ROOTING STEM CUTTINGS OF NORTHERN RED OAK (*QUERCUS RUBRA* L.) UTILIZING HEDGED STUMP SPROUTS FORMED ON RECENTLY FELLED TREES

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Abstract—The ability to root stem cuttings collected from hedged stump sprouts formed on recently felled trees was evaluated for 26 codominant northern red oak (*Quercus rubra* L.) trees growing in Durham County, NC. Sprouting occurred, the same year as felling, on 23 of the 26 tree stumps and sprout number was significantly and positively correlated with stump diameter. The following year the stump sprouts were pruned to 20 cm and allowed to produce one new flush of growth. Fourteen of the 23 tree stumps produced a suitable number of stem cuttings to be evaluated for rooting ability. Stem cuttings collected from these 14 tree stumps rooted in percentages ranging between 35 and 100 percent. Stem cuttings from 11 of the 14 tree stumps in this study rooted at 65 percent or higher. Rooting percentage was significantly and negatively correlated with tree age. In general, as tree age increased rooting percentage decreased. However, stem cuttings from six trees between the ages of 20 and 45 years rooted at 100 percent. First year overwintering survival for the newly rooted stem cuttings was 71.5 percent. At the end of the second growing season a sub-sample of the rooted cuttings had an average height of 54 cm and an average root collar diameter of 9.7 mm.

INTRODUCTION

Regenerating natural hardwood timber stands in upland regions of eastern North America with northern red oak (*Quercus rubra* L.) as a significant component, has proved challenging to foresters. Two major limitations to such regeneration efforts are the lack of advance northern red oak (NRO) regeneration in preharvested or predisturbed stands and the slow growth and high mortality rates of existing advanced NRO regeneration after canopy removal as a result of intense herbaceous and woody competition. In some cases, this regeneration dilemma has been addressed by employing artificial regeneration techniques, such as plantation systems and enrichment plantings.

Planting stock utilized in these systems is commonly obtained from bare-root nurseries growing seedlings from unimproved, bulk collected acorns. Efforts to genetically improve NRO planting stock exist, but have been limited largely due to the costs associated with relatively long periods of juvenility, episodic acorn crops, abundant acorn predators, and long-term progeny trials (Robison and others 2004). However, recent advances in the vegetative propagation of NRO by means of rooting stem cuttings may offer a viable alternative to conventional oak improvement practices by improving growth rates, consistency, and quality of artificial planting stock. In most oak rooted cutting studies, rooting juvenile stem material has provided the best results. For detailed discussion on efforts to vegetatively propagate stem cuttings of NRO, see Dreps (2007), Drew and Dirr (1989), Fishel and others (2003), Teclaw and Isebrands (1987), and Zazcek and others (2006).

In this study, we report on an effort to vegetatively propagate juvenile stem cuttings of NRO collected from stump sprouts of 14 recently felled trees ranging in age from 18 to 62 years. Though successfully accomplished by Duncan and Matthews (1969) for southern red oak (*Quercus falcata* L.) and water oak (*Quercus nigra* L.), the only reported effort to root stem cuttings collected from stump sprouts of NRO (Fishel and others 2003) was not successful. The ability to root stem cuttings of NRO stump sprouts would allow tree selection for cloning based on identification of phenotypically superior individuals.

Once selected and cloned post-rooting cultural practices aimed at optimal first year overwintering survival and second year nursery growth of the rooted cuttings are necessary. Select genotypes could be multiplied by means of serial propagation, utilizing similar techniques employed in rooting stem cuttings of oak from hedged seedlings (Dreps 2007).

METHODS

In January 2003, 26 codominant NRO trees growing in the North Carolina State University Hill Forest in central NC (Durham County) were chainsaw felled and allowed to stump sprout during the subsequent growing season. Cut trees ranged in age from 12 to 70 years and 4 to 34 cm in basal diameter. Each tree stump was encircled by wire screening to protect sprouts from browsing. In February 2003, the total number of sprouts per tree stump was counted and all sprouts were cut to 20 cm above the stump to stimulate new growth. Three trees did not produce any sprouts. On May 25, 2004, after a single, fully developed flush of new shoot growth had formed on the pruned stump sprouts, 15-cm terminal stem cuttings were collected. Only 14 of the 23 tree stumps with pruned stump sprouts produced an adequate supply of stem cuttings (> 20) during 2004 to be included in the rooting study. These 14 trees ranged in age from 18 to 62 years and had a basal diameter ranging from 10 to 34 cm.

The cuttings were prepared for rooting and stuck in rooting containers the same day as collection (May 25, 2004). The cuttings were prepared by removing the leaves and petioles from the lower half of each cutting, recut at the base, and dipped 2 cm deep into a liquid solution of 1 percent IBA (Indole-3-butyric acid)/50 percent EtOH (95 percent). After allowing the bases to dry for one minute, the cuttings were stuck 4 cm deep into rooting containers (Ray Leach SC-10 Super Cell Cone-tainers™, Stuewe and Sons, Inc. Corvallis, Oregon) filled with a moist media mixture of 3

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peat: 2 perlite: 1 vermiculite (v/v/v). Rooting occurred in a misting chamber covered with a shade cloth (55 percent of ambient light) and constructed around propagation tables in a shaded, polyethylene-covered, Quonset-styled greenhouse. Combined the greenhouse and rooting chamber provided 15 percent of ambient light within the rooting chamber. Overhead mist irrigation was provided initially to the cuttings every 12 minutes for 15 seconds for the first 50 days and then gradually tapered until day 75. Sticking techniques and rooting environment conditions for stem cuttings of northern red oak are described in greater detail in Dreps (2007).

The rooting study was a randomized complete block design with four replications of five cutting row plots per individual tree genotype (n=14). Rooting percentage was assessed after 75 days on August 7, 2005 as indicated by live tops and roots projecting from the bottom of the container or live cuttings resistant to being pulled from their containers.

Following rooting, the cuttings were acclimated to a greenhouse environment without mist. On August 21, 2004 after two weeks of acclimation, 56 of the rooted cuttings were placed outside in a shaded (70 percent of ambient light), open-air structure and hand watered every two days. In December the rooted cuttings were moved into an unheated overwintering house to protect them from winter ice and wind and hand watered twice a month until bud break the following spring.

On May 5, 2005, overwintering survival was assessed. The rooted cuttings were considered successfully overwintered if they broke bud and produced new shoot growth. On the same day, 16 successfully overwintered rooted cuttings were transplanted into 6.23 L Treepot2™ (Stuewe and Sons, Inc., Corvallis, Oregon) containers filled with composted pine bark and top dressed with 29.5 c.c. of Nutricote Total (13-13-13) slow release fertilizer (Chisso-Asahi Fertilizer Co., Tokyo, Japan). The rooted cuttings were then placed under shade (70 percent of ambient light), hand watered every two to three days, and allowed to grow for the remainder of the 2005 growing season. On November 16, 2005, shoot height and root collar diameter were measured in order to provide a morphological assessment of northern red oak rooted cutting stock quality after two years of container growth.

STATISTICAL ANALYSIS (2003-2004)

Correlation analysis of stump sprout number, rooting percentage, age, and stump diameter during the 2003 and 2004 growing seasons were performed with the correlation procedure in SAS (SAS Institute, Cary, NC). Analysis of variance (ANOVA) for rooting percentage was conducted using the general linear model procedure in SAS and included both fixed (genotype) and random (replication) factors and their interactions. When ANOVA results indicated rooting percentage differences ($p < 0.05$) among genotypes, Duncan's multiple range test was used to separate the means at $p < 0.05$.

RESULTS AND DISCUSSION

Stump Sprout Production

Twenty-three of the 26 trees felled in 2003 produced stump sprouts. Of these 23 trees, sprout number was significantly ($p=0.0035$) and positively correlated ($r=0.58$) with stump diameter. For these same trees, however, age was not significantly correlated ($p=0.2723$) with sprout production. Age is often considered a poor sprout predictor because of weak correlations with stump diameter (Wendel 1975). Similarly, in the current study stump diameter was not significantly correlated ($p=0.088$) with tree age. The 23 tree stumps evaluated in this study ranged in diameter from 4 to 34 cm, were between 12 and 62 years of age, and produced between 2 and 50 sprouts. Lynch and Bassett (1987) found that sprouting was greatest for felled NRO trees in the 12.7 to 20.3 and 22.9 to 30.5 cm diameter classes, while declining in larger diameter classes. Nine trees in our study had stump diameters smaller than these two diameter classes, 12 were within these two categories, and two had stump diameters larger than Lynch and Bassett's diameter categories. On average these three groups produced 13, 26, and 32 sprouts, respectively.

Stem Cutting Production and Rooting Percentages

The number of new shoots produced in 2004, following pruning, was not determined. However, 14 of the 23 trees with pruned stump sprouts produced more than 20 new shoots each. Rooting percentages for stem cuttings collected from these 14 trees varied significantly according to tree ($p= <0.0001$), averaging 78 percent and ranging from 35 to 100 percent. Rooting percentage was significantly ($p=0.0497$) and negatively correlated ($r = - 0.53$) with tree age, but was not significantly ($p=0.879$) correlated with stump diameter.

Several NRO studies demonstrate high rooting percentages for juvenile stem cuttings obtained from hedged seedlings (Dreps 2007, Zaczek and others 2006). Stump sprouts also represent juvenile plant material (Johnson and others 2002) and therefore, it was expected that cuttings collected from pruned stump sprouts would also root in high percentages. Eleven of the 14 trees in this study rooted at 65 percent or higher. Even though rooting was only 35 percent for one tree, this percentage may still be adequate to move the genotype into a serial propagation system. Additional research should be undertaken to determine if poor rooting stump sprouts pass on this trait during serial propagation.

The negative correlation between tree age and rooting percentage partially explained the range of rooting percentages among these 14 trees. Cuttings collected from the oldest (62 years) and youngest (18 years) two trees in this study rooted at significantly different percentages, 55 and 95 percent, respectively. Six trees, however, ranging in age from 20 to 45 years, rooted at 100 percent. Though this outcome somewhat suggests decreased rooting with advanced age, a larger sample size may provide a more accurate picture of the relationship between tree age and rooting.

Overwintering Survival and Second Year Growth

The overall survival rate for the 56 rooted cuttings placed in the overwintering house following rooting was 71.5 percent. Some researchers have suggested that forcing treatments (e.g., a period of post-rooting growth in a greenhouse under warm temperatures and extended day length) are necessary to promote high rates of overwintering survival for several woody plant species. Dirr and Heuser (1987) hypothesized that forcing treatments allow newly rooted cuttings to replenish carbohydrate reserves that may be lacking immediately following root formation. However, Dreps (2007) found no difference in first year overwintering survival between NRO rooted cuttings subjected to a 74-day forcing treatment prior to overwintering and those not receiving a forcing treatment.

Average height and root collar diameter for the 16 rooted cuttings transplanted into larger containers and grown for a second year in 2005 were 54.1 cm and 9.7 mm, respectively. Above ground, these plants were morphologically similar to well cultured 1-0 bare-root seedlings. Below ground, however, their root systems were more branched and fibrous than most NRO bare-root seedlings.

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LITERATURE CITED

Drew, J.J.; Dirr, M.A. 1989. Propagation of *Quercus* L. species by cuttings. Journal of Environmental Science. 7: 115-117.

Dirr, M.A.; Heuser, C.W., Jr. 1987. The reference manual of woody plant propagation: from seed to tissue culture. Varsity Press, Athens, GA: 239 p.

Dreps, H. 2007. Production system factors affecting rooting and subsequent performance of northern red oak (*Quercus rubra* L.) cuttings for outplanting. M.S. thesis. North Carolina State University, Raleigh, NC: 61 p.

Duncan, H.J.; Matthews, F.R. 1969. Propagation of southern red oak and water oak by rooted cutting. Res. Note SE-107. U.S. Forest Service, Southeastern Forest Experimental Station Asheville, NC: 3 p.

Fishel, D.W.; Zaczek, J.J.; Preece, J.E. 2003. Positional influence on rooting of shoots forced from the main bole of swamp white oak and northern red oak. Canadian Journal of Forest Research. 33: 705–711.

Johnson, P.S.; Shifley, S.R.; Rogers, R. 2002. The Ecology and Silviculture of Oaks. CABI Publishing, New York: 503 p.

Lynch, A.M.; Bassett, J.R. 1987. Oak stump sprouting on dry sites in northern lower Michigan. Northern Journal of Applied Forestry. 4: 142-145.

Robison, D.J.; Schuler, J.L.; Jervis, L. [and others]. 2004. Individual tree release and enrichment planting in young natural upland hardwoods. In: Connor, K. F. (ed.) Proceedings 12th biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-71. U.S. Forest Service, Southern Research Station, Asheville, NC: 283-286.

Teclaw, R.M.; Isebrands, J.G. 1987. Stage of shoot development and concentration of applied hormone affect rooting of northern red oak softwood cuttings. In: McKinley, C.R. (ed.) Proceedings of the 19th southern forest tree improvement conference. U.S. Forest Service: 101-107.

Wendel, G.W. 1975. Stump sprout growth and quality of several Appalachian hardwood species after clearcutting. Res. Pap. NE-329. U.S. Forest Service, Northeastern Forest Experiment Station, Upper Darby, PA: 9 p.

Zaczek, J.J; Steiner, K.C.; Heuser, C.W., Jr. 2006. Effects of serial grafting, ontogeny, and genotype on rooting of *Quercus rubra* cuttings. Canadian Journal of Forest Research. 36: 123-131.