Scion and Rootstock Effects on Growth and Early Acorn Production of Grafted Swamp White Oaks©

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Swamp white oak (*Quercus bicolor* Willd.) is an important mast species, producing medium-sized acorns found highly desirable by wildlife in both upland and bottomland forests. In addition, the Northern Nut Growers Association <www.nutgrowing.org> is promoting acorns from selections within this species as a new edible food crop. 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% of the swamp white oak saplings started producing acorns in as few as 3 years from seed. This early fruiting trait is highly desirable and should be the basis of selection when identifying individuals for deployment in bottomland plantings.

There appears to be little information available documenting the heritability of precocity and acorn production in swamp white oak. In addition, we have found no information on how scion and/or rootstock source may affect precocity or productivity of grafted swamp white oak trees. For a grafting program to be successful, it is desirable that the grafted ramets exhibit similar patterns of precocity as the selected ortets and that any rootstock effects on precocity are clearly defined. 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 the magnitude of any rootstock effects 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, Missouri. Acorns were sent to the Forrest Keeling Nursery to produce both 1-0 bare-root seedlings and their patented Root Production Method (RPM) seedlings (Lovelace 1998). In spring 1997, seedlings were planted on an upland ridge with deep loess soils at the University of Missouri, Center for Agroforestry (UMCA), Horticulture and Agroforestry Research Center in Howard County, Missouri. Eight seedlings of each stock type (i.e., bare-root seedlings vs. RPM containerized seedlings) were planted in each of four single row plots within a larger study comparing growth and early fruiting of saplings for eleven hardwood species. Factorial treatments with and without drip irrigation and with and without annual fertilization using slow-release 27N-3P-6K were applied to pairs of trees of each stock type within each 16-tree row plot. Initial tree spacing was 10 ft within row and 20 ft 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 2002.

In fall 2001, acorns were collected from six precocious trees and used to grow seedlings following the RPM method (Lovelace, 1998). In this method, acorns were sown on the surface of potting medium within 15 × 15 × 4-inch deep Anderson trays, which were then stacked, placed within a closed polyethylene bag and then stratified for 3 to 4 months at 36 °F within a walk-in refrigerator. Trays were moved to a heated greenhouse in March 2002. One-flush germinates were shifted up to Anderson ($3^{5}/_{8} \times 3^{5}/_{8} \times 5$ inch) plant bands and then to 1-gal pots to produce 1-year-old, three-flush container-grown seedlings during the 2002 growing season and then overwintered outdoors under 0.25-inch 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. Whip and tongue grafts were made in the greenhouse in early spring 2003 on the 1-gal potted rootstocks produced in 2002. Successful grafts were shifted up to 3-gal pots in June 2003 and maintained in a shade house under 55% shade screen with daily overhead irrigation. A total of 127 grafts representing 8 scion × 6 rootstock combinations were planted in October 2003 on a north-facing slope at the Horticulture and Agroforestry Research Center. Grafts were randomly planted on a 12 × 15-ft spacing within a 0.5-acre 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, and the number of nuts were recorded for each graft. These data were subjected to analysis of variance for a completely randomized design. Due to unbalance, Type III sums of squares were used to determine if differences existed among scion, rootstock, and/or scion × rootstock at the 5% level. Fisher's unprotected least significant differences were calculated to separate statistically different means at the 5% levels.

RESULTS AND DISCUSSION

The RPM™ seedlings in the study established in 1997 were only slightly 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. 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 reforestration project. Although the RPM seedlings in our study maintained a slight size advantage over the bare-root seedlings, differences were not statistically significant after the second growing season. We also 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 2002 may in large part be due to two exceptionally productive trees established as bare-root seedlings (Ortet #1 and #3). Likewise, 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. If so, it may be better to vegetatively propagate these highly productive trees via grafting rather than by seed.

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

Ortet number[1]	Stock type	Fall 2002 DBH (cm)	First year for acorns	Acorn production by year				Acorns total
				1999	2000	2001	2002	
1	Bare-root	8.6	1999	10	205	158	220	593
2	RPM	6.4	1999	4	10	48	140	202
3	Bare-root	7.3	2000	0	188	181	142	511
4	Bare-root	7.4	2000	0	28	56	96	180
5	RPM	7.3	2000	0	98	91	46	235
6	Bare-root	6.8	2000	0	31	175	24	230
7	Bare-root	7.8	2000	0	59	52	116	227
8	RPM	8.2	2001	0	0	20	106	126
9	RPM	7.3	2002	0	0	0	14	14
10	RPM	6.1	>2002	0	0	0	0	0
All[2]	RPM	7.3	2002	5	650	275	695	1625
All	Bare-root	6.7	2002	9	511	896	1168	2584

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

[2] All equals the total acorns produced by all 32 trees established as either bare root or RPM seedlings.

Table 2. Stem diameter and acorn production by 4-year-old ramets grafted with scionwood of the eight ortets described in Table 1.

Ortet number[1]	Ramets (no.)	Percent bearing	Acorns per grafted ramet Average	maximum	Average DBH (cm)	Acorns/ TCSA (no./cm^2)
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] Scions were not collected from ortet #4 and 5.

Table 3. Stem diameter and acorn production averaged across eight scion sources when grafted onto half-sib seedling rootstocks derived from the ortets described in Table 1.

Ortet no.	Ramets (no.)	Percent bearing	Acorns per grafted ramet Average	maximum	Average DBH (cm)	Acorns/ TCSA (no./cm^2)
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

We found that swamp white oak can be easily grafted. We observed no evidence of any graft incompatibilities (i.e., reduced growth or stunted foliage) among the 48 scion × rootstock combinations. Survival after 3 years for grafts planted into the field exceeded 90%. Although we did not find any significant stock × scion interactions, we did find both significant scion and rootstock effects for stem diameter and for number of acorns produced per grafted tree (Tables 2 and 3).

Acorn productivity was more strongly influenced by the source of the scionwood than the rootstock 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 (Table 1). Because the grafts had slightly different growth rates, acorn production data were standardized by converting to number of acorns per cm^2 trunk cross-sectional area (TCSA). We also found that the ortet rankings for cumulative acorn production during the 4-year period from 1999 to 2002 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). There was a trend for seedlings of Ortet #5, when used as a rootstock, to exhibit reduced stem diameter growth and acorn productivity.

CONCLUSIONS

Our study demonstrated that swamp white oak can be easily 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. The nonsignificant rootstock × scion interaction for acorn production in this species will provide the flexibility to utilize a range of swamp white oak seed sources for use as rootstocks, if needed. 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 planting in landscapes which may include wildlife enhancement as a management objective.

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