.35 ab
	136 oz./ac	89.2	27.2	3.93	2.40	12.52 a
Longleaf	0.0 oz./ac	85.0	25.7	8.21	3.03	14.14
	34 oz./ac	82.8	25.7	7.98	3.04	14.18
	68 oz./ac	82.8	26.2	8.31	2.94	14.10
	136 oz./ac	83.4	25.9	7.88	3.02	14.22
Shortleaf	0.0 oz./ac	87.8	20.9	3.99	1.90	11.67
	34 oz./ac	77.7	21.2	3.91	1.83	11.53
	68 oz./ac	81.3	20.9	3.93	1.92	11.73
	136 oz./ac	80.7	21.4	3.96	1.86	11.66
Slash	0.0 oz./ac	92.2	25.4	4.02	2.38	12.60
	34 oz./ac	90.9	26.0	4.03	2.45	12.58
	68 oz./ac	87.0	26.1	4.06	2.43	12.36
	136 oz./ac	85.0	26.0	4.04	2.45	12.67

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 Pendulum® AquaCap™ 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	26.7	80.0
	34 oz./ac	**73.3**	73.3
	68 oz./ac	**86.7**	93.3
	136 oz./ac	**100.0**	93.3
Longleaf	0.0 oz./ac	78.6	92.9
	34 oz./ac	92.9	100.0
	68 oz./ac	100.0	92.3
	136 oz./ac	100.0	100.0
Shortleaf	0.0 oz./ac	*	80.0
	34 oz./ac	*	93.3
	68 oz./ac	*	100.0
	136 oz./ac	*	93.3
Slash	0.0 oz./ac	*	40.0
	34 oz./ac	*	80.0
	68 oz./ac	*	80.0
	136 oz./ac	*	73.3

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 populations present