Southern Forest Nursery Management Cooperative™

RESEARCH REPORT 24-02

ARKON™ (PYRIMISULFAN) TRIALS FOR NUTSEDGE CONTROL IN BAREROOT PINE SEEDLING BEDS

by
Nina Payne and Annakay Newell

INTRODUCTION

In 2021, when the Southern Forest Nursery Management Cooperative (SFNMC) installed its first trials of Vexis®, a granular herbicide targeting nutsedge, its manufacturer expressed interest in also testing a liquid formulation when it became available on the market. That product, Arkon™, was introduced in late 2022 by PBI-Gordon for use on turf, non-cropland sites, and sod production areas. As with the granular product, conifer nurseries were not listed as approved sites for use.

Arkon™ is a Group 2 post-emergent selective herbicide in liquid formulation. It contains 1.24% pyrimisulfan as its active ingredient. In comparison, the granular pyrimisulfan product currently under testing in SFNMC nurseries, Vexis®, contains 0.025% pyrimisulfan. Weeds listed as controlled on its label include annual sedge, yellow and purple nutsedge, rushes, kylinga, and broadleaf species including chickweed, henbit, dollarweed, bittercress, buttonweed, wild garlic, and wild onion. Technical information provided by the manufacturer states that Arkon™ applications 'reduce both tuber number and viability of purple and yellow nutsedge'. It is currently sold in 1-gallon and 2.5-gallon jugs, 30-gallon drums, and 275-gallon totes.

As the SFNMC Vexis® trials have progressed, the need for annual sedge and nutsedge control herbicides that can be applied over the top of pine seedlings still exists. Because Arkon™ provides a different formulation and a different delivery method, it was selected for use in trials targeting these weeds in conjunction with ongoing Vexis® trials in 2023. Safe and successful testing of the granular product (Research Reports 22-03 and 23-05) provided the impetus for testing this liquid product in multiple nurseries in its first year of testing. The purpose of this initial Arkon™ testing was to evaluate loblolly and slash pine seedling tolerance and to provide data to member nurseries and PBI-Gordon for possible inclusion in future 24(c) labeling.

METHODOLOGY

To utilize already-scheduled trips to SFNMC nurseries for the 2023 Vexis® trials, the Arkon™ installations were made at the same nurseries on the same application schedule as the Vexis® trial plans. The Arkon™ label provides for the use of 1.2 to 1.7 ounces per 1000 square feet or the equivalent of 3.4 to 4.7 pints per acre, with a maximum allowable use per year of 7 pints per acre. Because this is the first SFNMC trial of Arkon™, three rates were tested: 1) one-half of the label rate of 1.7 fluid ounces/1000 square feet rate (0.85 fluid ounces/1000 square feet); 2) the label rate of 1.7 fluid ounces/1000 square feet; and 3) two times the label rate of 1.7 fluid ounces/1000 square (3.4 fluid ounces/1000 square feet). A single application was made at 7 weeks after the seeds were sown, with all treatments made in June 2023.

Individual plots of 10 feet in length were measured and flagged for identification in loblolly and slash pine beds prior to herbicide application. SFNMC staff applied the herbicide with a CO_2 hand sprayer calibrated to broadcast a spray volume of 25 gallons of water per acre. Five replications were installed, for a total of 200 feet per seedling bed used. Field plot layouts are shown in Figure 1. The Arkon™ manufacturer recommends a minimum drying time of 2 to 3 hours prior to irrigation.

Three nursery sites of varying soil types were selected for testing. These nurseries and soil types are listed below:

Nursery	Soil type
ArborGen Nursery, Shellman, GA	Lucy loamy sand, 0-5% slopes (0-24 inches loamy sand, 24-35 inches sandy loam, 35-70 inches sandy clay loam)
PRT-IFCO Pine Hill Nursery, Pine Hill, AL	Lenoir silt loam, 0-2% slopes (0-2 inches silt loam, 2-6 inches loam, 6-12 inches clay loam, 12-80 inches clay)
Weyerhaeuser Quail Ridge Nursery, Aiken, SC	Lakeland sand, 0-6% slopes (0-80 inches sand)

Treatment information is listed below:

Treatment No.	Description	Rate/Timing
1	control	no treatment
2	½X rate @ 7 weeks	0.85 fl oz/1000 ft^2 at 7-weeks post-sow
3	1X rate @ 7 weeks	1.7 fl oz/1000 ft^2 at 7-weeks post-sow
4	2X rate @ 7 weeks	3.4 fl oz/1000 ft^2 at 7-weeks post-sow

At the end of the growing season, seedling samples were collected from each plot in each installation. All seedlings within a 9-inch by 4-foot counting frame placed in each plot were lifted by hand, with outside rows' seedlings marked and separated from inside rows' seedlings. These were taken to the SFNMC laboratory in Auburn, Alabama for measurements. Notes of nutsedge populations in each plot were made.

From seedlings collected in each plot, total seedlings were counted to measure bed density. From each plot's inside rows, a random selection of 25 seedlings were measured for shoot height, root collar diameter, shoot dry weight, and root dry weight. Data was analyzed using R Statistical Software (v4.1.2; R Core Team 2021) to identify significant differences between the means of each measured characteristic with Tukey's Honest Significant Difference (HSD) post hoc test. A significance level at alpha = 0.05 was used for comparisons.

RESULTS

Loblolly pine: No statistically significant negative effects of Arkon™ (pyrimisulfan) were quantified in loblolly seedling samples from the Weyerhaeuser Quail Ridge Nursery or the PRT-IFCO Nursery.

Data from samples taken at the ArborGen Nursery showed statistically significant negative effects in shoot height (up to 7.7 centimeters shorter), root collar diameter (up to 0.81 centimeters smaller) and shoot dry weight (up to 1.74 grams less) at all rates tested. The shoot height differences were easily visible during the collection of seedling samples at the end of the growing season. After discussions with the nursery manager, it was noted that the loblolly bed was not top clipped during the growing season. This deviation from standard operational procedure, while unexpected, provided data on the effect of Arkon™ on seedlings without top clipping. When seedlings in all plots (including control

and treated plots) are top clipped multiple times during the growing season, this allows for slower growing or shorter seedlings to 'catch up' to faster growing or taller seedlings whose tops are trimmed. A more uniform seedling height is achieved by this method. Biologically, shorter seedlings would be expected to have smaller root collar diameters and shoot dry weights. Root dry weights of these shorter seedlings were numerically smaller than seedlings from nontreated control plots but were not statistically significant.

Data and analyses from loblolly pine installations are reported in Tables 1, 2, and 3.

Slash pine: Similar results to loblolly pine were found in slash pine seedling characteristics measured. No statistically significant negative effects of Arkon™ (pyrimisulfan) were quantified in loblolly seedling samples from the Weyerhaeuser Quail Ridge Nursery or the PRT-IFCO Nursery.

Analysis of data from samples taken at the ArborGen Nursery showed no statistically significant negative effects of Arkon™ on any seedling characteristic except for seedling height at the two higher rates tested (the label rate and two times the label rate). These heights measured 1.1 centimeters shorter (in the label rate plots) and 1.5 centimeters shorter (in the two times label rate plots) than seedlings from nontreated control plots. Although statistical analyses showed a difference, SFNMC members concur that these are not biologically significant amounts, considering the use of multiple top clipping passes made on these seedlings during the growing season.

Data and analyses from slash pine installations are reported in Tables 4, 5, and 6.

Nutsedge: Not all beds included in these trials contained nutsedge. For those that did have patches of nutsedge during the growing season, the presence of healthy nutsedge in nontreated control plots and dead or dying nutsedge in treated plots was seen. The boundary lines between control and treated plots were evident in those beds with nutsedge.

MANAGEMENT IMPLICATIONS

The use of Arkon™ in loblolly and slash pine seedling beds shows promise as an effective tool to control nutsedge and annual sedge during the growing season in bareroot loblolly and slash pine. In future trials, the effect of Arkon™ on seedling height should receive additional attention to denote the herbicide's effect as one of concern or no concern to SFNMC growers. As with SFNMC Vexis® trials, multiple years of testing will be required to ensure safe treatment to the seedling crop with sufficient target weed control prior to the initiation of 24(c) application procedures.

With this new product on the market, SFNMC member nurseries wishing to conduct in-house trials of Arkon™ should follow the guidelines for testing contained in "How To Test Herbicides In Forest Tree Nurseries", USFS General Technical Report PNW- 127, accessible at https://research.fs.usda.gov/treesearch/7521.

ACKNOWLEDGEMENTS

Our gratitude goes to the managers and staff of the ArborGen's Shellman Nursery, PRT-IFCO's Pine Hill Nursery, and Weyerhaeuser's Quail Ridge Nursery for their provision of bed space and, more importantly, their time and help in trial installation and seedling sample collections. Our thanks also go to Dr. Eric Reasor of PBI-Gordon for his recommendations on these initial Arkon™ trials and for providing product samples of this recently released herbicide product.

REFERENCES

PBI-Gordon Corporation. Arkon™ herbicide liquid label. Retrieved from: https://www.cdms.net/ldat/ldITI000.pdf

PBI-Gordon Corporation. Arkon™ Technical Data Sheet 680815. Retrieved from: https://www.pbigordonturf.com/products/herbicides/selective-herbicides/arkon-herbicide-liquid

Payne, N., T. Stokes, A. Newell, J. Fields, and R. Ayres. (2022). The efficacy of pyrimisulfan on nutsedge control and the tolerance of loblolly and slash pine in bareroot seedling beds. Auburn University, Southern Forest Nursery

Management Cooperative. Research Report 22-03:6 pp.

Payne, N. and A. Newell. (2023) Pyrimisulfan trials for nutsedge control in bareroot loblolly and slash pine beds: a second year of study. Auburn University, Southern Forest Nursery Management Cooperative. Research Report 23-05:7 pp.

Sandquist, R., P. Owston, and S. McDonald. (1981). How to test herbicides at forest tree nurseries. Gen. Tech. Rep. PNW-GTR-127. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 24 pp.

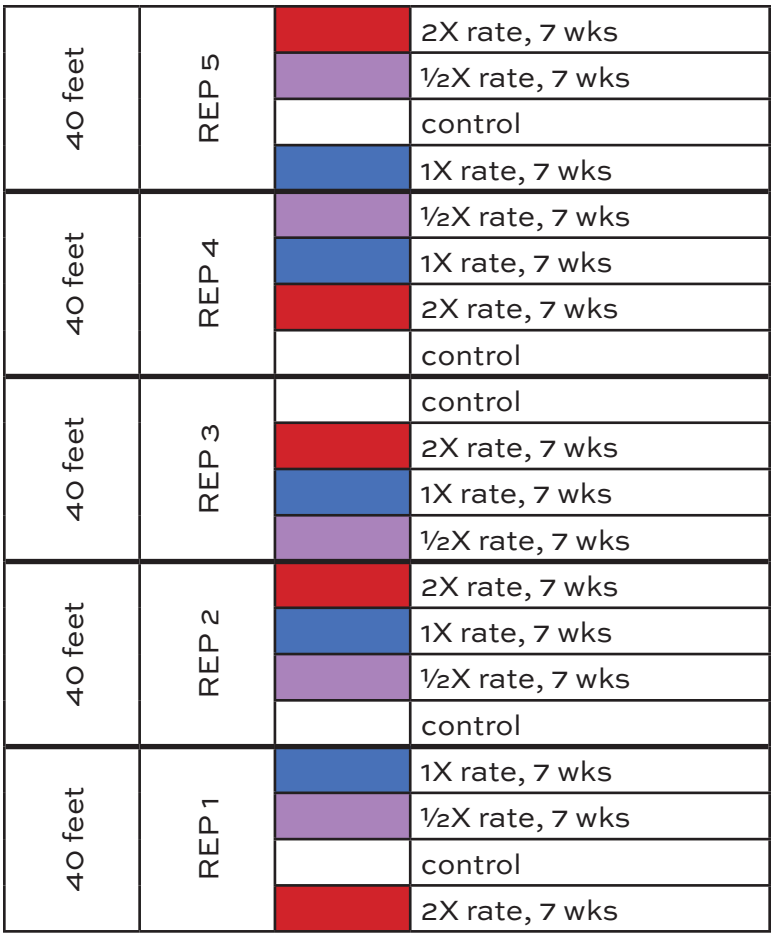

Figure 1. Field layout of plots in pyrimisulfan (Arkon™) trials conducted by the SFNMC in 2023.

Table 1. Bareroot loblolly pine seedling characteristics treated with pyrimisulfan (Arkon™) at 7 weeks post-sowing on June 2, 2023, at Weyerhaeuser Quail Ridge Nursery, Aiken, SC.

Treatment	Rate (fl oz/1000 ft²)	Density (seedlings/ft²)	Shoot height (cm)	Root collar diameter (mm)	Shoot dry weight (g)	Root dry weight (g)[1,2]
Control	0.0	31.7 ± 0.96	28.0 ± 0.26	4.45 ± 0.04	2.24 ± 0.10	0.42 ± 0.02 b
½X label rate	0.85	33.3 ± 0.97	28.0 ± 0.27	4.40 ± 0.05	2.25 ± 0.05	0.44 ± 0.02 ab
1X label rate	1.7	33.1 ± 0.66	27.8 ± 0.28	4.45 ± 0.04	2.35 ± 0.05	0.47 ± 0.02 ab
2X label rate	3.4	31.9 ± 0.62	28.0 ± 0.25	4.43 ± 0.05	2.39 ± 0.08	**0.50 ± 0.02** a
p>f		*0.422*	*0.938*	*0.850*	*0.389*	*0.044*

[1]Bold within a seedling characteristic indicates significant difference between that rate and control.

[2]Different letters within a seedling characteristic indicate significant differences in rates.

Table 2. Bareroot loblolly pine seedling characteristics treated with pyrimisulfan (Arkon™) at 7 weeks post-sowing on June 17, 2023, at PRT-IFCO Pine Hill Nursery, Camden, AL.

Treatment	Rate (fl oz/1000 ft²)	Density (seedlings/ft²) [1,2]	Shoot height (cm)	Root collar diameter (mm)	Shoot dry weight (g)	Root dry weight (g)
Control	0.0	21.7 ± 2.60	29.6 ± 0.32	5.27 ± 0.06	3.35 ± 0.17	0.72 ± 0.05
½X label rate	2.0	25.4 ± 0.54	29.5 ± 0.32	5.44 ± 0.18	3.47 ± 0.08	0.72 ± 0.03
1X label rate	2.0 + 2.0	25.7 ± 1.07	30.0 ± 0.30	5.51 ± 0.06	3.73 ± 0.12	0.76 ± 0.04
2X label rate	4.0	24.6 ± 0.77	29.4 ± 0.31	5.62 ± 0.15	3.86 ± 0.15	0.85 ± 0.04
p>f		*0.255*	*0.467*	*0.239*	*0.062*	*0.095*

Table 3. Bareroot loblolly pine seedling characteristics treated with pyrimisulfan (Arkon™) at 7 weeks post-sowing on June 8, 2023, at ArborGen Nursery, Shellman, GA.

Treatment	Rate (fl oz/1000 ft²)	Density (seedlings/ft²)	Shoot height (cm)[1,2]	Root collar diameter (mm)[1,2]	Shoot dry weight (g)[1,2]	Root dry weight (g)
Control	0.0	16.4 ± 0.78	29.4 ± 0.38 a	6.53 ± 0.10 a	5.03 ± 0.12 a	1.19 ± 0.01
½X label rate	0.85	17.4 ± 0.62	**22.0 ± 0.32** b	**6.04 ± 0.19** b	**3.41 ± 0.16** b	1.00 ± 0.04
1X label rate	1.7	17.1 ± 0.73	**21.7 ± 0.41** b	**5.72 ± 0.10** b	**3.29 ± 0.30** b	1.01 ± 0.07
2X label rate	3.4	18.8 ± 1.01	**22.9 ± 0.34** b	**5.98 ± 0.10** b	**3.67 ± 0.17** b	1.05 ± 0.06
p>f		*0.233*	*<0.001*	*<0.001*	*<0.001*	*0.043*

[1]Bold within a seedling characteristic indicates significant difference between that rate and control.
[2]Different letters within a seedling characteristic indicate significant differences in rates.

Table 4. Bareroot slash pine seedling characteristics treated with pyrimisulfan (Arkon™) at 7 weeks post-sowing on June 2, 2023, at Weyerhaeuser Quail Ridge Nursery, Aiken, SC.

Treatment	Rate (fl oz/1000 ft²)	Density (seedlings/ft²)	Shoot height (cm)	Root collar diameter (mm)	Shoot dry weight (g)	Root dry weight (g)[1,2]
Control	0.0	18.1 ± 0.44	29.7 ± 0.21	5.84 ± 0.06	4.06 ± 0.16	0.78 ± 0.02 a
½X label rate	0.85	18.5 ± 0.34	29.4 ± 0.18	5.91 ± 0.06	3.98 ± 0.12	0.86 ± 0.01 ab
1X label rate	1.7	18.8 ± 0.76	29.6 ± 0.21	5.85 ± 0.07	3.94 ± 0.11	**0.90 ± 0.02** bc
2X label rate	3.4	17.8 ± 0.51	29.0 ± 0.20	6.32 ± 0.28	4.27 ± 0.10	**0.97 ± 0.03** c
p>f		*0.583*	*0.073*	*0.064*	*0.267*	*<0.001*

[1]Bold within a seedling characteristic indicates significant difference between that rate and control.
[2]Different letters within a seedling characteristic indicate significant differences in rates.

Table 5. Bareroot slash pine seedling characteristics treated with pyrimisulfan (Arkon™) at 7 weeks post-sowing on June 17, 2023, at PRT-IFCO Pine Hill Nursery, Camden, AL.

Treatment	Rate (fl oz/1000 ft²)	Density (seedlings/ft²)	Shoot height (cm)[2]	Root collar diameter (mm)[1,2]	Shoot dry weight (g)	Root dry weight (g)
Control	0.0	23.2 ± 0.75	26.0 ± 0.32 ab	5.76 ± 0.08 b	4.36 ± 0.16	0.95 ± 0.05
½X label rate	0.85	21.3 ± 1.10	24.7 ± 0.34 a	5.90 ± 0.15 ab	4.55 ± 0.31	0.98 ± 0.07
1X label rate	1.7	20.0 ± 0.95	25.1 ± 0.37 a	6.06 ± 0.08 ab	4.82 ± 0.13	1.05 ± 0.03
2X label rate	3.4	19.8 ± 1.27	26.6 ± 0.35 b	**6.34 ± 0.19** a	5.13 ± 0.24	1.13 ± 0.05
p>f		*0.117*	*<0.001*	*0.014*	*0.119*	*0.099*

[1]Bold within a seedling characteristic indicates significant difference between that rate and control.
[2]Different letters within a seedling characteristic indicate significant differences in rates.

Table 6. Bareroot slash pine seedling characteristics treated with pyrimisulfan (Arkon™) at 7 weeks post-sowing on June 8, 2023, at ArborGen Nursery, Shellman, GA.

Treatment	Rate (fl oz/1000 ft²)	Density (seedlings/ft²)	Shoot height (cm)[1,2]	Root collar diameter (mm)	Shoot dry weight (g)	Root dry weight (g)
Control	0.0	31.3 ± 1.06	25.4 ± 0.16 a	5.54 ± 0.06	3.08 ± 0.13	0.86 ± 0.04
½X label rate	0.85	29.9 ± 0.74	25.1 ± 0.20 a	5.63 ± 0.22	3.15 ± 0.17	0.93 ± 0.04
1X label rate	1.7	28.7 ± 0.48	**24.3 ± 0.22** b	5.46 ± 0.06	3.20 ± 0.12	0.95 ± 0.02
2X label rate	3.4	30.1 ± 0.98	**23.9 ± 0.20** b	5.42 ± 0.07	3.06 ± 0.07	0.93 ± 0.03
p>f		*0.237*	*<0.001*	*0.601*	*0.857*	*0.264*

[1]Bold within a seedling characteristic indicates significant difference between that rate and control.
[2]Different letters within a seedling characteristic indicate significant differences in rates.