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A TRIAL OF HERBICIDE TREATMENTS FOR ENRICHMENT PLANTINGS OF CHERRYBARK OAK[1/]

James H. Miller and E. C. Burkhardt[2/]

Abstract.--An ongoing screening trial is testing nine herbicide treatments for establishing planted cherrybark oak (*Quercus falcata* var. *Pagodaefolia* Ell.) on the loessial bluff forests in western Mississippi. The test treatments include tree injection (Tordon™ RTU) and two rates of two soil-active pelleted herbicides (Velpar™ and Spike™) applied both as broadcast treatments before planting and as inter-row banded treatments at the time of planting. Seedling and competition measurements have been made for 3 years. Preliminary results show that the application of Spike (tebuthiuron) at 2 lb active ingredient per acre in 24-inch bands yielded seedling volumes significantly greater than those on the untreated plots after 3 years, but not greater than other tested herbicide treatments. Further competition control treatments for vines and shrubs appear necessary.

INTRODUCTION

Application of soil-active herbicides in bands between planting rows has shown promise for controlling competing hardwoods when establishing pine plantations (Miller 1985; Griswold and Gonzalez 1981; Hinton 1970). This method of applying concentrated bands of herbicides has also been effective in controlling stands of hardwood brush for range improvement (Herrifield and Hansbrough 1960; Meadors *et al*. 1956). With a one-pass approach, application can be made simultaneously with the planting operation, thereby lowering application costs compared to tvo-pass broadcast procedures.

The inter-row banding method appears feasible for competition control with enrichment plantings of hardwoods. Also, new soil-active herbicides need further testing for their effectiveness in controlling the complex communities found on highly productive hardwood sites. This study was initiated to screen tvo new soil-active herbicides, both as band and broadcast applications, for increasing growth and survival of enrichment plantings of cherrybark oak.

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[2/] Research Forester in Silviculture Research, USDA Forest Service, Southern Forest Experiment Station, Auburn University, AL 36849 and Consulting Forester, 5423 Fisher Rd., Vicksburg, MS 39180.

STUDY AREAS AND METHODS

The study was installed at two locations 10 miles apart in vest-central Mississippi on the loessial bluffs within 15 miles of the Mississippi River. The mixed hardwood forests at both sites developed through old-field succession after farm abandonment some 100 years ago. The estimated site index at both sites for cherrybark oak is 105 to 115 feet at 50 years. The soil is Memphis silt-loam (a fine-silty, mixed, thermic, Typic Hapludalf) in the eroded to severely eroded phases, having low organic matter. These loessial bluff forests are strongly and frequently dissected by ephemeral streams. Narrow ridges (20 to 30 feet wide), short steep slopes (40 to 100 feet long), and U-shaped ephemeral stream channels characterize the topography.

A randomized complete block design was used, with 3 blocks and 10 treatments. Treatment plots were 0.1 acre (66 by 66 feet) and were located on the upper slopes, with none on the flat ridge tops. Most of the study plots encompassed stream heads or old gulleys that were actively eroding, even under a multi-layered forest cover. Block 1 plots were at the first location and occurred on all aspects along several ridges. At the second location, Block 2 plots extended along the more exposed southeast slopes, and Block 3 plots were positioned on the opposite northwest slope and cove area. Terrain was steeper at the first location.

Plots were installed just before harvesting operations in May 1981. All merchantable trees (DBH > 30 inches) on the plots and within 33 feet of the lower boundaries were harvested. Trees were directionally felled during logging to minimize tree tops within plots. An average of two sawlog-size trees that measured 100 to 120 feet in total height were cut from each plot. The plots were positioned in areas understocked with desirable regeneration and heavily shaded by unmerchantable species.

After harvest, a nearly complete lower canopy with a mean height of about 30 to 50 feet occupied the areas (Table 1). The residual stands were diverse in species, with each block presenting a somevhat different spectrum of competition. Added to this complexity and enormity of hardwood and shrub competition was the scattered occurrence of vine arbors.

Table 1.--Stand composition after harvest of the three study blocks, by basal area in feet (and number of stems) per acre.[1/]

Block 1		Block 2		Block 3	
S. red oak	19.7 (30)	Elms	13.2 (93)	Elms	21.1 (85)
Hophornbeam	12.6(238)	Boxelder	7.1 (34)	Hickory	11.4 (43)
Sweetgum	10.3 (19)	Chinaberry	6.6 (13)	Sassafras	7.4 (24)
Beech	6.6 (15)	Hickory	5.5 (25)	Magnolia	6.8 (30)
Hickory	4.4 (43)	Hackberry	5.5 (26)	Hackberry	6.7 (23)
Water oak	3.3 (19)	S. red oak	4.1 (5)	Boxelder	6.6 (15)
Dogwood	2.3 (36)	Basswood	3.5 (32)	White ash	3.5 (38)
Hornbeam	2.1 (38)	Sassafras	3.2 (9)	Hornbeam	3.1 (68)
White ash	1.5 (4)	Bl. locust	3.0 (7)	Bl. locust	2.1 (8)
Sourwood	0.9 (11)	Hophornbeam	2.0 (26)	S. red oak	1.6 (6)
Bl. cherry	0.7 (9)	Hornbeam	1.8 (28)	Water oak	1.4 (6)
Basswood	0.4 (7)	Maple	1.7 (25)	Basswood	1.3 (17)
Elms	0.3 (6)	White ash	1.7 (19)	Devil's club	0.7 (4)
Sassafras	0.1 (2)	Laurelcherry	1.4 (23)	Hophornbeam	0.6 (17)
Maple	0.1 (2)	Bl. cherry	0.9 (7)	Maple	0.6 (17)
Others	0.3 (16)	Others	4.7 (61)	Others	2.3 (24)
TOTAL	65.6(495)	TOTAL	66.0(437)	TOTAL	77.3(425)

[1/] Scientific names of these species are given in Appendix Table I.

The test herbicide formulations are presented in Table 2. For ease of hand application, soil-active pelleted herbicides were selected to compare with the standard tree injection treatment (Table 3). The large hexazinone pellets (½ and 2 cc) are no longer manufactured, but another pelleted hexazinone formulation, Buckshot 10-PH[1/], and a granular product, Pronone 10G[2/], are currently labeled for pine establishment in the South. Spike 20P pellets are not currently labeled for forest lands in the South, but a similar tebuthiuron fcraulation, Graslan[3/], is labeled for hardwood control for rangeland improvement in some western and midwestern states. Tordon RTU was used for tree injection because it is the most effective herbicide presently used in the South for broad-spectrum hardwood control (Campbell 1985).

[1/] Buckshot LO-PK is a 10% a.i. ½ cc pellet of hexazinone manufactured by Forshaw Chemical Co., Greensboro, SC.

[2/] Pronone 10G is a 10% a.i. sintered-clay granule of hexazinone manufactured by Proserve Inc., Memphis, TN.

Table 2.--Test herbicide formulations.

Trade name	Active ingredient (a.i.)	Formulation	Manufacturer
Tordon RTU	picloram+2,4-D	5.42 a.i.+20.9% a.i.	Dow
Spike 20P[1/]	tebuthiuron	20% a.i. pellet	Elanco
Velpar Gridball[2/]	hexazinone	10% a.i. 2cc pellet	DuPont
Velpar ½cc Gridball[2/]	hexazinone	10% a.i. ½cc pellet	DuPont

[1/] Not labeled for forest land applications.

[2/] No longer manufactured.

Table 3.--Teat Treatments.

Method	Application date	Herbicide	Rate
Injection	July 1981	Tordon RTU	1 ml per incision
Broadcast	May 1981	Spike 20P	3 lb a.i./A
			2 lb a.i./A
		Velpar Gridball	2 lb a.i./A
			1.5 lb a.i./A
Banded	Feb. 1982	Spike 20P	3 lb a.i./A
			2 lb a.i./A
		Velpar ½cc Gridball	3 lb a.i./A
			2 lb a.i./A
Untreated Check	--	--	--

Pelleted herbicides were tested at two-rates in both broadcast and banded applications. Broadcast treatments were applied in the 1981 growing season before planting. To assure uniform distribution, a grid-pattern placement of premeasured amounts was used with the large Velpar Gridball pellets, and plot subsectioning was used with the smaller Spike 20P pellets. Several 1- and 2-inch rainfall events occurred within 3 weeks of application to activate the herbicides.

The injection treatments with Tordon were applied in July 1981 as a continuous frill of

[3/] Graslan is a 20% a.i. pellet of tebuthiuron manufactured by Elanco Chemical Co., Indianapolis, IN.

Table 5.--Topkill of the overstory competition (>1.6 inches DBH) in the second groving season.

Treatment	Rate	Application method	Topkill[1/]
	lb a.i./A		percent
Injection	--	--	100 a
Spike	2.0	broadcast	76 ab
Velpar	3.0	band	71 ab
Spike	3.0	broadcast	71 ab
Spike	2.0	band	65 ab
Spike	3.0	band	54 bc
Velpat	1.5	broadcast	41 bcd
Velpar	2.0	broadcast	40 bcd
Velpar	2.0	band	28 cd
Check	--	--	x4 d

[1/] Means within the column followed by the same letter are not significantly different at the 0.05-level by Duncan's multiple range test:

Table 6.--Average topkill (and number of observations) of the prevalent hardwood species by injcctioo and broadcast applications (lb a.i./A,) of Spike and Velpar.

Species	Injection	Spike[1/] 3 lb	Spike[1/] 2 lb	Velpar[1/] 2 lb	Velpar[1/] 1.5 lb
	---- percent(number of trees) ----				
Hophornbeam	100 (28)	100 (5)	50 (4)	43 (7)	100 (3)
Hornbeam	100 (2)	54 (18)	20 (5)	19 (5)	9 (14)
Elm	100 (12)	100 (4)	88 (9)	65 (6)	69 (16)
Hickory	100 (18)	100 (1)	33 (6)	37 (5)	26 (10)
Basswood	100 (2)	80 (3)	100 (2)	57 (5)	82 (6)
Dogwood	100 (3)	--	97 (2)	43 (4)	11 (7)
White ash	100 (5)	100 (2)	100 (1)	--	51 (9)
Maple	100 (1)	50 (2)	100 (1)	0 (5)	0 (3)
S. red oak	100 (2)	100 (2)	--	37 (5)	60 (2)
Water oak	100 (4)	100 (2)	--	7 (2)	--
Sassafras	100 (4)	--	10 (1)	0 (3)	0 (2)

[1/] A dash indicates the lack of that species on treated plots.

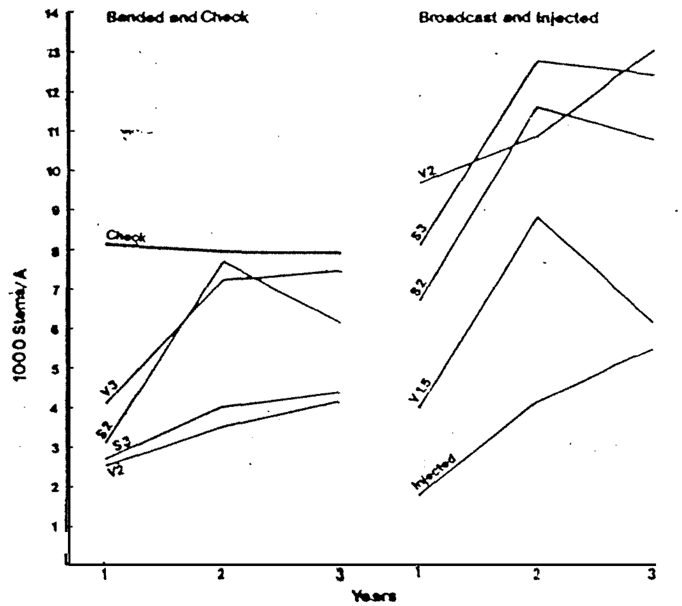

figure 1. Numbers of hardwood and shrub stems (<1.6 inches DBH) per acre after the first, second and third graving seasons of the planted seedlings. Spike and Velpar treatments are labeled by the first letter followed by the rate in a.i./acre (i.e. V3=Velpar at 3 lb a.i./acre).

Figure 1 shows the trends in the number of small stems. The banded applications during planting yielded significantly less small-stem competition during the first three growing seasons of the seedlings than the broadcast treatments, as determined from orthogonal contrasts ($p=0.05$). Interestingly, the injection of stems greater than 1.6 inches DBH probably resulted in some small-stem control as judged by the low number of stems. Figure 1 also shows the resiliency of these communities with the rapid regrowth of hardwoods and shrubs in the second year. In general, small-stem dompetition increased in the second year with all treatments, but numbers in the third year either started to decline or showed less increase (except for Velpar broadcast at 2 lb).

More vines occurred on treated plots in the second growing season (Table 7) than on the check plots. Rapid proliferation of vines occurred due to increased sunlight resulting from overstory control. There were significantly fever vines in the second year on plots treated with Spike than on plots treated with Velpar, as determined by orthogonal contrasts. Vines heavily infested the areas of injection treatment, even though the larger vines were injected and controlled.

The application of Spike at 2 lb a.i. per acre in bands yielded the greatest seedling volume basal incisions around the stems, with 1 milliliter of herbicide injected per cut. The use of continuous incisions is recommended for difficult-to-control species but exceeds label recommendations Eor other species. Contract applicators, such as the one that did these treatments, often use the continuous frill method. All stems 1.6 inches DBH and greater, and some large vines, were injected.

Banded application of herbicides was done simultaneously with planting in February 1982. Bare-root cherrybark oak seedlings (1-O) were dibble-planted on a precise 8- by 8-foot spacing at marked locations. Following the planting of each seedling , experienced planters applied a measured amount of herbicide in a band P-feet wide and 8-feet long that was centered between rows. To prevent herbicide from washing downslope onto the seedlings, application was made either to the side of the row as the planter moved forward, or if upslope, across in front of the planted seedling. Thus, after planting the seedling, the planter had to decide on the location of the band, to the side or in front. The planters gradually became accustomed to this procedure with continued supervision, and most of them actually welcomed another task to break the monotony of seedling planting. This approach afforded a trial of a one-Pass method. But with this method the Velpar was applied earlier than the recommended period, which is late March to June. Rainfall following application was ideal by starting lightly and increasing in intensity, providing 2 inches of activating rainfall within 2 weeks.

Cherrybark oak seedlings were obtained from a Tennessee nursery and were speed-shipped in bags with good moist packing. As an unplanned factor in the study, the seedlings were graded into three groups, as large, medium, and small. Block 1 received the largest seedlings, Block 2 the medium, and Block 3 the smallest. Thus, seedling size and blocks were confounded. Table 4 presents the mean groundline diameters (GLD) and heights after planting.

Table 4. Initial seedling size by block.[1/]

Block	Ground line diameter	Height
	inches	feet
1	0.19 a	1.0 a
2	0.17 b	0.7 b
3	0.15 b	0.7 b

[1/] Means within a column followed by the same letter are not significantly different at the 0.05-level by Duncan's multiple range test.

For assessing overstory control, all hardwoods 1.6 inches DBH and larger were identified within an interior measurement plot that was 54 by 54 feet. Topkill was assessed in 5-percent increments in September 1983, the second and third growing seasons after the banded and broadcast applications, respectively. To assess small-stem hardwood control, 6 milacre circular plots were systematically located within each measurement plot. The number of hardwoods (< 1.6 inches DBH), shrubs, and vines were counted after the first, second, and third growing seasons on these plots.

Heights and groundline diameters (immediately above the root-collar swell) were measured annually on the interior 36 seedlings of each plot during the dormant season for 3 years. Only the third-year summaries are presented herein. A volume index per plot was calculated by summing $(GLD^2)(Ht)$ for each surviving seedling. This volume index integrates the measures of diameter and height with survival and is considered a prime response variable for judging treatment success.

Several extraneous factors contributed to seedling mortality, and these factors were examined by ascribing a causal agent to each dead seedling. The causal agents were: (a) erosion, (b) animal predation (deer and rabbit nipping), and (c) tree fall (killed trees falling on seedlings).

Duncan's multiple range test was applied to both seedling and competition measurements to compare treatment differences ($p=0.05$), and orthogonal contrasts were calculated for selected comparisons.

RESULTS AND DISCUSSION,

The injection treatment with Tordon yielded 100 percent control of the overstory hardwood competition (Table 5). Although less than that, statistically comparable topkill was provided by the two broadcast rates of Spike, the 3-lb rate of Velpar in bands, and the 2-lb rate of Spike in bands. The 3-lb rate of Velpar in bands was significantly more effective than the 2-lb rate, which gave the poorest control.

Broadcast applications of Spike were more effective in controlling each of the prevalent hardwood species than were broadcast applications of Velpar (Table 6). Hornbeam was difficult to control with either herbicide but was essentially resistant to Velpar. Maple and sassafras were completely resistant to control by Velpar at these rates. Spike provided increased control of most species at the higher rate, which was less frequently the case with Velpar.

Table 7.--Number of vine stems in the second year by treatment.

Treatment	Rate	Application method	Vines[1/]
	lb a.i./A		[illegible]
Check	--	--	1225 a
Spike	3.0	band	1503 a
Spike	2.0	band	1559 a
Spike	3.0	broadcast	1837 a
Velpar	3.0	band	2227 a b
Velpar	1.5	broadcast	2338 ab
Velpar	2.0	broadcast	2338 ab
Spike	2.0	broadcast	2561 a b
Injection	--	--	3173 ab
Velpar	2.0	band	5789 b

1/ Means within the column followed by the same letter are not significantly different at the 0.05-level by Duncan's multiple range test.

index per acre after three growing seasons (Table 8), although not significantly different from the other treatments. The 2-lb rate of Spike in bands was the only treatment with third-year seedling volumes different from the check. Spike brosdcast at 3 lb and Velpar banded at 3 lb yielded seedling volumes similar to the injection treatment'.'

Table 8.--Volume index per acre, survival, and size of cherrybark oak seedlings after three growing seasons by treatment.[1/]

Treatment	Rate	Application method	Volume index	Adjusted survival[2/]	Height	GLD
	lb a.i./A		feet³/A	percent	feet	inch
Spike	2.0	band	[illegible] a	57 a	1.4 .	0.22 a b
Spike	[illegible]	broadcast	[illegible] ab	43 a b	1.7 a	0.22 a [illegible]
Injection	--	--	0.21 a [illegible]	47 a [illegible]	[illegible]	0.23 .
Velpar	3.0	band	0.26 a [illegible]	51 a [illegible]	1.3 .	0.23 .
Velpar	[illegible]	broadcast	0.24 a [illegible]	52a b	1.4 .	0.21 a [illegible]
Spike	2.0	broadcast	0.23 a [illegible]	41 a b	[illegible]	0.21 a [illegible]
Spike	3.0	band	0.11 ab	34 a b	1.2 .	0.23 a b
Velpar	2.0	broadcast	0.16a [illegible]	57 [illegible]	1.4 .	[illegible] a b
Velpar	2.0	band	0.16 a b	59 [illegible]	1.3 .	0.20 a b
Check	[illegible]	--	0.05 b	25 b	1.3'.	0.17 b

1/ Means within a column followed by the same letter are not significantly different at the 0.05-level by Duncan's multiple range test.

2/ Losses by erosion, animal predation, and tree fall are not included.

Spike at 3 lb in bands resulted in the lowest survival for a treatment (though not significantly different). because of herbicide kill of some seedlings. The "adjusted survival" presented in Table 8 discounted mortality by extraneous factors that-did not appear to be connected or that were only veakly connected to treatment. The first-year mortality due to these factors was as follows: erosion 7.2%, animal predation 3.7%, and tree fall 7.8%. Erosion was significantly greater in Block 1 on slopes that were about 20 percent steeper than slopes in Blocks 2 and 3. Tree fall damage was greater for treatments with more overstory control, but not significantly greater.

Seedling survival and growth were greatest in Block 1 (Table 9). This greater survival and growth occurred even with a significantly greater component of small stems (hardwoods and shrubs < 1.6 inches DBH) in Block 1: Block 1, 9,919 stems/acre; Block 2, 2,989; and Block 3, 2,305. Although confounded with blocks, the better survival and growth in Block 1, which had more competition, was probably because of the larger planting stock used in this block.

Table 9.--Seedling volume index, survival, and size by block.[1/]

Block	Volume index	Adjusted survival[2/]	Height	GLD
	feet³/A	percent	feet	inch
1	0.45 a	66 a	1.7 a'	0.45 a
2	0.11 b	42 b	1.3 b	0.11 b
3	0.08 b	32 b	1.2 b	0.08 b

1/ Means within a column followed by the same letter are not significantly different at the 0.05level by Duncan's multiple range test.

2/ Losses due to erosion, animal predation, and tree fall are not included.

CONCLUSIONS

Enrichment plantings of cherrybark oak in loessial bluff forests appear questionable after 3 years of data collection. In these erodible soils, seedlings should nat be planted at the head of ephemeral streams or actively eroding soils. Thfs is an obvious waste of planting stock and time. It is also evident in the field that planting is questionable along well used deer trails where seedlings are repeatedly nipped and eventually killed.

Vine control is a necessity in these loesslal forests because most arbors will expand following harvest and can cover up to 0.05 acre. Under these arbors, all regeneration is killed. The problem is worsened when overstory control results in falling infested trees.

The most promising treatments for controlling the overstory hardwoods are tree injection with Tordon RTU, broadcast and banded applications of Spike, and banded applications of Velpar at rates exceeding 3 lb a.i./acre. After initial treatment, competition becomes severe due to overstory removal, and further control treatments will probably be required. Overstory control only enhances ground competition by primary invaders. More important than treatment is the planting of good quality, large seedlings that can enhance establishment under these highly competitive situations.

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DISCLAIMER

Appendix Table 1.--Scientific nomenclature of hardwood species.

Common name	Scientific name
American beech	Fagus grandifolia
Basswood spp.	Tilia spp.
Black cherry	Prunus serotina Ehrh.
Black locust	Robinia pseudo-acacia L.
Boxelder	Acer negundo L.
Carolina laurelcherry	Prunus caroliniana (Mill.) Ait.
Chinaberry	Melia azedarach L.
Devil's club	Aralia spinosa L.
Dogwood	Cornus florida L.
Elm	Ulmus spp.
Hackberry	Celtis occidentalis L.
Hickory	Carya p .
Hophotnbeam	Ostrya virginiana Koch.
Hornbeam	Carpinus caroliniana Walt
Magnolia	Magnolia spp.
Maple	Acer spp.
Sassafras	Sassafras albidum Nutt. (Nees)
Southern red oak	Quercus falcata Michx.
Sourwood	Oxydendrum arboreum D.C.
Sweetgum	Liquidambar styraciflua L.
Water oak	Quercus nigra L.
White ash	Fraxinus americana L.

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