FIVE-YEAR EVALUATION OF LOBLOLLY PROGENY TESTS ESTABLISHED WITH BOTH BARE-ROOT AND CONTAINERIZED SEEDLINGS

C. R. McKinley 1/

Abstract.--Two loblolly pine (*Pinus taeda* L.) progeny tests, planted with both containerized and bare-root seedlings, were evaluated after five years in the field. Containerized seedlings were consistently smaller. Survival differences by seedling type were not apparent in either test. Family rankings across the two seedling types were generally more closely correlated for height and diameter than for volume. In one test family rankings were highly correlated for the two seedling types. In the other test, family rankings were more consistent in drought-hardy sources than in sources selected for growth rate and form. The lack of significant family rank correlations for the two seedling types in the second test raises questions regarding family selection from containerized tests. One family, in particular, showed dramatic rank changes between bare-root and containerized material.

Keywords: *Pinus taeda* L., containerized seedlings, progeny testing, family selection.

INTRODUCTION

A considerable number of genetic tests have been and are continuing to be established with greenhouse-grown containerized seedlings. The advantages of using these seedlings for genetic tests are well presented by van Buijtenen and Lowe (1981). Tests established with containerized seedlings are generally assumed to provide source or family information consistent with that obtained from tests established from bare-root seedlings. However, little information is available to verify or disprove this assumption. Studies directed at performance of containerized vs bare-root seedlings offer little guidance as conflicting results has often been reported. For example, South and Barnett (1986) showed containerized loblolly pine (*Pinus taeda* L.) seedlings were taller than bare-root seedlings after three growing seasons on a relatively dry site. However, the bare-root seedlings were taller on a moist site. Goodwin (1976) reported containerized loblolly seedlings were taller than bare-root seedlings after three years in North Carolina. Conversely, Barnett (1981) showed greater height for bare-root seedlings after three years in Louisiana when March and April plantings were evaluated. Studies involving shortleaf pine (*Pinus echinata* Mill.) have also given different results depending upon site conditions (Ruehle et al., 1981), although Brissette and Barnett (1989) recommended using containerized material for shortleaf. Containerized longleaf (*Pinus palustris* Mill.) was reported to outperform bare-root material on a dry site in North Carolina (Goodwin, 1976).

The Texas Forest Service (TFS) has been utilizing container-grown greenhouse seedlings to establish genetic field tests for a number of years. In order to further examine the question of how containerized seedlings perform relative to bare-root seedlings, two loblolly pine tests were established at separate locations using both types of material. Results after five years of field growth ares reported in this paper. The objectives of this analysis are

1/ Associate Geneticist, Texas Forest Service, Texas A&M University, College Station, Texas

to 1) determine if significant growth differences exist between the two seedling types and 2) determine if family by seedling type interaction is of large enough magnitude to merit concern in selecting families from containerized-grown tests.

METHODS

Seedling Production

Seedlings for the two field tests were grown at different times using different material. Field test #221 was sown in the greenhouse in spring 1982, with bare-root seedlings grown during the 1982 season at the TFS Indian Mound Nursery. Nine control-pollinated families from both superior and drought hardy material were evaluated. Four of the nine crosses were reciprocals. Field test #238 was sown in the greenhouse in fall, 1984, with bare-root seedlings grown during the 1984 season at the Indian Mound Nursery. A total of twelve open pollinated sources were utilized with **six** characterized as drought hardy (based on previous TFS information) and six selected for growth rate and form (obtained from Louisiana, east of the Mississippi River). Containerized seedlings were grown in 163 cu.cm. commercially-available containers with a 1:1 mixture of peat and vermiculite. Supplemental heating and lighting were provided the fall sown seedlings. Bare-root seedlings were grown according to standard TFS nursery practices. Table 1 indicates the appropriate growing regime for each of the seedling types.

Table 1. General production schedule for bare-root (nursery) and containerized (greenhouse) seedlings.

		- - - - Greenhouse - - - -	
Activity	Nursery	Spring Sown	Fall Sown
Seed Stratification	February	March	September
Sowing	April	April	October
Fertilization	May-August	May-September	November-March
Outplanting	December-April	November	April

Field Plantings

Planting #221 was established in fall, 1982, while planting #238 was established in spring, 1985. Greenhouse schedules resulted in each type of seedling being planted at different times at each site. Both tests utilized a split-plot design (Snedecor and Cochran, 1967) with seedling type (containerized or bare-root) included in the main plots and families as sub-plots. Planting #221 is located near Alto, (Cherokee County) and consists of the nine sources with three replications and **six** tree row plots. Planting #238 is located near San Augustine (San Augustine County) and consists of the twelve sources with 12 replications and six tree row plots. Both **sites are** located in East Texas with the largest nearby town being Lufkin. The Alto site is approximately 83 km. west of San Augustine. The Alto site is located on a sandy loam soil, while the San Augustine site tends more toward a clay loam.

Plantings were measured for height and diameter after five years in the field. Volume per tree was calculated using total height and diameter. Average family volume also included dead or missing trees. Number of trees living at age five provided survival information.

RESULTS

Tables 2 and 3 indicate the characteristics of the two plantings after five years. Survival was similar for the two seedling types in both plantings. However, in Planting #238, survival for drought-hardy sources was somewhat higher than for the growth rate and form (superior) sources (90 percent vs 82 percent). This difference dictated that the two groups be separated for further analysis of that planting, as growth traits (most notably, volume) are directly affected by number of living stems.

Table 2. Characteristics of plantation #221 for both bare-root and containerized seedlings after five years.

Trait	Bare-root	Containerized
Survival (%)	94.5	92.6
Height (m.)	5.26	4.32
Diameter (cm.)	7.81	6.05
Volume (cu. dm.)	8.55	4.35

Table 3. Characteristics of plantation #238 for both bare-root and containerized seedlings after five years.

	----Superior Sources----		-Drought-Hardy Sources--	
Trait	Bare-root	Containerized	Bare-root	Containerized
Survival (%)	81.3	82.8	90.5	89.0
Height (m.)	4.12	3.77	4.01	3.64
Diameter (cm.)	**5.47**	4.62	5.74	4.82
Volume (cu. dm.)	3.04	2.08	3.62	2.31

Statistical analysis (Tables 4, 5 and 6) show significant differences (prob.=.10 or less) between the two seedling types with only one exception (volume in Planting #221), with bare-root seedlings out-performing containerized trees. This result implies that growth characteristics can be expected to vary depending on whether seedlings are grown as containerized or bare-root. Family differences were also significant within each planting for the traits analyzed.

In evaluating the results of this analysis, the most critical question relates to the degree which family rankings are similar across the two seedling types. Selection of specific families in containerized tests should result in the same (or nearly so) families as those selected from bare-root tests of the same material. Since most artificial regeneration programs utilize nursery-grown seedlings, the 'correct' family ranking must be assumed to be that obtained from the bare-root tests. Containerized tests are, thus, actually utilized to predict the performance of those families if they had been grown as nursery seedlings.

Table 4. Results of split-plot analysis for five-year height, diameter and volume for plantation #221.

		----Height	- -	-----Diameter---		----Volume----	
Source	d.f.	Mean Squares	F	Mean Squares	F	Mean Squares	F
Main Plots							
Replication (R)	2	1.26	.25	5.84	.29	93.75	.56
Seedling Type (T)	1	66.58	13.53*	237.73	11.99*	1414.56	8.49
Error (RxT)	2	4.92		19.82		166.57	
Sub-Plots							
Cross (C)	8	3.54	5.21***	9.76	3.81***	49.94	2.84**
C x T	8	.21	.30	1.04	.41	11.27	.60
Error ((RxC)+(RxTxC))	32	.68		2.56		17.60	

* Indicates significance at .10 **level** of probability
** Indicates significance at .05 level of probability
*** Indicates significance at .01 level of probability

Table 5. Results of split-plot analysis for five-year height, diameter and volume of drought-hardy material in plantation #238.

		----Height	- -	- - -Diameter---		----Volume----	
Source	d.f.	Mean Squares	F	Mean Squares	F	Mean Squares	F
Main Plots							
Replication (R)	11	5.3	**4.22****	32.3	5.86**	72.1	3.76**
Seedling Type (T)	1	28.3	23.17***	163.0	29.75***	**365.2**	19.02***
Error (RxT)	11	1.2		5.5		19.2	
Sub-Plots							
Female (F)	5	1.6	3.10**	5.0	1.93*	12.4	2.09*
F x T	5	.1	.18	.62	.24	6.0	1.01
Error ((RxC)+(RxTxC))	110	.5		2.56		5.1	

* Indicates significance at .10 level of probability
** Indicates significance at .05 level of probability
*** Indicates significance at .01 level of probability

Table 6. Results of split-plot analysis for five-year height, diameter and volume of superior material in plantation #238.

		----Height	- -	- - -Diameter---		--Volume--	
Source	d.f.	Mean Squares	F	Mean Squares	F	Mean Squares	F
Main Plots							
Replication (R)	11	2.0	.65	13.8	1.23	22.8	1.07
Seedling Type (T)	1	27.0	8.79**	142.6	12.63***	198.7	9.33**
Error (RxT)	11	3.1		11.3		21.3	
Sub-Plots							
Female (F)	5	3.2	4.50***	**4.6**	1.91*	14.8	2.54**
F x T	5	1.12	1.60	5.7	2.39**	**10.7**	1.84
Error ((RxC)+(RxTxC))	110	.7		2.4		5.8	

* Indicates significance at .10 level of probability
** Indicates significance at .05 level of probability
*** Indicates significance at .01 level of probability

Table 7 shows family rank correlations (Snedecor and Cochran, 1967) for the two plantations evaluated. Plantation #221 showed a high correlation between the two seedling types for all the three traits. Plantation #238 demonstrated significantly less family rank correlation than Planting #221 for both the superior and drought-hardy material. In both plantings, family rankings were more highly correlated for height and diameter than for volume. In Planting #238, ranking between the two seedling types tended to be more closely correlated for the drought-hardy sources than for the superior sources. Height ranking had a higher correlation than either diameter or volume, but in this test, only non-significant correlations were observed, and that higher correlation may not prove useful.

Table 7. Family rank correlation between bare-root and containerized seedlings after five years.

		- - - - - - Plantation #238	- - - -
Trait	Plantation #221	Drought-Hardy Sources	Superior Sources
Height		.49	.43
Diameter	.90**	.60	.26
Volume	.77*	.43	.14

* Indicates significance at .05 level of probability
** Indicates significance at .01 level of probability

In most programs, families are selected on the basis of total volume. Thus, family ranking for volume for the two seedling types is the variable of interest. Figure 1 shows volume production for Planting #221. In this test, the better families generally performed well regardless of seedling type (as demonstrated by the family rank correlations). Separate statistical analysis indicated that significant differences occurred for volume among greenhouse-growr families (prob. = .009), but differences did not occur among nursery-growr families (prob.= .39). Therefore, family selection in this test, if based or seedlings grown in containers, would not adversely affect the amount of genetic gain which could be expected.

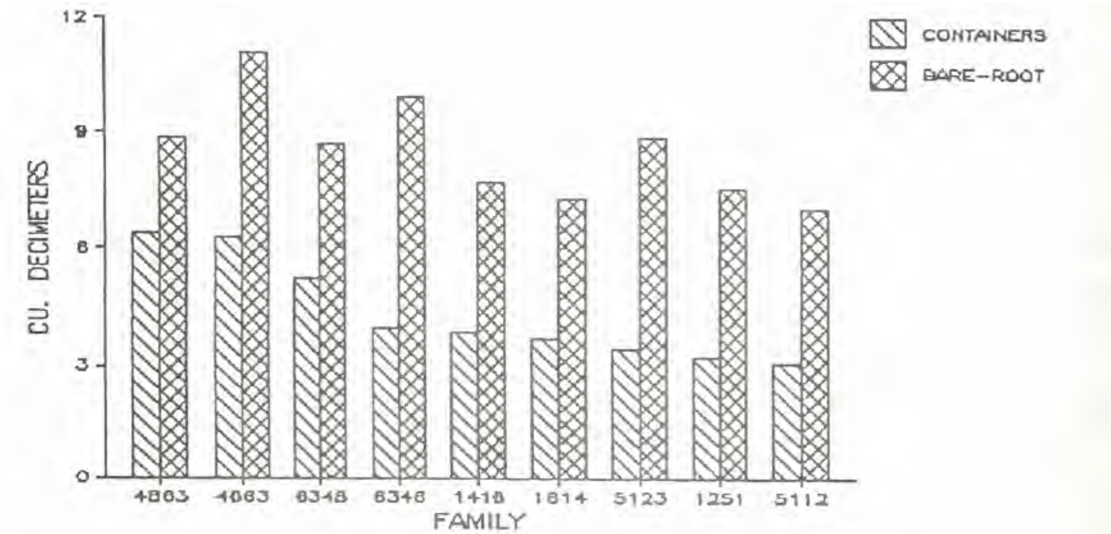

Figure 1. Five-year family volumes for containerized and bare-root seedlings for planting #221.

Planting #238 presents contrasting results relative to family selection from containerized tests, depending upon which group of families are considered (Figure 2). For the drought-hardy material, separate analysis indicated that significant volume differences occurred among families in the containerized-grown material (prob.= .005), but not among families in the nursery-grown material (prob.= .82). In the superior material, significant differences occurred among nursery grown-material (prob.= .011) but not in the containerized-grown families (prob.= .50). Selection in the drought-hardy sources would, thus, result in essentially the same scenario as presented above for Planting #221. From Figure 2, it can be observed that family 2015 (drought-hardy) ranked considerably different for the two seedling types, thus explaining a large part of the low family rank correlation for this material. Figure 2 also demonstrates why family rank correlation was low in the superior families. Source 3117 performed quite well in the bare-root part of the test but very poorly in the containerized plots. Additionally, this family was the only source shown to be significantly different from all other nursery-grown families (prob.=.05). Examination of data showed that survival for this family was the same for both greenhouse and nursery seedlings, and volume differences are consistent with both height and diameter differences.

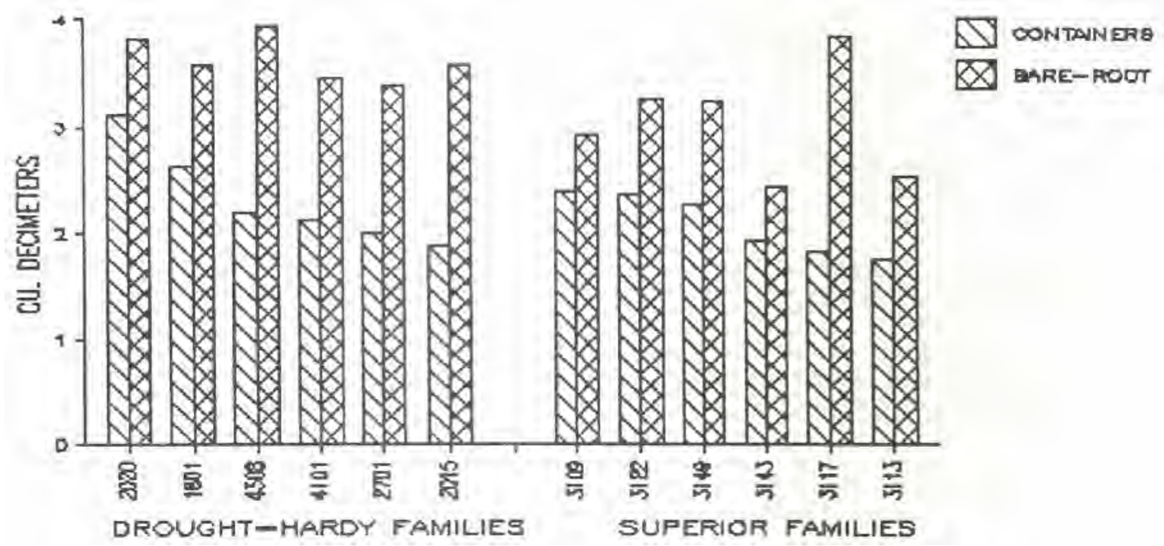

Figure 2. Five-year family volumes for containerized and bare-root seedlings for planting #238.

An argument can be made that non-significant family differences in the containerized material would preclude selection from within the superior sources, and thus differences in nursery-grown material would not result loss of genetic gain through family selection (as nursery-grown material is usually not established for progeny tests). However, the fact that one family in six performed so differently between the two seedling types should be of concern.

The data from this test is evidence that containerized-grown tests should be not be considered as totally representative of family performance regardless of seedling type. Several genetic testing procedures currently in practice, such as multiple tests in multiple locations, etc., provide some insurance against inaccurate selection. It is quite possible that additional measures (e.g. establishing tests using both seedling types) may be required to assure that family selection from genetic tests is most efficient.

CONCLUSIONS

Evaluation of five-year data of two loblolly progeny tests showed greater growth for seedlings established from bare-root material than from containerized material. Whether differences will continue to exist is not known, but based on these results, it would seem advisable to modify growth and yield information to account for differences in seedling type.

Family differences within seedling types varied from test to test and from drought-hardy to superior sources. Family rank correlations ranged from relatively high in the Alto test to quite low for superior sources in the San Augustine test. Upon examination, one superior family in the San Augustine test was observed to make significant rank changes, thus having a major effect on the overall correlations.

Results presented here do not imply that greenhouse-grown progeny tests should not be used for selection purposes. Rather, they suggest that the **possibility exists** for some loss of genetic gain if family performance is affected by seedling type, and for at least one family, that effect was demonstrated.

LITERATURE CITED

Barnett, J.P. 1981. Selecting containers for southern pine seedling production. In Proc. Southern Containerized Forest Tree Seedling conference. Savannah, GA. P. 15-24.

Brissette, J.C. and J.P. Barnett. 1989. Comparing first-year growth of bare-root and container plantings of shortleaf half-sib families. In Proc. Southern Forest Tree Improvement Conf. Charleston, SC. P. 354-361.

Goodwin, **O.C.** 1976. Summer-planted loblolly and longleaf pine tubelings outgrow 1-0 nursery seedlings in North Carolina. Journal of Forestry. 74:515-516.

Ruehle, J.L., D.H. Marx, J.P. Barnett, and W.H. Pawk. 1981. Survival and growth of container-grown and bare-root shortleaf pine seedlings with Pisolithus and Telephora ectomycorrhizae. Southern Jour. of Applied Forestry. 5:20-**24**.

Snedecor, G.W. and W.G. Cochran. 1967. Statistical Methods. Sixth Ed. The Iowa State Univ. Press. Ames, Iowa. 593 p.

South, D.B. and J.P. Barnett. 1986. Herbicides and planting date affect early performance of container-grown and bare-root loblolly pine seedlings in Alabama. New Forests. 1:17-27.

van Buijtenen, J.P., and *W.J.* Lowe. 1981. Use of containerized seedlings for progeny testing. In Proc. Southern Containerized Forest Tree Seedling conference. Savannah, GA. P. 145-148.