ROOTING ABILITY AND VEGETATIVE GKOWTH PERFORMANCE OF STEM CUTTINGS FROM ONE- AND FIVE-YEAR-OLD ORTETS OF LOBLOLLY PINE

Michael S. Greenwood[1/] and Emily S. Nussbaum[2/]

Abstract.--Mist provided by nozzles on a gantry boom provide much more even mist than fixed nozzles, which has apparently doubled the percentage of cuttings with roots. Cuttings from 5-year-old ortets rooted significantly better than those from 1-year-old ortets, and rootability varied significantly according to the origin of the cutting in the crown. Cuttings from 1-year-old ortets have grown significantly more than those from 5-year-old ortets after 1 year in the field.

Additional key words: competition, juvenility, Pinus taeda, vegetative propagation.

The purpose of this study is to a) evaluate rooting under a new gantry system; b) compare rooting ability from ortets of loblolly pine aged 1 and 5 years; and c) compare the growth potential of cuttings from these ortets.

Greenwood et al (1980) report that amount of mist fall may explain as much as 75% of the variation observed in rooting loblolly and shortleaf pine stem cuttings. Mist systems with fixed nozzles, which provide an overlapping circular spraying pattern, are bound to provide variable mist fall. Here *we* report on results obtained with nozzles attached to a moving boom which produce a flat, fan-shaped pattern.

In addition, given the current interest (See Zobel, these Proceedings) in the possibility of mass propagation of select genetic material, we report on the rootability and early growth performance of cuttings from 1- and 5-year-old ortets. One-year-old loblolly pine trees possess a number of traits, both morphological and developmental, which appear to be lost with maturation. Among them are differences in branching and growth characteristics (Greenwood, 1980). There is also a significant decline in the ability of 4-year-old scions to elongate and an increase in ability to flower when compared with 1-year-old scions (Greenwood, 1981). Lambeth (1980) suggests that selections in loblolly pine tests can be made early as age five with relatively high efficiency in gain per year. Even if families or individual selections can be made at this early age, the consequences of possible loss of juvenile growth characteristics of vegetative propagules must be carefully considered.

1/Tree Improvement Physiologist, Weyerhaeuser Company, Southern Forestry Research Center, Hot Springs, AR 71901.

2/Graduate student, Department of Horticulture, Oregon State University, Corvallis, Oregon 97332. We would like to acknowledge the help of Tom Marino in the design of the gantry system.

Similar problems in the vegetative propagation of *Pinus radiata* have already been dealt with extensively (E.G. Sweet, 1973 and Libby, et al, 1972).

METHODS

Plant Material

Cuttings were taken from trees representing five coastal North Carolina half-sib families in two different aged plantings. The older planting was established with containerized seedlings sown on 5-7-73 in 131 ml plastic containers, which were later transplanted into 400 ml plastic cups. The medium consisted of Redi-earth® (W.R. Grace and Co., Cambridge, Mass. 02140) and the seedlings were watered weekly with 5 N Hoagland's solution. The trees were planted north of Hot Springs, Arkansas on 4-1-74, and received complete fertilization (about 200 Kg/ha) in the early spring of 1975 and 1978. During their first three years, tip moth control was applied using either Dursban®, Guthion®, or Disyston® according to the manufacturers recommendation.

The younger planting consisted of trees sown on 6-29-77 in 164 cm^3 plastic tubes, in a medium consisting of peat:vermiculite:perlite (5:5:1 by volume) containing a timed release fertilizer (Osmocote® 18-6-12 at 11.3 g per 4.5 1 of medium). The seedlings were kept in a shade house and received 5 N Hoagland's solution weekly until the end of September, 1977. In April, 1978, the seedlings were repotted into 3.8 1 pots (medium sand:vermiculite:peat moss, 2:1:1 by volume with Osmocotea® added), and placed outdoors. Disyston® (.375 g/pot) was applied to control tip moth.

Thus the older trees were between 5 and 6 years, and the younger between 1 and 2 years from seed when cuttings were taken.

Two rooting experiments were carried out, with cuttings for the first taken on 10-25-78 and the second on 3-5-79. Cuttings were taken from 3 parts of the live crown, as shown in Figures 1 and 2. Twelve trees per family were sampled as 1-year-old ortets, while 6 trees per family were sampled as 5-year-old ortets. Individual ortets identities were not maintained. A single cutting (from the main stem) was removed from each third of the crown of the 1-year-old trees while 2 cuttings were taken from each third of the 5-year-old trees. The cuttings were stored in plastic bags at 4°C for about 24 hours until they were placed in the rooting bench. Prior to sticking, the needles were removed from the base of the cuttings, the base reclipped, wetted, and dipped in 0.5 strength Hare's powder (Greenwood et al, 1980 and Hare, 1974). After trimming the needles to a length of 7-8 cm, the cuttings were stuck 6 cm apart in perlite:vermiculite (1:1 by volume). The average total length of the cuttings was 10 cm for the 5-year-old cuttings and 8 cm for the 1-year-old cuttings. A total of 360 cuttings were stuck in each experiment, with a total of 12 cuttings in each family-age-crown position combination. Each combination was represented by two 6 cutting row plots randomly located in the rooting bench.

Rooting Bench

The rooting bench consisted of a 1.8 x 1.4 x 1.2 m tubular aluminum frame covered with a clear polyvinyl tent. Uniform mist was provided by a gantry boom equipped with 6 nozzles spaced 20 cm apart (#500017, Spraying Systems Co., 4735 Sanford Street, P. O. Box 7278, Metairie, LA). The gantry boom was controlled by a timer (#7994, Veeder-Root Digital Systems Div., Hartford, Conn.) and moved at 2.7 cm/sec. The boom made 2 sweeps 4 times per hour from 7 a.m. to 4 p.m., one time per hour from 4 p.m. to 2 a.m., once per two hours from 2 a.m. to 7 a.m. Overall, the cuttings received between 0.1 and 0.2 mm of mist per hour.

Photoperiod was extended to 20 hours with incandescent lamps, providing an intensity of 2 w/m^2. Bottom heat of 29°C was provided, and an exhaust fan provided cooling when the air temperature in the bench exceeded 26°C. Carbon dioxide levels of 1500-2000 ppm were maintained by timed addition of CO_2. The delivery system was calibrated using an infra-red gas analyzer (Infra-red Industries, Inc., Box 989, Santa Barbara, CA 93102).

The cuttings were sprayed 3 times weekly with 1 N Hoagland's solution and 1 time per week with AgNO3 (250 mg/l). The silver nitrate spray inhibits algae growth. The cuttings in both experiments remained in the bench about 100 days, when all were lifted and scored for rooting.. The rooted cuttings from Experiment 1 were potted as described earlier, and kept in the greenhouse until 7-12-79, when they were moved into a shade house where they overwintered. The cuttings from Experiment 2 were potted and kept in the greenhouse until September, 1979, when they were moved into the shade house. About the same number of rooted cuttings resulted from each eXperiment and the healthiest, straightest plants from both experiments were selected for field planting. Only plants representing cuttings from the terminal shoot from 1-year-old ortets were outplanted, because cuttings not taken from the terminal shoot had several well-developed lateral branches which tended to be plagiotropic. Many cuttings from the 5-year-old ortets have continued to grow plagiotropically. The cuttings have received both weed control and complete fertilization each spring. Plants resulting from both 1- and 5-year-old cuttings from each family were outplanted near Hot Springs on 3-26-80. The planting consists of 5 replications, each containing a single cutting from each age and family. Plant height was measured and total numbers of growth cycles were counted on 3-27-80 and 3-2-81. Analysis of variance was done on rooting results after arc-sin transformation of each row plot rooting percentage. Growth data were also subjected to analysis of variance.

RESULTS

Rooting by Age and Family

Significant differences in rooting between cuttings from different ortet ages, crown position and half-sib families occurred (see Table 1). In addition, there were some significant two-way interactions. Only one higher order interaction was significant ($p<.01$), experiment x year x position, which probably reflects the variation in rooting by crown position in the two experiments for both 1-and 5-year-old ortets (see Figures 1 and 2). The combined means for Experiments 1 and 2 by half-sib family and ortet age

Table 1.--ANOVA for rooting by ortet age, crown position and half sib family

Source of Variation	DF	F	Significance
Experiment 1 vs 2	1	.007	0.935
Ortet Age	1	9.222	0.002
Crown Position	2	4.554	0.011
Family	4	8.033	0.000
Experiment x Age	1	7.336	0.007
Experiment x Position	2	3.422	0.033
Experiment x Family	4	1.539	0.189
Age x Position	2	17.568	0.000
Age x Family	4	1.559	0.183
Position x Family	8	0.899	0.517
Residual	660	0.206	

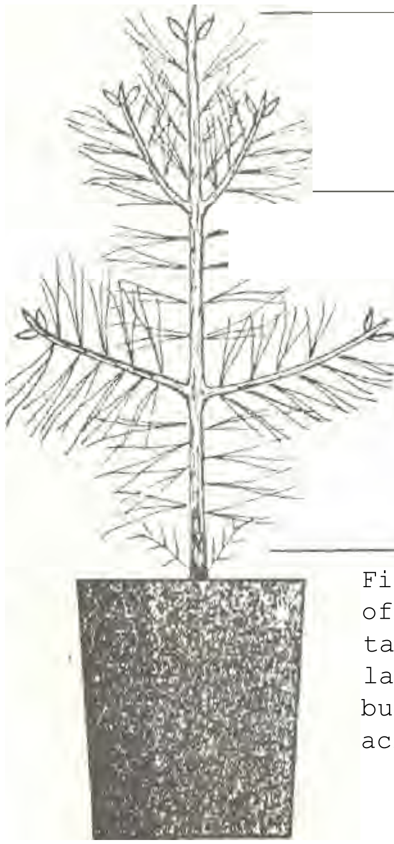
Table 2.--Rooting (%) by Family and Ortet Age. Different letters indicate significant differences at $p < .05$ (Duncan's Test). Overall means are different at $p < .05$.

	ORTET AGE	
FAMILY	1 YR	5 YR
8-59	42 a	40 b
8-86	34 a	44 b
8-66	15 b	22 c
8-76	31 a	40 b
8-01	39 a	60 a
Overall	32	41

Table 3.--Elongation growth and number of cycles produced by field planted cuttings from 1-and 5-year-old ortets in 1979 and 1980 growing seasons. Differences in height and number of cycles by ortet age are significant at $p < .05$.

	ORTET AGE			
	1 YR		5 YR	
	Height		Height	#Cycles
March 27, 1980	41.3 cm	5.4	33.6	4.8
% Change	516	540	336	480
March 2, 1981	80.7	8.0	63.4	7.0
% Change	96	49	89	46

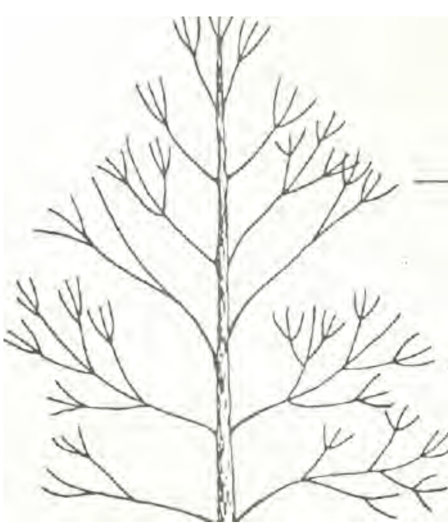
I YEAR OLD TREES



ROOTING % (n = 60)	Expt, I	Expt, 2
Upper	33 a	57 a
Middle	28a	38b
Lower	22a	I 3c

Figure 1.--Rooting (%) by cuttings from 3 parts of 1-year-old potted trees which were about .5 m tall. Each cutting included either a whorl of lateral branches or lateral buds and the terminal bud at the apical end. Results were combined across all 5 families.

5 YEAR OLD TREES



ROOTING % (n 60)	Expt, I	Expt, 2
Upper	30 b	26 b
Middle	68 a	37 b
Lower	37b	50a

Figure 2.--Rooting (%) by cuttings from 3 parts of the live crown of 5-year-old trees, which were about 5 m tall. Results were combined across all 5 families.

are shown in Table 2. Family 8-66 is a poor rooter regardless of ortet age, while Families 8-59 and 8-01 rooted relatively well. Variation due to the interaction between ortet age and family was not significant. Overall, cuttings from 5-year-old ortets rooted better ($p < .05$) than cuttings from 1-year-old ortets.

The results of rooting by crown position for both experiments are shown in Figure 1 for 1-year-old ortets and Figure 2 for 5-year-old ortets. The cuttings from the upper third of the I-year-old ortets rooted best in both experiments, but the differences were significant only in Experiment 2. In contrast, cuttings from the upper third of 5-year-old ortets rooted less well in both experiments (note significance of the age x position interaction in Table 1). In Experiment 1, cuttings from the middle third of the crown showed the best rooting, while in Experiment 2 those from the lower third rooted best, which is reflected by the significance of the position by experiment interaction (see Table 1).

Field performance of cuttings

After field planting, survival of the rooted cuttings has been greater than 90%. Height, growth and number of cycles of growth produced during the 1979 and 1980 growing seasons are shown in Table 3. Although the cuttings from the 5-year-old ortets were initially larger and on the whole rooted better than those from 1-year-old ortets, the latter grew significantly more in both growing seasons.

DISCUSSION

Rooting under the gantry system was much improved over previous results that we obtained with fixed nozzles. Overall, rooting of 21% was obtained for loblolly pine using cuttings obtained from the middle to lower part of the crown of 4-year-old trees (Greenwood et al, 1980). Under the gantry system, we obtained 48% rooting with cuttings from the middle to lower crown of 5-year-old loblolly pine (combined results for Experiments 1 and 2, see Figure 2). All cuttings received half strength Hare's powder and supplemental CO_2. Rooting frequency in different parts of the bench did not vary under the gantry system, probably because there was very little variation in mist fall. The results reported here compare favorably with those obtained by Grigsby (1961), who obtained 52% rooting of loblolly pine cuttings in his best experiment. Using similar methods, he was subsequently able to obtain only 23% rooting (Grigsby, 1971).

While the literature abounds with reports of decreased rooting with increased ortet age (E.G. Thimann and Delisle, 1939), we actually obtained better overall rooting on cuttings from 5-year-old ortets than on those from 1-year-old ortets. Grigsby (1961) also obtained better rooting on loblolly pine cuttings from 25-year-old ortets than with cuttings from 6-year-old ortets. However, if rooting is compared only between cuttings from the upper third of the crown, cuttings from 1-year-old ortets appear to root better (see Figures 1 and 2). Thus, comparisons of rooting by ortet age can be confounded by crown position. Nonetheless, rootability of loblolly pine appears to change little between ages 1 and 5.

The growth performance of the cuttings from the two ortet ages is significantly different. Even though the cuttings from the 5-year-old ortets rooted better, they have grown less than those from 1-year-old ortets (see Table 3). The differences between the two age groups developed in the first growing season when the 1-year-old cuttings grew much more, relative to the original size of the cuttings. In the second growing season, although the total increment was again greater for the 1-year-old cuttings, the percentage change in height growth and number of cycles for cuttings of both ages was about the same. We have obtained closely similar results with grafted scions taken from ortets of different ages (Greenwood, 1981). Scions from 1-year-old trees grew significantly more than those from 4-, 8-, and 12-year-old trees. The decline between ages 4 and 12 is not as great but is still significant. While the plagiotropic behavior of some of the cuttings from 5-year-old ortets may have affected their growth, no plagiotropic behavior was observed on grafted scions at any age. Franklin (1969) also reports an apparent decline in propagule growth due to increased ortet age (ranging from 10 to 30 years) for slash pine. A similar decline has been reported for _Pinus radiata_ (Libby et al, 1972, and Sweet, 1973).

RECOMMENDATION

A successful effort to vegetatively propagate loblolly pine must take into account the effect of ortet age on the growth performance of the resultant propagules. The relatively more vigorous growth of the 1-year-old cuttings probably results from the ability of young trees to grow more rapidly in their first year or two in the field. Without these growth characteristics, propagules from ortets older than 1 year will probably be at a severe disadvantage.

. Therefore, any vegetative propagation program for loblolly pine should use propagules from very young ortets as a standard for evaluation of growth performance of propagules from older ortets, or from procedures which are supposed to maintain or restore juvenile growth behavior. To my knowledge, the youngest ortet age tested in other _Pinus_ species is 4 years (Libby, _et_ al, 1972)© The use of seedlings for such comparisons is also desirable, but obtaining seedlings and cuttings of comparable size simultaneously is very difficult, and it is impossible to compensate for the effects of origin (seed vs. cutting or plantlet) on subsequent growth. Since we have observed a rapid decline in vegetative growth capability of loblolly pine between ages 1 and 4, we strongly recommend that the standard for juvenile growth characteristics of loblolly pine be propagated from material no older than one year from seed.

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