ESTABLISHMENT AND GROWTH OF CHERRYBARK OAK SEEDLINGS UNDERPLANTED BENEATH A PARTIAL OVERSTORY IN A MINOR BOTTOM OF SOUTHWESTERN ARKANSAS: FIRST YEAR RESULTS'

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Abstract-Advance regeneration is frequently inadequate to sufficiently restock the oak component of many bottomland stands, especially on productive sites with high levels of competition. We initiated a study near Beirne, AR to examine the effects of pre-plant control of Japanese honeysuckle (*Lonicera japonica* Thunberg) and seedling quality on establishment success and vigor of oak reproduction beneath a partial canopy. Nine, P-acre plots were delineated in the stand that was harvested to a residual stocking level of 30 percent in the fall of 1996. Honeysuckle pre-plant control treatments randomly applied to the nine plots were an Escort application in the spring of 1997, an Escort application in the late summer of 1997, and a control (no herbicide application). In 1998, 1-O chenybark oak (*Quercus pagoda* Raf.) seedlings were planted at a 12 ft x 12 ft spacing in each treatment plot. One-half of each treatment plot received seedlings with four or more lateral roots > 0.04 in. diameter, while the other half of each plot received seedlings with fewer than four lateral roots > 0.04 in. The spring application of Escort provided effective control against Japanese honeysuckle, thereby producing potentially promising conditions for oak seedling growth and development. First-year seedling survival and growth did not respond to honeysuckle control treatments. Survival was not related to seedling quality, and first-year differences in seedling size were attributed to initial size differences in stock types.

INTRODUCTION

The problem of obtaining adequate oak regeneration on high quality hardwood sites has been documented for several decades in many different forest types (Clark 1993). Encouraging advances have been made towards techniques that promote size and vigor of natural oak regeneration (Janzen and Hodges 1987, Loftis 1990). But, artificial regeneration techniques are still needed where stands lack en adequate stocking of advance oak reproduction.

One successful method of establishing artificial reproduction was developed by Johnson and others (1988) for northern red oak (*Quercus rubra* L.) in the Missouri Ozarks. Their prescription calls for controlling undesirable vegetation, reducing the overstory canopy to increase light reaching the forest floor, and underplanting large seedlings. Over-wood is removed about 3 years after planting when seedlings are well established. Typically, about 50 to 80 percent of the planted seedlings are free-to-grow 5 years after the overwood is removed (Johnson 1989). A modification of this prescription has been successfully applied to establish northern red oak regeneration in Wisconsin (Teclaw and lsebrands 1993). Though very different forest systems, these practices may serve as a starting point for developing regeneration strategies for bottomland oaks.

A growing interest surrounds the use of partial cutting and underplanting to establish oak regeneration in bottomland hardwood stands, but few studies have evaluated these practices. In two different studies, 1-O Nuttall oak (*Quercus nuttallii* Palm.) seedlings were successfully underplanted on bottomland sites of Louisiana (Chambers and Henkel 1988, Chambers and others 1988). Unfortunately, these seedlings were never released from overwood, so long-term success can not be evaluated. In South Carolina, Nix and Cox (1987) found that cherrybark oak seedlings were successfully established, but logging activities during overwood removal destroyed a significant amount of regeneration. Nevertheless, underplanting beneath a partial overstory to establish artificial oak regeneration in hardwood bottoms appears promising.

Midstory and partial overstory removals 'benefit underplanted seedlings by improving the light environment, but light may also invigorate competition (Nix and Cox 1987). Competition from vines, such as, Japanese honeysuckle (*Lonicera japonica* Thunberg), is of particular concern on many bottomland sites. Japanese honeysuckle grows poorly under the heavy shade of mature bottomland forests. Under these conditions, it can be difficult to control because of low physiological activity or litter coverage over foliage (Yeiser, In press). However, honeysuckle grows aggressively once released (Schmeckpeper and others 1987). and can quickly overtop slow growing hardwood regeneration. Vegetation control may be necessary to optimize establishment of oak regeneration where honeysuckle competition Is likely. Johnson (1989) found that vegetation control improved regeneration establishment of northern red oak, but he stressed that large seedlings are still essential to success.

This manuscript reports first-year results from a study designed to address two gaps in our knowledge about underplanting cherrybark oak (*Quercus pagoda* Raf.) in bottomlands. Objectives of this study were 1) to test the importance of pre-plant control of Japanese honeysuckle and season of application to establishment and growth of underplanted oak seedlings; and 2) to compare the suitability of two oak stock types for underplanting.

METHODS

The study site was located adjacent to the Little Missouri River, near Beirne in Clark County, Arkansas. The mixed bottomland hardwood stand on the site was considered typical of many minor bottoms throughout the South, with an

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overstory of mature red oak (*Quercus* spp.) and **sweetgum** (*Liquidambar styraciflua* L.), Basal area averaged about 118 ff per acre with oaks comprising about 26 percent of the standing **basal area.** A dense **midstory** layer of American holly (*Ilex* opaca Aft.), bluebeech (*Carpinus caroliniana* Walt.), winged elm (*Ulmus alata* Michx.), American elm (*Ulmus americana* L.), and other tolerant species was present in the stand. The understory was stocked with about 1,000 oak seedlings per acre. This amounted to only 15 percent of the total hardwood regeneration pool, and most of the oak seedlings were less than 12 in. tall.

In June 1998, a series of nine, P-acre (5 chains x 4 chains) plots were delineated on the site. Plots were arranged in three blocks to provide three replications of three honeysuckle control treatments. Honeysuckle pre-plant control treatments included 1) a spring application (May 1997) of herbicide, 2) a late summer application (August 1997) of herbicide, and 3) a control • no herbicide applied. The herbicide solution was 1 **oz** (product) per acre Escort (metsulfuron-methyl), 1.5 percent Red River 90 non-ionic surfactant, and 30 gal of water which was broadcast with backpack sprayers. Prior to herbicide application (October **1996),** two-thirds of the plots (those scheduled to receive a herbicide application) were harvested to a residual stocking level of about 30 percent (basal area ≈ 35 ff per **acre)(Goelz** 1995). Most stems > 1 in. d.b.h. were severed during the logging operation, and all merchantable volume was removed from the site. The partial cutting was done on the, site to increase light **availability** at the forest floor and promote a growth response by Japanese honeysuckle. Control plots were harvested in October 1997, so that seedlings underplanted in these treatment plots would not be planted amongst a year's growth of competition.

The entire study site was underplanted in February 1998 on a 12 ft x 12 ft spacing with I-O bareroot, cherrybark oak seedlings. Seedlings were graded into two classes to determine if stock type influenced establishment and growth of underplanted seedlings. The first stock type (grade 1) included seedlings with four or more first-order lateral roots having a diameter > 0.04 in., and the second stock type (grade 2) included seedlings with fewer than four first-order lateral roots having a diameter > 0.04 in. One hundred seedlings of each stock type were flagged in each plot to serve as measurement seedlings.

First-year measurements taken on the outplanted seedlings included initial and final stem height, initial and final **root-**collar diameter, and presence of honeysuckle contact. Data were analyzed according to a randomized block design with split-plots (table I), and percentages were transformed with a square root transformation prior to analysis. All tests were conducted at an alpha level of 0.05, and Duncan's Multiple Range Test was used for mean separations.

RESULTS AND DISCUSSION

Pre-plant herbicide treatments were designed to reduce Japanese honeysuckle competition, because observations indicate that planting sites with severe honeysuckle competition may result in early growth reductions and shoot malformations from honeysuckle twining. Partial cutting in the stand prompted a vigorous growth response by honeysuckle present on the site. As a result, 19 percent of seedlings planted in control plots were in direct contact with honeysuckle by the end of the first growing season (table 2).

Table I-Analysis of Variance sketch for a randomized block design with split-plots, used for analysis of response variable plot means

Source	Degrees of freedom[a]
Total	**rab - 1 = 17**
Block	(r-l)= 2
Honeysuckle control	(a-l)= 2
Error (Honeysuckle control)	**(r-1)(a-1)** = 4
Stock type	**(b-1) = 1**
Honeysuckle control x stock type	**(a-1)(b-1)** = 2
Error (honeysuckle control x stock type)	**a(r-2)(b-1)** = 8

[a] r = 3 blocks, a = 3 honeysuckle control levels, b = 2 stock **types.**

Table 2-Percentage of underplanted cherrybark oak seedlings In direct contact with Japanese honeysuckle 1 year after underplanting on a minor bottom site near Belme, AR

Treatment effect	Percent[a]
Honeysuckle **control**[b]	
Spring application of Escort	2.7 b
Late-summer application of Escort	20.5 a
Control	19.1 a
Stock **type**[c]	
1) ≥4 first-order-lateral roots	13.8 a
2) <4 first-order-lateral roots	14.6 a

[a] For each treatment effect, means followed by the same letter are not different at alpha = 0.05.
[b] **Probability = 0.0486.**
[c] Probability = 0.7764.

The spring application of Escort, however, provided very effective honeysuckle control. Only 3 percent of **seedlings** planted in plots receiving the spring application were in direct contact with-honeysuckle after the first growing season (two seasons after herbicide application) (table **2).** This pre-plant treatment appears to have reduced honeysuckle substantially enough to allow for potentially promising early oak seedling development. In contrast, **the** late-summer herbicide application provided no **noticeable** honeysuckle control (table 2). It is **likely** that rank herbaceous competition established on the site by the **time** of the late-summer application reduced application **efficiency** and protected honeysuckle vines from receiving an adequate amount of herbicide for effective control. Honeysuckle vines established a similar percentage of contact with both grades of seedlings (table 2).

Seedling survival was excellent across the study site sveraging about 98 percent after 1 year. Though honeysuckle contact was greatly reduced on seedlings planted in piots receiving the spring application of herbicide, first-year seedling survival was not influenced by honeysuckle control (table 3). This finding is in agreement with other research on cherrybark oak regeneration (Kennedy 1985, Nix 1989). Kennedy (1985) found that disking or mowing did not increase survival on a minor bottom site with grass and herbaceous weed competition. Likewise, mulching or herbicide application did not increase cherrybark oak survival on a bottomland site in South Carolina (Nix 1989). In contrast, Ezell and Catchot (1998) reported a 20 percent increase in first-year survival of cherrybark oak after pre-bud break applications of herbaceous weed control treatments. We note that our study site received abundant rainfall throughout the growing season which may have helped to maintain early seedling survival. Root system development provided no early survival benefit as both stock types exhibited similar mortality (table 3).

Table 3-First-year survival of cherrybark oak seedlings underplanted on a minor bottom site near Beime, AR

Treatment effect	Percent[a]
Honeysuckle control[b]	
Spring application of Escort	98.8 a
Late-summer application of Escort	97.4 a
Control	98.5 a
Stock type'	
1) ≥4 first-order-lateral roots	98.4 a
2) <4 first-order-lateral roots	97.9 a

[a] For each treatment effect, means followed by the same letter are not different at alpha = 0.05.
[b] Probability = 0.2888.
[c] Probability = 0.3833.

First-year height growth of cherrybark oak seedlings was not influenced by pre-plant control of honeysuckle, as all seedlings showed a 75 percent height increment (table 4). Nevertheless, we feel the substantial reduction in honeysuckle achieved in plots receiving the spring application of herbicide will prove important to seedling growth and form in future years. Though others have demonstrated increased growth of cherrybark oak seedlings receiving broad spectrum weed control in bottomlands (Nix 1989), we did not expect our honeysuckle pre-plant control treatments to provide early growth benefits. Two factors may attribute to the lack of an early growth response to the herbicide application in this study. First, Escort has a fairly narrow spectrum of control, and species not controlled by the Escort applications were released prior to oak underplanting. Secondly, the oak seedlings were under-planted the year following the pm-plant herbicide applications. We did not expect residual weed control, other than for Japanese honeysuckle, to extend into the first oak growing season.

Seedling size and root morphology is of great concern when planting oaks, because it is believed that seedlings must be relatively large and have a well developed root system to be competitive (Kormanik and others 1998). On upland sites in Missouri, Johnson and others (1986) suggests underplanting northern red oak seedlings with an average height greater then 3 feet (before shoot clipping) and an average diameter of at least 0.5 in. measured 1 in. above the root-collar. Seedlings underplanted in this study were small (table 4 & 5) compared to recommendations for oaks in other regions of the country (Bowersox 1993, Johnson and others 1986). Stock types did have different initial heights, as grade 2 seedlings were about 1 in. shorter than grade 1 seedlings. The initial difference in seedling height was maintained through the first growing season with grade 1 seedlings averaging about 3 in. taller than the others. However, relative growth of both stock types was similar (table 4).

Seedling root-collar diameter increased about 51 percent regardless of honeysuckle control treatment (table 5). As expected, grade 1 seedlings had a root-collar diameter

Table 4-First-year height variables (mean ± standard error) for cherrybark oak seedlings underplanted on a minor bottom site near Beime, AR

Treatment effect	Initial	Final	Growth
	-------- Inches --------		Percent
Honeysuckle control[a]			
Spring application of Escort	12.5±0.1 a	21.1±0.3 a	72.5f2.9 a
Late-summer application of Escort	12.7±0.1 a	22.4±0.4 a	81.0i3.4 a
Control	12.2±0.1 a	20.9±0.3 a	74.9i2.9 a
P-value	.36	.4868	.7800
Stock type			
1) ≥4 first-order-lateral roots	12.9±0.1 a	22.9±0.3 a	79.1±2.3 a
2) <4 first-order-lateral roots	11.8±0.1 b	19.9±0.3 b	72.5±2.7 a
P-value	.0001	.0001	.0762

[a] For each treatment effect, means followed by the same letter are not different at alpha = 0.05.

Table 5—First-year root-collar diameter (mean ± standard error) variables for cherrybark oak seedlings underplanted on a minor bottom site near Beirne, AR

Treatment effect	Initial	Final	Growth
	----------- Inches -----------		Percent
Honeysuckle control[a]			
Spring application of Escort	0.15±0.001 a	0.22±0.002 a	49.4±1.8 a
Late-summer application of Escort	.16±0.001 a	.23±0.003 a	53.1±2.1 a
Control	.15±0.001 a	.23±0.002 a	52.5k1.8 a
P-value	.7387	.6877	.8685
Stock type			
1) 24 first-order-lateral roots	.17±0.001 a	.25±0.001 a	44.8kl.2 b
2) <4 first-order-lateral roots	.13±0.001 b	.20±0.001 b	59.5±1.8 a
P-value	.0001	.0001	.0001

[a] For each treatment effect, means followed by the same letter are not different at aloha = 0.06.

initiaily larger than the others. This initial difference was maintained through the first growing season even though growth rate of grade 2 seedlings was greatest (table 5).

We should note that a problem with our planting stock was noticed after seedlings broke bud. About 9 percent of the seedlings outplanted were southern red oak (*Quercus falcata* Michx.) (table 6). interestingly, a large percentage of the southern red oak was found among the grade 2 seedlings (table 6). Since success at establishing high quality hardwood stands hinges on matching appropriate species to site conditions, care should be taken to procure high quality planting stock when planning reforestation activities on bottomland hardwood sites.

CONCLUSIONS

Excellent survival was observed across the entire study site, but was not influenced by pre-plant control of honeysuckle control or seedling stock type. Pre-plant control of honeysuckle did not influence first year height and diameter growth of cherrybark oak seedlings. Differences found among the two stock types were mostly initial size differences maintained through the first growing season. Japanese honeysuckle competition was most effectively reduced with a spring application of Escort, and this control is expected to benefit future oak seedling form and growth. If vegetation control treatments target honeysuckle, applications should be timed to maximize coverage on foliage. Late season applications where dense herbaceous cover is expected to develop may not prove effective. Care should be taken when purchasing seedlings for hardwood reforestation projects so that appropriate species are outplanted.

Table 6-Percentage of southern red oak seedlings underplanted on a minor bottom site near Beirne, AR

Treatment effect	Percent"
Honeysuckle control[b]	
Spring application of Escort	8.9 a
Late-summer application of Escort	11.1 a
Control	7.2 a
Stock type[c]	
1) ≥4 first-order-lateral roots	3.5 b
2) 4 first-order-lateral roots	14.7 a

[a] For each treatment effect, means followed by the same letter are not different at alpha = 0.05.
[b] Probability = 0.4473.
[c] Probability ≤ 0.0004.

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