WHITE OAK SEED SOURCE PERFORMANCE ACROSS MULTIPLE SITES IN INDIANA THROUGH AGE 16

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Abstract.—In 1984, a series of combined provenance/progeny tests was established by the Indiana Department of Natural Resources, Division of Forestry. Three plantings were established using a maximum of 70 open-pollinated families representing 17 natural stands (15 Indiana, 1 Illinois, and 1 Missouri). Height data were collected periodically through age 16. Early analyses (ages 3 and 5) showed demonstrable but statistically insignificant variation based on stand level means, while 10- to 25-percent increases in height could be realized by selecting at the family level and a 30-percent increase could be achieved by selecting the best individuals within families. Similar increases in height growth were noted for both the 10th- and 16th-year measurements. Potentially, a 42-percent increase in height growth could be obtained by selecting the best performing individuals from the best performing families at age 16.

INTRODUCTION

White oak (*Quercus alba* L.) is one of the most commercially important hardwoods in the North Central United States (Rink 1980). As of 2005, the most recent year for which such data have been tabulated, annual harvest of white oak in Indiana approached 45.6 million board feet for use as sawlogs, veneer, and staves (Piva and Gallion 2007). According to the *Hardwood Leader* (December 2009), white oak export volume has continued to increase at a rate of 8 to 12 percent during the preceding quarter. Natural regeneration of all oaks is insufficient to replace stocking of these species, so the majority of reforestation relies on planted nursery seedlings. To address this need, nursery sales of white oak have averaged 292,000 seedlings annually over the past 5 years in Indiana, enough to plant almost 500 acres each year. With this increased demand for regeneration seedlings comes an awareness of the use of well adapted seed sources when new plantings are being established across the state. Growers should consider the significance of provenance since the supply of acorns from any one stand can be irregular (Hubert 2005).

Within their native ranges, oaks vary considerably in growth rate, leaf color, habit, and stature, as well as in ease of transplanting and ability to tolerate variable soil moisture and pH (Bassuk 2001). Trees within a species can exhibit tremendous variation in seed size and appearance. Large acorns will normally produce larger and more vigorous seedlings in the nursery (Coggeshall 1995, Purohit and others 2003). Such maternal effect does not last for the life of the tree, but rather is lost several years after field establishment (Coggeshall 1995). Seed sources, however, can have a great impact on the long-term productivity of white oak plantings (O'Connor and Beineke 2004).

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Several provenance/progeny tests already exist for other oak species (Rink 1980). However, very limited information has been made available for use in assessing the long-term growth rates and other phenotypic traits in white oak in the midwestern United States. To address this need, a series of provenance/progeny test plantings was established in 1984 to quantify variations within these traits for white oak planted in Indiana.

METHODS

Acorns were collected in fall 1982 from one to five parent trees in each of 15 white oak stands throughout Indiana, as well as one stand each from Illinois and Missouri (Table 1). All parent trees exhibited at least average vigor and form when compared with adjacent trees within the same stand. There was no specified minimum distance between parent trees within a stand. All acorns were sown at the Indiana Department of Natural Resources, Vallonia State Nursery, in late October 1982. In fall 1983 1-0 seedlings were lifted and held over winter in refrigerated storage in accordance with standard hardwood nursery procedures. All study seedlings were out-planted in spring 1984 at three locations: Jasper-Pulaski State Nursery, Starve Hollow State Recreation Area, and Harrison-Crawford State Forest (Table 2).

Table 1.—Collection sites for white oak acorns used to produce provenance/progeny test seedlings.

State	Location	N Latitude	W Longitude	Provenance ID	Families per Stand
Illinois	Boskeydell	37° 44’	89° 13’	IL-01	5
Indiana	Vallonia	38° 49’	86° 05’	IN-01	5
	Lake Monroe	39° 08’	86° 27’	IN-02	5
	Shakamak	39° 10’	87° 14’	IN-03	1
	North Vernon	39° 00’	85° 38’	IN-04	1
	Martin SF	38° 42’	86° 45’	IN-05	5
	JP F&W Area	41° 05’	86° 55’	IN-06	5
	Laporte	41° 37’	85° 45’	IN-07	5
	South Bend	41° 40’	86° 12’	IN-08	5
	Rochester	41° 04’	86° 14’	IN-09	5
	Lafayette	40° 25’	86° 53’	IN-10	5
	Marion	40° 33’	85° 40’	IN-11	5
	Connersville	39° 39’	85° 08’	IN-12	1
	Wyandotte Cave	38° 15’	86° 18’	IN-13	5
	Evansville	37° 58’	87° 35’	IN-14	5
	Huffman	38° 07’	86° 45’	IN-15	3
Missouri	Rolla	37° 58’	89° 30’	MO-03	4

Table 2.—Outplanting locations and number of included families for 1983 white oak provenance/ progeny test plantings in Indiana.

Provenance Test Site	Number of Families	Location	Latitude, Longitude	Soil Type
Harrison-Crawford State Forest	57	Corydon, IN	38° 15’ N, 86° 15’ W	Haymond silt loam
Starve Hollow State Recreation Area	63	Vallonia, IN	38° 49’ N, 86° 05’ W	Bloomfield sandy loam
Jasper-Pulaski Nursery	53	Medaryville, IN	41° 09’ N, 86° 54’ W	Maumee sandy loam

Site preparation at each location employed the broadcast of an herbicide mixture (glyphosate at 0.6 gallons/acre and simazine at 4.5 pounds/acre) applied prior to planting. Weed control was then strip-applied annually through crown closure utilizing the same mixture.

The outplantings consisted of four-tree open-pollinated family plots arranged in a randomized complete block design. For each family, six blocks were established at Starve Hollow as four-tree squares, with 4 feet between trees in the family plot, and 8 feet between plots. The plantings at Jasper-Pulaski and Harrison-Crawford were installed in four-tree row plots with 8-foot spacing within and between rows. Six blocks were established at Jasper-Pulaski and eight blocks were established at Harrison-Crawford. Due to seed availability and seedling survival, not all sources are represented at all three test locations. The Starve Hollow planting was subsequently thinned from four tree family plots to the single best tree in each family plot at age 7. The other planting sites remain unthinned.

Total height data were collected on all live trees in each planting during the 1999/2000 dormant season. To minimize the confounding effects of various conditions at each planting site (i.e., thinning at Starve Hollow, depredation by white-tail deer [*Odocileus virginiana* Zimmerman] at Jasper-Pulaski), the plot means were presented as percentages of each overall plantation mean.

Data were analyzed using basic statistical functions available with Microsoft Excel Analysis ToolPak™ (Microsoft Corporation, Redmond, WA). Separate analyses of variance were conducted at the family and stand (provenance) level. The software utilized did not allow for including interaction between family and stand in the analysis. When the null hypothesis was rejected, the mean separations were determined using least significant difference (LSD) analysis.

RESULTS

Overall plantation survival at Harrison-Crawford, Starve Hollow, and Jasper-Pulaski was 84.9, 81.6, and 48.0 percent respectively. Most of the mortality was evident prior to the fifth-year measurements.

Growth of the trees at Starve Hollow generally exceeded twice that of either of the other planting locations. Stand-level (provenance) variation was not significant for measured heights at any of the planting locations. In contrast, family-level (progeny) variance was significant for 16-year heights across all three plantings ($p < 0.05$). Figures 1, 2, and 3 show the families whose heights exceeded the plantation mean by at least one standard deviation at Harrison-Crawford, Starve Hollow, and Jasper-Pulaski respectively. Family mean separations were determined by LSD.

Comparisons with 10-year height data (data not shown) suggest 82-percent parity at the level of mean plus one standard deviation for families in the Harrison-Crawford planting. By this we mean that 82 percent of the families exceeding the plantation mean by at least one standard deviation at 16 years had also done so at 10 years of age. Only 50- and 46-percent parity was demonstrated for those in the Jasper-Pulaski and Starve Hollow plantings, respectively.

Family IN 10-04 from Lafayette performed well across all three planting sites. In contrast, IN 07-04 was a high performer at both the northern site (Jasper-Pulaski) and the southern site (Harrison-Crawford) but was only average at the Starve Hollow planting.

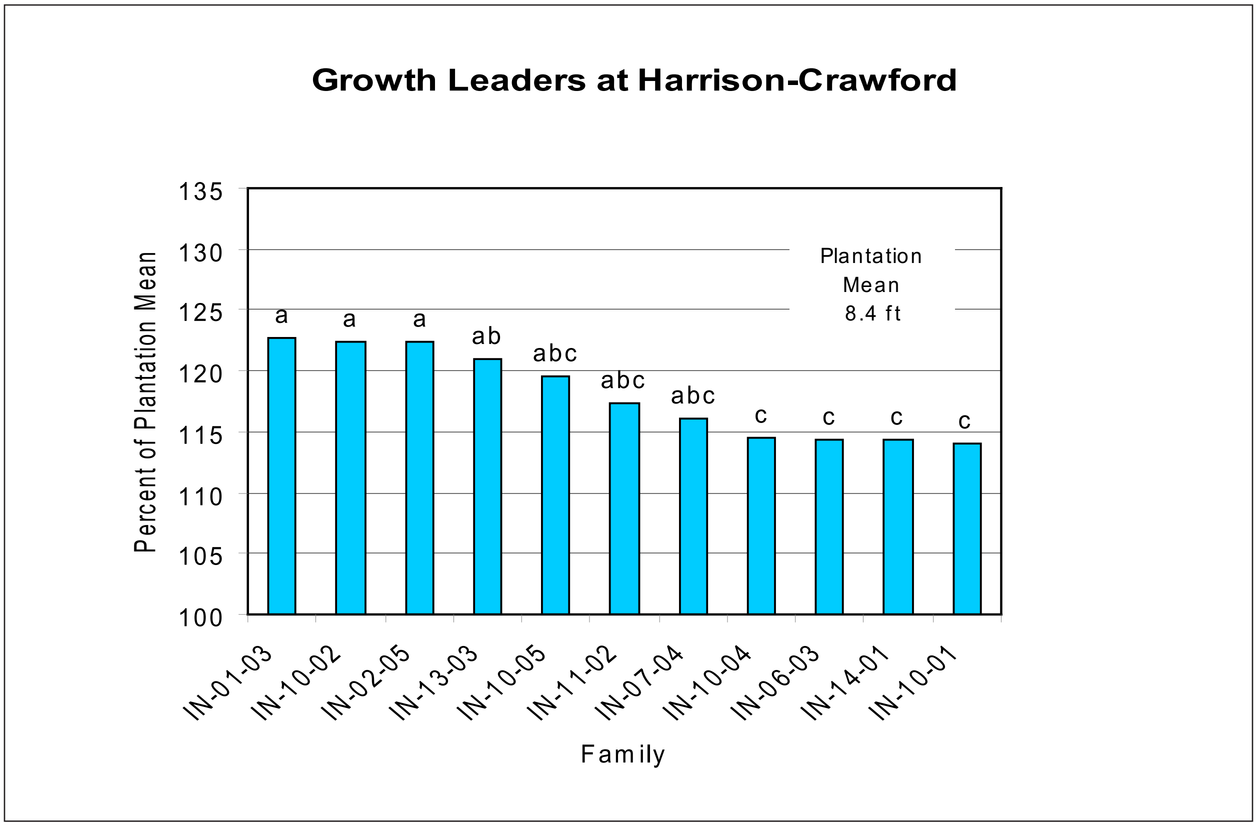

Figure 1.—Families whose 16-year mean heights exceeded the plantation mean by at least 1 standard deviation at Harrison-Crawford.

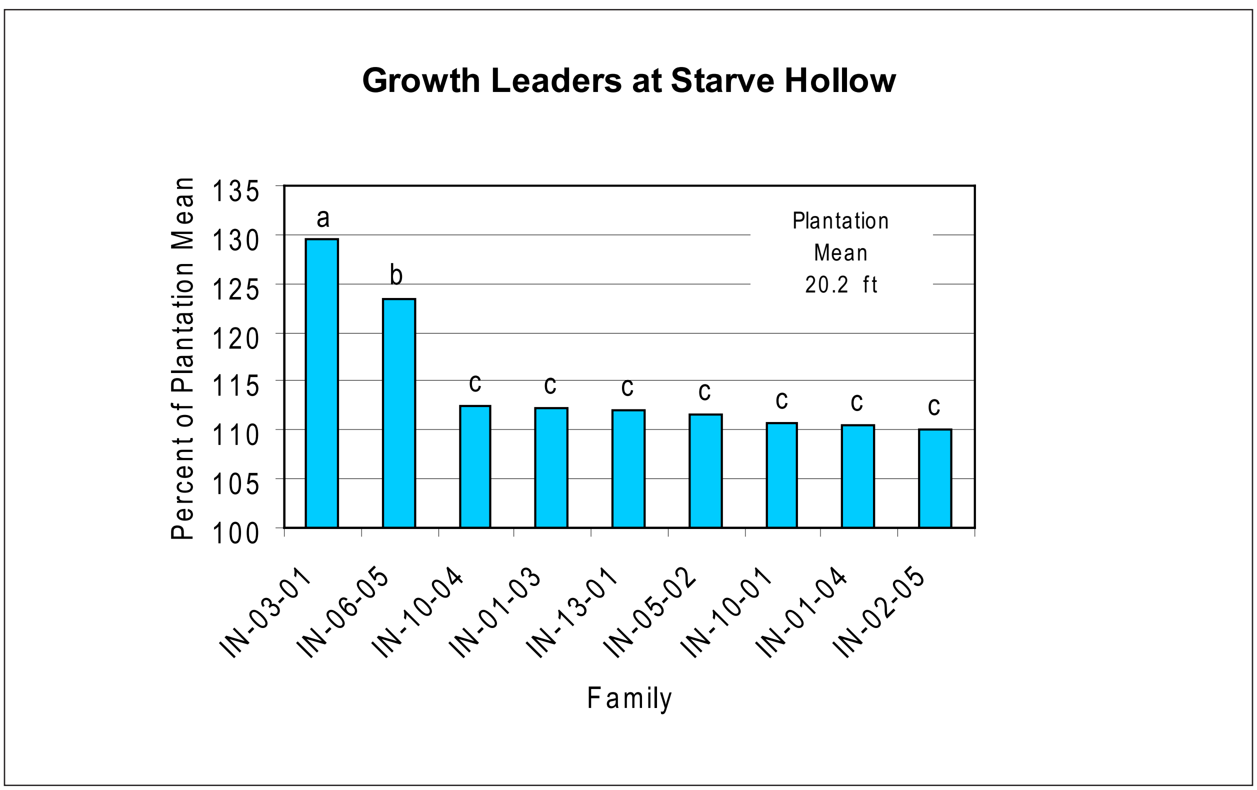

Figure 2.—Families whose mean 16-year heights exceeded the plantation mean by at least 1 standard deviation at Starve Hollow.

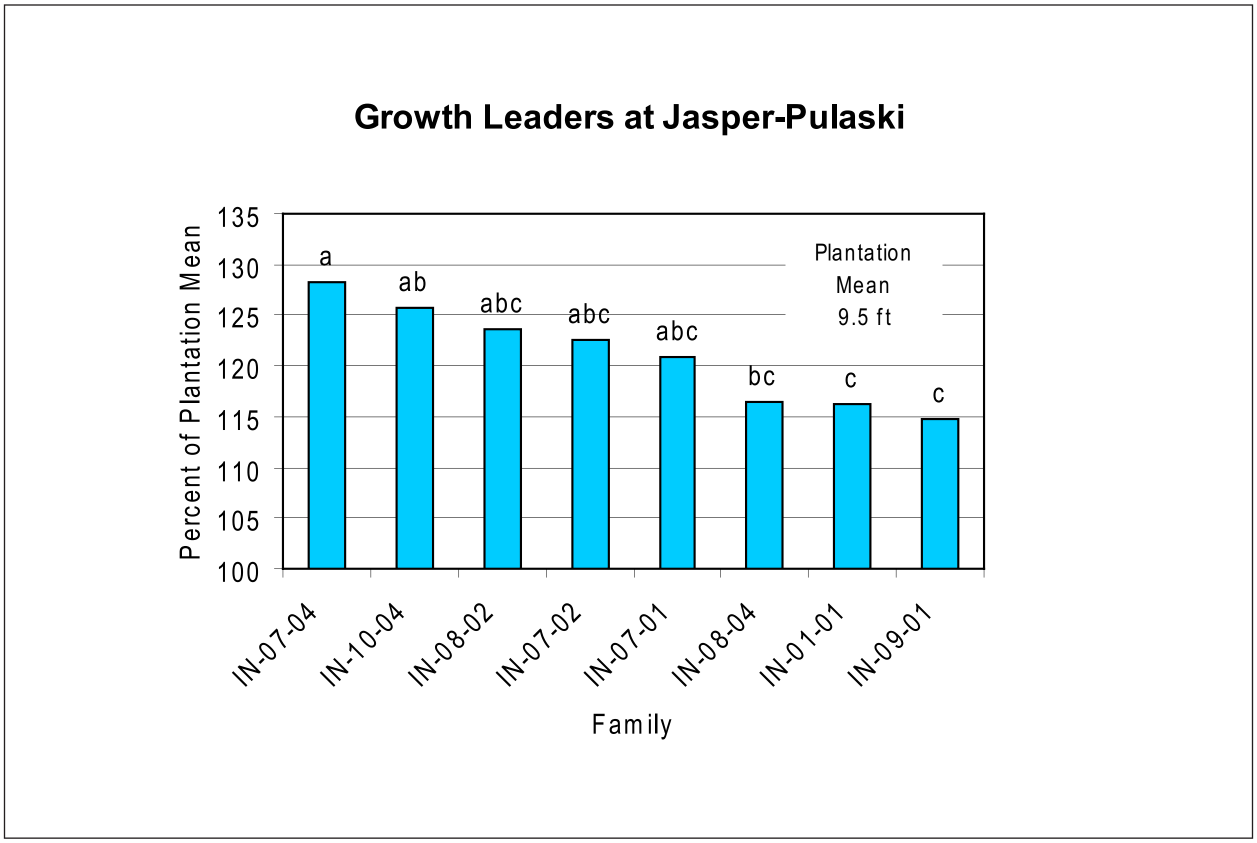

Figure 3.—Families whose 16-year mean heights exceeded the plantation mean by at least 1 standard deviation at Jasper-Pulaski.

The best-performing families were: IN 01-03 at Harrison-Crawford with an average height of 10.3 feet, which represents the potential for a 22.8-percent increase in height growth; IN 03-01 at Starve Hollow with an average height of 26.2 feet, representing a potential 29.6-percent increase, and IN 07-04 at Jasper-Pulaski with an average height of 12.3 feet, representing a potential height increase of 28.3 percent after 15 growing seasons.

Within the fastest-growing families, individual trees exhibited even greater improvement in height growth. For example, the best-performing tree within IN 14-04 at Harrison-Crawford grew at 209.7 percent of the plantation mean. At Starve Hollow, the best tree within the best family (IN 03-01) grew 142.2 percent of the plantation mean. Similarly, for IN 10-04 at Jasper-Pulaski the height gain was 182.7 percent of the plantation mean.

DISCUSSION

The higher growth rate at Starve Hollow was the result of several factors. The 1990 thinning, which eliminated all but the best trees in each family plot, increased the plantation mean by 22.5 percent and extended the free-to-grow period prior to crown closure in contrast to the other two study sites. In addition, the close proximity of this planting site to the Vallonia Nursery facilitated timely and regular weed control during the study period.

Ten-year height growth appears to be a good indicator of sixteenth-year height growth at Harrison-Crawford, but not at the other two planting sites. The Harrison-Crawford planting has not been thinned and is assumed to be fully stocked with an average tree height of 8.4 feet. At Starve Hollow, the lower parity may be due in great part to the effect of the 1990 thinning, which retained only the best trees for each family plot. Similarly, the Jasper-Pulaski site suffered high mortality associated with predation by white-tailed deer, leaving a number of large, irregular canopy gaps that likely favored the growth of some trees in some family plots at random.

While the influence of stand origin was not significant in this study, it is suggested that increases in 15-year height growth of planted white oak seedlings will be obtained by utilizing seeds from specific family origins. For example, family IN 10-04 and IN 07-04 were among the best performers in both northern and southern Indiana (Figs. 1, 3) and should be considered as superior seed sources for future regeneration plantings throughout the state. It is recommended that a combination of those high-performing seed sources from the families shown in Figures 1, 2, and 3 will give a higher likelihood of successful plantings with potential for improved growth rates over the long run.

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