GRAFTING INFLUENCES ON EARLY ACORN PRODUCTION IN SWAMP WHITE OAK (*QUERCUS BICOLOR* WILLD.)

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Abstract.—Early fruiting of swamp white oak planting stock has been observed. The potential to exploit this trait for wildlife enhancement purposes was evaluated in a grafting study. Scions from both precocious and non-precocious ortets were grafted onto a series of related seedling rootstock sources. Acorn production was recorded through age 4 years. Acorn productivity of the grafts was identical to their ortet rankings for cumulative acorn production over a 5-year period when graft productivity was standardized on a trunk cross-sectional area basis. There was no significant scion x rootstock family interaction for acorn production. However, significant scion and rootstock effects were detected for both stem diameter and number of acorns produced per grafted tree. No single rootstock source proved to be superior in terms of acorn production. Based on these results, it is anticipated that precocious tree genotypes can be readily multiplied by grafting, and high acorn productivity can be maintained via this grafting approach. Subsequent establishment of grafted seed orchards for the production of precocious seedling planting stock for reforestation purposes should be possible, depending upon the heritability of this important trait.

INTRODUCTION

Swamp white oak (*Quercus bicolor* Willd.) is an important mast species, producing medium-sized acorns that are highly desirable to wildlife in both upland and bottomland forests. Dey and others (2004) reported wide variation in both precocity and acorn productivity for swamp white oak within their bottomland oak plantings. They reported that 3.5 percent of the saplings started producing acorns in as few as 3 years from seed. This early fruiting trait is highly desirable and should serve as the basis of selection when individuals are being identified to deploy in bottomland plantings for wildlife enhancement purposes. Farmer (1981) suggested that selecting for fecundity within a population of grafted white oak (*Q. alba* L.) clones should be successful since more than 50 percent of the variance in seed production was associated with clonal origin, regardless of tree size. This strategy is in contrast to other clonal seed orchard programs that focus on the production of genetically improved oak seed stocks for timber purposes. For such programs, seed production within the orchard can be highly irregular from clone to clone because inclusion within the orchard is based on selection for a series of timber traits rather than fruiting capacity (Kleinschmit 1986).

Little information is available documenting the heritability of precocity and acorn production in swamp white oak. In addition, we have found no information on how scion or rootstock source may affect the precocity or productivity of grafted swamp white oak trees. In many fruit crops, the use of specific rootstock sources can result in earlier fruiting and increased yields (Rom and Carlson 1987). For a grafting program to be successful as part of an applied tree improvement program, the grafted ramets should exhibit similar patterns of precocity as the selected ortets, and any rootstock effects on precocity should be clearly defined.

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Vegetative propagation of swamp white oak by use of softwood cuttings is difficult (Fishel and others 2003), especially in comparison to other native oak species such as northern red oak (*Q. rubra* L.). To our knowledge, no tissue culture protocols have been developed for this species to date although Gingas (1991) did have limited success in culturing somatic embryos of this species derived from male catkins. However, the resulting plantlets failed to acclimate in the greenhouse.

Delayed graft compatibility in *Quercus* has been observed, especially for species in the Lobatae sub-genus (Santamour and Coggeshall 1996). However, few such problems appear to be associated with species in the white oak, or *Quercus* sub-genus. To illustrate this fact, of the 252 valid oak cultivar names listed by McArdle and Santamour (1985, 1987a, 1987b), a total of 224 are from the *Quercus* sub-genus while only 28 represent species in the Lobatae sub-genus. Expression of graft incompatibility can be delayed up to 7 years after grafting in *Q. rubra* (Coggeshall 1996). Symptoms include significant scion overgrowth of the rootstock, vigorous suckering, and precocious flowering (Coggeshall 1993). Our experience in grafting species of the white oak sub-genus led us to expect few if any delayed incompatibility problems for at least the first 10 years following grafting.

OBJECTIVES

Our objectives for this study were to determine if grafted swamp white oaks exhibit a similar trend in precocity as their selected ortets and to determine any rootstock effect on fruiting in grafted swamp white oaks.

MATERIALS AND METHODS

In fall 1995, acorns were collected from a single swamp white oak tree in Boone County, MO. Acorns were sent to the Forrest Keeling Nursery in Ellsberry, MO to produce both 1-0 bareroot seedlings and their patented Root Production Method (RPM®) seedlings. In spring 1997, seedlings were planted on an upland ridge with deep loess soils at the University of Missouri Horticulture and Agroforestry Research Center in Howard County, MO. Initial tree spacing was 3 m within row and 6.1 m between rows. Within-row vegetation was controlled with periodic application of glyphosate from 1997 through 2002 while the between-row tall fescue sod was periodically mowed. Individual tree height and basal diameter as well as annual acorn production were measured from 1997 through 2003.

Acorns were collected from six precocious trees and were sown in the fall of 2001 following the RPM® method (Lovelace 1998). These six parent trees were classified as being precocious based on their capacity to produce a minimum of 200 cumulative acorns each by age 7 (Table 1). In this method, acorns were sown on the surface of potting medium within 38 x 38 x 10.2 cm deep trays (Anderson Die and Manufacturing Co., Portland, OR). Then trays were stacked, placed within a closed polyethylene bag, and stratified for 3 to 4 months at 2.2 °C within a walk-in refrigerator. Trays were moved to a heated greenhouse in March 2002. One-flush germinants were shifted to Anderson™ (9.2 x 9.2 x 12.7 cm) plant bands, and then to 6.2-L pots (15 x 15 x 41 cm) to produce 1-year-old, three-flush container-grown seedlings during the 2002 growing season. Seedlings were overwintered outdoors under 0.63-cm thick closed-cell white polyethylene foam covered by a single layer of 4-mil white polyethylene sheeting.

In January 2003, scionwood was cut from five precocious and three non-precocious trees from the study established in the spring 1997. A total of 192 whip-and-tongue grafts were made in the greenhouse in early spring of 2003 on the 6.2-L potted rootstocks produced in 2002. Grafting success rates exceeded 90

Table 1.—Stem diameter and number of acorns produced for 10 swamp white oak trees (ortets) used as sources for either scionwood or acorns for production of rootstocks

Ortet Number[1]	Stock type	Fall 2002 d.b.h. (cm)	First year for acorns	Cumulative no. acorns from 1999-2003
1	Bare-root	8.6	1999	593
2	RPM	6.4	1999	202
3	Bare-root	7.3	2000	511
4	Bare-root	7.4	2000	180
5	RPM	7.3	2000	235
6	Bare-root	6.8	2000	230
7	Bare-root	7.8	2000	227
8	RPM	8.2	2001	126
9	RPM	7.3	2002	14
10	RPM	6.1	>2002	0

[1]Ortet #1 through #7 were considered to be precocious and ortet #8 through #10 non-precocious.

percent for all scion x rootstock combinations. Successful grafts were moved outdoors in May 2003 to a shade house (55 percent shade) and received daily overhead irrigation. A total of 127 grafts representing eight scion x six rootstock (half-sib family) combinations were planted in a random design during October 2003 on a north-facing slope at the Horticulture and Agroforestry Research Center. Grafts were planted on a Menfro silt loam soil at 3.7 x 4.6-m spacing within a 0.2-ha plot with no obvious site variation. Grafts have received annual spot weed control with glyphosate and periodic mowing to control grass competition.

In September 2006, survival, diameter at breast height (d.b.h.; cm), and number of nuts were recorded for each graft. In addition, the trunk cross sectional area (TCSA) of each graft based on d.b.h. was calculated. These data were subjected to analysis of variance for a completely randomized design. As a result of unbalance, Type III sums of squares were used to determine if differences existed among scion, rootstock, and scion x rootstock at the 5-percent level. Fisher's unprotected least significant differences were calculated to separate statistically different means at the 5-percent level.

RESULTS AND DISCUSSION

The RPM® seedlings in the study established in 1997 were larger in basal stem diameter (11.2 vs. 8.3 mm) and stem height (1.1 vs. 0.5 m) than the bare-root seedlings at outplanting. It is unknown what effect size may have; however, recent advances in the RPM® technology now produce much larger swamp white oak seedlings such as those used by Dey and others (2004) in their bottomland reforestation project. Although the RPM® seedlings in our study maintained a slight size advantage over the bare-root seedlings, we found no differences between stock types as to the age when trees began producing acorns (Table 1). Lack of statistical differences between stock types for cumulative total acorn production from 1999 through 2003 may in large part be because of two exceptionally productive trees established as bare-root seedlings (ortet #1 and #3). Neither fertilization nor irrigation increased acorn production of either stock type on this excellent oak site (data not shown). The wide variation in acorn precocity and production found among the 64 half-sib seedlings grown on a deep soil with adequate soil moisture and nutrients suggests that fruiting is likely under strong genetic control.

Table 2.—Stem diameter, acorn production and the number orf acorns per TCSA produced by 4-year-old ramets grafted with scionwood of the eight ortets described in Table 1

Scion wood Ortet number[1]	No. of ramets	Percent bearing	Acorns per grafted ramet		Average d.b.h. (cm)	Acorns/TCSA (no./cm^2)
			Average	Maximum		
1	21	100	41	126	2.8	1.55
2	16	100	33	77	3.3	0.91
3	22	96	75	186	2.8	2.59
6	12	100	57	112	3.4	1.52
7	8	83	51	105	2.9	1.67
8	10	67	13	57	2.2	0.64
9	16	45	5	25	3.4	0.13
10	10	19	4	22	2.6	0.09
	5% lsd=		30	----	0.5	0.37

[1]Scionwood was not available because of tree removal of ortet #4 and #5.

Table 3.—Stem diameter, acorn production after 4 years, and the number of acorns per trunk cross sectional area (TCSA) averaged across eight scion sources when grafted onto half-sib family seedling rootstocks derived from the ortets described in Table 1

Rootstock Family no.	No. of ramets	Percent bearing	Acorns per grafted ramet		Average d.b.h. (cm)	Acorns/TCSA (no./cm^2)
			Average	Maximum		
1	22	83	51	126	2.9	1.66
2	10	100	57	146	3.1	1.78
3	23	92	27	126	2.8	0.98
4	22	75	44	186	3.2	1.32
5	15	62	21	116	2.7	0.73
6	23	85	34	91	2.9	1.23
	5% lsd=		26	-	0.9	0.28

Swamp white oak can be easily propagated by grafting. The use of specific scion genotypes or rootstock families did not increase grafting success rates in this limited study as all graft combinations exceeded 90 percent. Further, we did not observe any evidence of graft incompatibilities (i.e., reduced growth or stunted foliage) among the 48 scion x rootstock combinations. Survival after 3 years for grafts planted into the field exceeded 90 percent. We did not find any significant scion x rootstock interactions, which may be a result of the low numbers of scion x rootstock combinations used in this study (mean = 2.6). Significant scion and rootstock family main effects were detected for both stem diameter and number of acorns produced per grafted tree (Tables 2 and 3).

Acorn productivity was more strongly influenced by the source of the scionwood than rootstock origins based on the probabilities for significant differences. The average number of acorns per grafted tree for the ramets from the precocious (ortet #1 through #7) and non-precocious (ortet #8 through #10) sources closely paralleled cumulative acorn production of the ortets themselves (Tables 1 and 2). Because the grafts had slightly different growth rates, acorn production data were standardized by converting to number of acorns per cm^2 TCSA. It was also found that the ortet rankings for cumulative acorn production during the 4 years from 1999 to 2003 were identical to the scion rankings for the number of acorns produced in 2006 on a TCSA basis except for ortet #1. None of the half-sib progeny from the highly productive swamp white oaks yielded a superior rootstock for grafting (Table 3). Seedlings of ortet #5, when used as a rootstock, tended to exhibit reduced stem diameter and acorn productivity.

CONCLUSIONS

Our study demonstrated that swamp white oak can be readily vegetatively propagated using a whip and tongue graft. Field-planted grafts showed high survival rates with no graft incompatibility evident after four growing seasons when using scion and rootstocks originating from a common maternal source. Unlike half-sib seedlings, the 127 grafts used in this study exhibited similar patterns of precocity and acorn production as the source tree used for scionwood. It is suggested that the number of acorns produced per unit TCSA in young swamp white oak grafts can serve as an indirect measure of ortet acorn productivity when such cumulative seed production figures are unknown. Based on these findings, highly precocious individual swamp white oak trees can be readily identified and potentially utilized as grafted stock for the production of reforestation seedlings that may be capable of flowering and fruiting at a young age, depending upon the heritability of this important trait. In addition, if delayed compatibility does not become a problem in this species, such grafted trees may possibly be planted directly into landscapes where wildlife enhancement is a management objective. While the results derived from the present study hold promise, we suggest more research by utilizing a greater range of swamp white oak origins to determine if such findings can be generalized across the species.

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