ALTERNATIVE DESIGNS FOR PROGENY TESTING SLASH PINE

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Abstract.--Juvenile performance of slash pine progenies in row, block, and Nelder's plots was compared. Progeny x planting density and progeny x competition level interactions were minimal in individual tests. Correlations of progeny performance across tests were positive but generally non-significant. The feasibility of close spacing, short-term assessments of progenies is uncertain

Additional keywords: *Pinus elliottii* var. *elliottii*, genetic tests, early evaluation, spacing.

Progeny tests of slash pine (*Pinus elliottii* var. *elliottii* Engelm.) have traditionally involved row plots and operational spacings. Under such conditions, reliable evaluation of slash pine parents has required 10 or more years. Progress in advanced generations is constrained by the time required to make field evaluations and selections, and numerous alternatives to long-term field testing are being explored (e.g., Waxler and van Buijtenen, 1981; Franklin, 1979; Lambeth et al., 1982). Recent field tests have provided data to critique some design alternatives for progeny evaluation.

METHODS

In 1978 and 1979, St. Regis Paper Company established 23 progenies in six tests near Cantonment, Florida (Table 1). Two 1978 plantings used nine progenies in 1) a split plot design involving two competition levels (pure = all trees of the same progeny, and maximum = each measurement tree surrounded by eight trees of the other eight progenies) in block plots at two densities (Test 8-78-1), and in 2) Nelder's plots (progenies assigned to spokes) representing 8 densities (Test 8-78-2). The 1979 plantings included as many as 23 progenies in pure vs. maximum competition block plots (Tests 8-79-3 and 8-79-4), Nelder's plots (Test 8-79-5), and 10-tree row plots (Test 8-79-6). Five- and four-year total height, DBH, rust incidence, and survival, respec-

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Table 1. Description of slash pine progeny tests included the analyses.

Test	Location in Florida/ Planting Year	Design
8-78-1	Cantonment/1978	RCB[1/], 2 reps; main plots, 1121 and 2242 trees/ha; subplots, 9 progenies; sub-sub-plots, pure and maximum competition
8-78-2	Cantonment/1978	RCB, 6 reps; 9 progenies; 8 densities from 472 to 3089 trees/ha
8-79-3	Cantonment/1979	RCB, 4 reps; 9 progenies in main plots; sub-plots, pure and maximum competition, row plots
8-79-4	Cantonment/1979	RCB, 4 reps; 9 progenies in main plots; sub-plots, pure and maximum competition
8-79-5	Cantonment/1979	RCB, 6 reps; 23 progenies; 8 densities from 472 to 3089 trees/ha
8-79-6	Cantonment/1979	RCB, 6 reps; 18 progenies in 10-tree row plots
0-58	Cantonment/1977	RCB, 3 reps; main plots, 1223 and 2446 trees/ha; subplots, 24 progenies plus check lot
0-59	Perry/1977	RCB, 3 reps; main plots, 1223 and 2446 trees/ha; sub-plots, 22 progenies plus check lot in block plots
0-60	Yulee/1977	RCB, 3 reps; main plots, 1223 and 2446 trees/ha; sub-plots, 22 progenies plus check lot in block plots
10-N	Gainesville/1980	RCB, 9 reps; 33 progenies in 7-tree spokes; 5 densities from 4300 to 43100 trees/ha
11-P	Trenton/1980	RCB, 3 reps; 14 progenies in 25-tree block plots
11-N	Trenton/1980	RCB, 8 reps; 23 progenies in 7-tree spokes; 5 densities from 4300 to 43100 trees/ha
11-S	Trenton/1980	CRD[2/], 3 reps; 3 progenies in 25-tree block blocks; 3 densities, 6667, 10000, and 20000 trees/ha

[1/] Randomized complete block design.
[2/] Completely randomized design.

tively, are reported for these studies.

Three 'wide' progeny tests established in 1977 on lands of ITT-Rayonier, buckeye Cellulose Corporation, and St. Regis consisted of up to 24 progenies,

Owe block plots at two densities. The 1980 plantings on properties of the University of Florida and ITT-Rayonier had block and Nelder plot components. In Test 11-P, progenies were planted in 25-tree block plots at 10,000 trees/ha. Three progenies were used in 25-tree block plots at three densities in Test 11-S. Nelders plots allocated as many as 33 progenies to spokes at five densities in Tests 10-N and 11-N.

Analyses of variance were performed for each study using appropriate models. Main effects and associated interactions were assessed at the 5% significance level. Clonal evaluations used for comparison with ratings derived from the above tests were based on individual tree volumes in numerous row-plot progeny tests planted at operational densities. Standardized evaluations relative to a check lot in each 5- to 10-year-old test were combined across tests to develop composite evaluations. Consistency of progeny performance across the various tests was based on correlation of progeny means (or clonal evaluations) in pairs of tests.

RESULTS AND DISCUSSION

The early growth observed in the various tests ranged from average to good (Table 2). Tests at Cantonment were located on good sites that had been used for agriculture prior to test establishment; tree size in Test 0-58, for example, was much greater than typically achieved on the flatwoods sites represented by Tests 0-59, 0-60, and 10-N. Test 11 was also situated on an above average site.

Competition among trees at the planting densities included in Tests 8-78-1, 8-79-3, 8-79-4, 8-79-6, 0-58, 0-59, and 0-60, was much less intensive than that created by the high planting densities of Tests 8-78-2, 8-79-5, 10-N, 11-P, 11-N, and ll-S at these young ages. The higher densities in Tests 8-78-1 and 0-58 were just beginning to have significant effects on tree DBH and/or plot volume at age 5. The extremely high densities in Tests 10-N, 11-N, and 11-S influenced tree height and/or DBH by age 3.

Progeny variation was observed in many tests but was somewhat determined by prior selection of progenies for the tests. The nine progenies in Tests 8-78-1 and 8-78-2 were a randomly chosen group of relatively untested clones, and their range in growth potential was evident as significant differentials in Test 8-78-1. Progenies in the other tests were representative of good performing clones typically growing 8 to 48% better than unimproved trees. Tests, such as 8-79-5, 8-79-6, 0-58, 10-N, and 11-N, including a large number of progenies had significant progeny differences.

Progeny x density and progeny x competition interactions, in terms of individual tree size, were remarkably minimal within tests (Table 3), despite varying progeny groups and competition levels. For example, in Test 8-78-1, progenies which grew best at 1121 trees/ha also tended to grow best at 2242 trees/ha. Only DBH of the 23 progenies in Test 8-79-5 was non-uniformly

Table 2.--Summary of growth in the slash pine tests analyzed.

Test	Age (yrs)	Height (m)	DBH (cm)	Rust (%)	Survival (%)
8-78-1	5	4.15	5.97	33.3	86.7
8-78-2	5	3.90	5.66	20.9	92.7
8-79-3	4	3.55	4.78	-	-
8-79-4	4	3.62	5.00	28.6	93.6
8-79-5	4	3.34	4.67	25.6	94.5
8-79-6	4	3.71	5.33	26.6	88.7
0-58	5	4.55	7.15	-	88.4
0-59	5	3.31	4.97	-	92.6
0-60	5	3.37	4.95	-	86.9
10-N	3	1.80	1.71	-	-
11-P	3	2.83	3.31	-	96.7
11-N	3	2.67	2.85	-	-
11-S	3	2.93	3.69	-	98.9

affected by eight planting densities. Otherwise, progenies responded similarly to 1) intergenotypic mixes of pure (half-sib neighbors) and maximum interprogeny competition such as would be found in non-contiguous plots, and 2) planting densities that bracket the usual range for pulpwood plantations (Tests 8-78-1, 0-58, 0-59, and 0-60), extend typical commercial densities (Test 8-78-2), or utilize very close spacings (Tests 10-N, 11-N, and 11-S).

Across tests that shared the same progenies but had different designs, progeny performance was statistically consistent in only one case (Table 4). Eighteen progenies in the 10-tree row plots of Test 8-79-6 (planting density of 1345 trees/ha) performed similarly in the 8-tree row plots (encompassing planting densities from 472 to 3089 trees/ha) of Test 8-79-5. Progeny stability over competition level and planting density (8-78-1 vs. 8-78-2, 8-79-3 vs. 8-79-5, 8-79-4 vs. 8-79-5), block plots and row plots (8-79-3 vs. 8-79-6, 8-79-4 vs. 8-79-6), and block plots and planting density (11-P vs. 11-N, 11-P vs. 11-S, 11-N vs. 11-S) was not indicated statistically, perhaps due to the uniformity and limited number of progenies involved.

Progeny performance in only one of the 13 tests examined was related significantly to clonal evaluations based on routine progeny tests (Table 5), as nineteen progenies in the block plots of Test 0-58 were similar to their row-plot evaluations. The inconsistency of the correlations in the other tests may reflect the variation frequently observed in progeny performance in single tests. For example, 10 of the 13 progenies common to Tests 0-58, 0-59, and 0-60, surpassed the standard check lot in at least two of the tests (Goddard et al., 1982), in accordance with their row-plot evaluations. The use of height as the progeny characteristic in most of these tests may also have contributed to low correlations with clonal volumes, although the volumes of progenies in Tests 0-59 and 0-60 were poorly related to clonal

Table 3.--Significance of progeny x density and progeny x competition interactions within 13 tests.

Test	Factor	Height	DBH
8-78-1	1121 vs. 2242 trees/ha	NS	NS
	Pure vs. Maximum Competition	NS	NS
8-78-2	8 Densities from 472 to 3089 trees/ha	NS	NS
8-79-3	Pure vs. Maximum Competition	NS	NS
8-79-4	Pure vs. Maximum Competition	NS	NS
8-79-5	8 Densities from 472 to 3089 trees/ha	NS	*
8-79-6	None	-	-
0-58	1223 vs. 2446 trees/ha	NS	NS
0-59	1223 vs. 2446 trees/ha	NS	NS
0-60	1223 vs. 2446 tres/ha	NS	NS
10-N	5 Densities from 4300 to 43100 trees/ha	NS	NS
11-P	None	-	-
11-N	5 Densities from 4300 to 43100 trees/ha	NS	NS
11-S	6667, 10000, and 20000 trees/ha	NS	NS

NS and * = Nonsignificant and significant at the 5% level, respectively.

Table 4.--Correlations (r) of slash pine progeny means for height across tests having different design factors but sharing common progenies.

Test Comparisons	No. of Progenies	r	Range of Progeny Means 1st Test	Range of Progeny Means 2nd Test
			----------(m)	---------
8-78-1 vs. 8-78-2	9	.402	3.98-4.52	3.46-4.08
8-79-3 vs. 8-79-5	9	.614	3.18-3.83	3.02-3.71
8-79-3 vs. 8-79-6	9	.597	3.18-3.83	3.30-3.90
8-79-4 vs. 8-79-5	9	.456	3.40-3.80	2.96-3.65
8-79-4 vs. 8-79-6	9	.424	3.40-3.80	3.30-4.11
8-79-5 vs. 8-79-6	18	.648*	2.96-3.71	3.30-4.11
11-P vs. 11-N	13	.378	2.65-2.99	2.53-2.95
11-P vs. 11-S	3	.995	2.78-2.97	2.35-3.02
11-N vs. 11-S	3	.669	2.75-2.91	2.35-3.02

*= Significant at the 5% level.

Table 5.--Correlations (r) of slash pine progeny means for height in various progeny tests with composite clonal evaluations.

Test	No. of Progenies	r	Test	No. of Progenies	r
8-78-1	8	.397	0-58[1/]	19	.486*
8-78-2	8	.369	0-59[1/]	19	-.120
			0-60[1/]	17	.132
8-79-3	9	-.204			
8-79-4	9	-.359	10-N	32	-.016
8-79-5	23	-.249	11-N	24	.224
8-79-6	18	-.142	11-P	17	.055
			11-S	3	.914

[1/] Progeny means were for individual tree volume
* = Significant at the 5% level.

evaluations. Another explanation may be the relatively young ages (i.e., small tree sizes) of many of the tests involving somewhat conventional planting densities. Juvenility may not be a sufficient explanation, however, for the correlations observed for the high density plantings, namely Tests 10-N, 11-N, and 11-P.

CONCLUSIONS

Results to date suggest that slash pine progenies, especially those selected by traditional progeny tests, have low degrees of progeny x competition level and progeny x planting density interactions within a designed test, unlike the observation of Stoneypher and McCullough (1981) of family x density interaction in Douglas fir. Consistency of progeny performance across different testing regimes (block plots, row plots, and competition levels) in different tests has not been sufficiently demonstrated. Juvenile growth of the progenies observed in these tests does not correspond closely enough with conventional clonal evaluations to advocate these alternative procedures. Closely-spaced, short-rotation evaluation systems, as observed by Franklin and Squillace (1973) and advocated by Franklin (1979), require further study.

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