Initial Results of Slash Pine Progeny Tests Replicated in Time and Space

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Progeny tests are essential features of the southern pine improvement programs currently in progress. Most of the parent trees used in the programs were selected in wild stands. As discussed in detail by Squillace[2] these selections were made on phenotypic appearance with little knowledge of the breeding value of trees chosen. Such information as was available on genetic variances was obtained from planted tests under environmental conditions having little similarity to those in natural stands. Selections were made on the basis of educated guesses as to their desirability for inclusion in an orchard. Final decisions concerning the validity of each selection must rest upon the value of progenies produced.

The objective of progeny testing is quite simple. Tests should be designed to show the breeding value of the various selections used in an orchard program. That is, tests should demonstrate the extent that the desirable characteristics of the parent trees are passed on to their offspring. With the arrangement of clones in our current orchards, genetic improvement depends on additive genetic variance and the ability of selections to combine well with numerous other selections. Clones are scattered more or less randomly over an orchard; thus the crossing of any two specific clones which combine to produce exceptionally fine offspring can be expected to occur only occasionally and can have but little impact on the mean performance of orchard progeny. On the other hand, use of clones in an orchard that produce outstanding progenies almost regardless of pollen parent will mean substantial improvement in genetic quality. Progeny tests will supp l y information needed to rogue orchards or establish new ones without the guesswork unavoidable when.. current programs were initiated.

For very accurate determination of breeding values, too many progenies can hardly be established and observed. However, progeny testing is expensive and involves much meticulous work and careful observation. From a practical standpoint, testing beyond the point of reasonably accurate estimates of the breeding value of the various selected parents cannot be justified. As results come in from early tests, they will establish a basis for compromise between the requirement for accurate evaluation and the expense of testing.

DESCRIPTION OF TESTS

To aid cooperators in the University of Florida forest tree improvement program, progeny testing guidelines were drawn several years ago. As is so often the case, no fully proven procedures were established and methods were needed which appeared to fit the existing circumstances. Orchards were beginning to produce cones but some trees produced cones sooner and in much greater quantity than others. Also, most cooperators had 75 or more selected clones and simultaneous testing of such large numbers of lines would be quite unwieldy, even if progenies were available from all of them. Delay until all clones became productive was not warranted; for progeny tests would not be started yet if we had waited. Thus, a testing plan was needed to utilize seed as it became available and avoid excessive testing of the early and highly productive clones.

The plan provided for the inclusion of progeny of each clone in a minimum of three tests. Tests were to be established on contrasting sites and during more than one establishment year. The plan suggested, for example, the initiation of two tests in one year on different sites and planting a third test a year or more later. No two tests needed, necessarily, to include exactly the same set of

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clonal progenies.

Provision was made for use of any one of three types of progenies — open-pollination in the seed orchard, poly-mix, or controlled crosses using tester pollens. For open-pollinated and poly-mix progenies, ten randomized blocks of 10-tree row-plots were suggested. Following this procedure, 100 seedlings of a clone would be established per test, and a minimum of 300 seedlings in combined tests for the evaluation of a clone.

The Florida progeny testing plan proposed the repetition of at least two check sources in each test. Seed for one check lot, used by all cooperators in the Florida program, was from a seed production area in Long County, Georgia, established by Continental Can Company. In addition, it was suggested that each cooperator draw sufficient seed from their current nursery supply for repeated use as a second check lot. Each check lot was established in at least two plots in each block of each test.

Tentatively scheduled were measurements at one, three, five, ten and fifteen years of age. Most tests were recently established and only a few are over two years old. Among the older tests are those established by Brunswick Pulp and Paper Company.

The progeny testing plan adopted by the Brunswick Pulp and Paper Company was reasonably close to the suggested outline. Open-pollinated progenies of individual clones in the company slash pine orchard were used for test establishment. In 1963, two sites were planted with ten blocks at each site. In 1964 and subsequent years, two sites were planted with only five blocks per site with the provision that test establishment would be continued until progeny of each clone had been planted three years. Thus, each progeny lot would appear in two 5-block tests per year for three years — 6 tests for each lot. This variation of the general plan provided a broader sampling of sites than the original proposal but established essentially the same number of seedlings for the evaluation of individual clones.

In addition to the uniform check lot used by all cooperators and the check lot drawn from seed used in the company nursery, since 1964 a third check lot, seed from a company seed production area, were included in all tests.

Data on certain progenies in Brunswick Pulp and Paper Company Tests 3, 4, 6, 7, 8, 9, 10, 11, established 1963 through 1966, are discussed in this paper. The discussion is limited to growth as indicated by total seedling height one and three years after field planting. Although a number of progeny lots were included in each of the several tests, only six were common to all four tests established in 1963 and 1964 for which third year measurements were available. In the six tests established 1964 through 1966, there were 24 lots common to all tests. For these lots data were available on height after one growing season in the field.

All tests were established on previously wooded sites. The normal site preparation procedures of Brunswick Pulp and Paper Company were followed. After the stands were harvested, remaining trees were removed with K-G blades and the sites were raked, harrowed, and bedded.

The sites were typical of the lower coastal plains in southeastern Georgia. Soil site estimates, soil profile description, and drainage classes at each

TABLE 1. DESCRIPTION OF TEST SITES

Test	Year Planted	Soil site index at age 25	Drainage Class	Soil Description
3	1963	60	Well drained	Sand over sandy clay at 4 to 5 feet
4	1963	65	Moderately well drained	Sand over sandy clay at 2½ to 3 feet
6	1964	65	Well drained	Loamy sand over sandy loam at 4 to 5 feet
7	1964	60	Moderately well drained	Sand over loamy sand with cemented hardpan at 18 inches
8	1965	70	Imperfectly drained	Loamy sand over sandy clay at 5 to 6 feet
9	1965	70	Imperfectly drained	Sand over loamy sand with 2 uncemented hardpans-one at 12 inches and one at 5 feet
10	1966	65	Imperfectly drained	Sand over loamy sand with uncemented pan at 18 inches
11	1966	65	Moderately well drained	Loamy sand over sandy clay at 4 feet

DATA ANALYSIS

Analytical procedures planned for these and other tests were analysis of variance coupled with a multiple range test to distinguish progenies performing significantly better than check lots. Each test is a complete experiment and will stand alone. Also, lots common to two or more tests can be included in combined analyses. A combined analysis is illustrated in (Table 2) concerned with first year heights of 24 lots which were established in six separate tests. every test. Additional check plots were included in several tests to square off the blocks. These check lots serve as a common yardstick for the evaluation of clonal progenies only if they have sufficiently broad genetic adaptation not to interact widely with the various environmental conditions. Plots of a check, within a block will vary due to within block differences, lack of genetic identity of seedlings in the several plots and other chance circumstances. If the check plots validly indicate random variables, the variance of check lots provides the best mate of experimental error for general conclusions. The block-lot interactions, commonly used as an error term, supply inferences more specific to the test site, and the variance of trees within plots is cumbersome and probably overly sensitive. As employed in these tests, check plots serve the dual purpose of estimating experimental error and of providing a basis for determination of the relative desirability of select lots.

TABLE 2. ANALYSIS OF VARIANCE OF FIRST YEAR HEIGHTS

	Degrees of Freedom	Sum of Squares	Mean Square
Progeny lots	23	3.0762	0.1337**
Environments	5	66.0564	13.2112**
Sites planted 1964	1	11.2200	11.2200**
Sites planted 1965	1	13.2605	13.2605**
Sites planted 1966	1	8.4429	8.4429**
Years and Sites	2	33.1331	16.5665**
Interaction (L x E)	115	9.2686	0.0805**
L x 1964 sites	23	0.8585	0.0373
L x 1965 sites	23	3.5325	0.1535**
L x 1966 sites	23	0.3753	0.0163
L x sites and years	46	4.5023	0.0978**
Variance of checks (error)	310	9.2702	0.0299

** Significant at the 1% level.

In combined tests with common progeny lots, it is possible to partition the environmental variance. This is not a major objective of progeny testing, for the purpose is testing lots, not planting sites. However, by looking at environmental variation, improved testing procedures may be indicated.

Very pertinent to progeny testing is the interaction between progeny lots and the various environmental conditions. Preferable at the present stage f development would be lots which are superior in all test environments rather than those which respond well under some conditions but not under others. Effective progeny testing must point out such possible interactions.

Of special note is the error term used in testing for significant differences in the analysis of variance and in multiple range tests. At least two plots of each check lot

RESULTS AND CONCLUSIONS

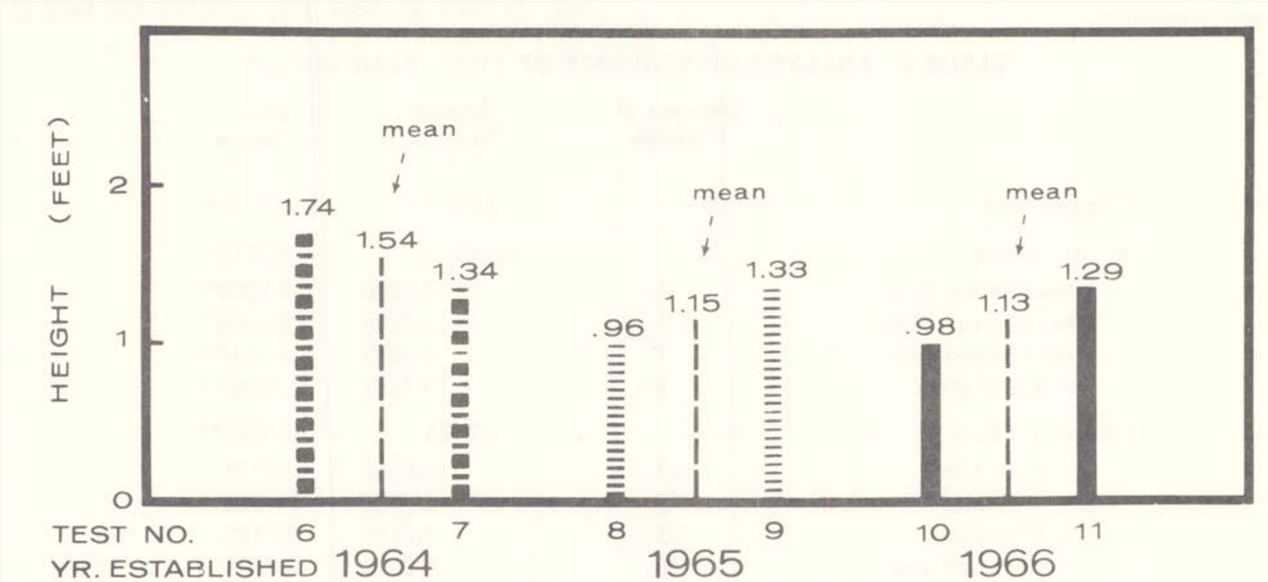
As only the Brunswick Pulp and Paper Company is directly concerned with the individual lot_ differences in these tests, it is sufficient to indicate that significant differences among lots were apparent in both one year and three year heights. Progenies of about one-half of the select trees were rather consistently superior in height to the average of the check lots.

The ranges in mean height were not large — 0.20 feet at one year and 0.66 feet at three years. The differences have little economic significance ex- cept as indices of possible future behavior.

The height growth indicated that the total environments tested were quite different (see Figure 1). The best first year growth was obtained in test 6 and first year growth was greater on both sites

only six lots involved. Height growth was not significantly different on sites planted in 1963 (Table 3). Growth was significantly different on sites planted in 1964 and the combined effect of establishment year and site was very highly significant. It must be remembered that trees in these tests were growing in 1964 and 1965. Therefore, the two sites planted in 1964 were inferior to those planted

Mean height at one year of 24 progeny lots established in 6 tests.



planted in 1964 than it was on sites planted in 1965 and 1966. In these tests, the effects of site and of year of establishment are confounded. It is impossible to tell whether the better growth in 1964 should be attributed to superior weather conditions that year or, possibly, to the better growth conditions on the sites on which the tests were established. Probably, it was the combined effect of both factors. Similarly, differences noted in average growth between tests established the same year may be, in part, influenced by variation in local weather conditions. It may be noted that neither first nor third year heights were related to the several site evaluation factors except, possibly, drainage class. It is of possible significance that approximately half of the sum of squares for environments (Table 2) was contributed by the combined effects of sites and year of establishment, suggesting a possible strong influence of establishment season on first year growth.

Third year data were much more limited with

in 1963 for seedling growth (see Table 4), the effects of weather conditions during the establishment year carried over into subsequent years, or local weather conditions at the individual test sites were strongly affecting growth. Again, the apparent results were probably influenced by a combination of factors.

The manner in which the various progeny lots reacted to these environmental differences is of particular interest and special importance. These reactions or lack of reactions will have a deciding influence on the make-up of second or third generation seed orchards. In tests 6 through 11, the interaction of 24 lots with 6 environments in first year height was highly significant (Table 2). The largest portion of the interaction sum of squares was contributed by the confounded effect of sites and establishment years. Figures 2-4 illustrate the interactions observed. Note particularly the shifts in relative heights of lots between the two 1965 tests.

TABLE 3. ANALYSIS OF VARIANCE OF THIRD YEAR HEIGHTS

	Degrees of Freedom	Sum of Squares	Mean Square
Progeny Lots	5	11.1609	2.2321**
Environments	3	226.9241	75.6413**
Sites planted 1963	1	1.1628	1.1628
Sites planted 1964	1	19.4168	19.4168**
Years and sites	1	206.3445	206.3445**
Interaction (L *x* E)	15	1.6161	0.1077
Blocks	26	100.3524	3.8597
Lots X Blocks	130	50.9300	0.3917
Variance of checks (Error)	78	31.9682	0.4098

In contrast to the vagaries of relative ranking of height growth after one year, the interaction of the six lots for which third year height data were available with sites was not significant. As indicated in Table 4, lots 4 and 5 had the greatest height and lot 12 had the least height at each location. Approximately the same conclusions could be drawn concerning the relative value of the lots involved from each individual test as from the combined analysis.

These data are insufficient for firm recommendations, but, if established tests continue to show a decline in the interaction between lot and environment with increasing age, some changes in test procedures may be warranted. First year data are of little significance except for possible differences in rates of survival and of disease. Unless first year height measurements predict future growth potential, the expense of recording and analysis of data at this stage is not justified.

The sites on which these tests were established were by no means identical. Yet they represent a relatively narrow range of site qualities (60 to 70 at age 25). The admittedly shaky evidence presented here suggests that environmental differences were too small to differentially affect growth of the various progenies after one year. Repeated testing, even in different years, on similar sites would appear to increase the accuracy of evaluation of parental clones only slightly. Assuming that other tests will substantiate this conclusion, no more than two well designed tests established on

TABLE 4. MEAN HEIGHT IN FEET AND RELATIVE RANKING OF 6 PROGENY LOTS AFTER 3 YEARS IN 4 TESTS.

Progeny Lot	Test 3 Mean	Test 3 Rank	Test 4 Mean	Test 4 Rank	Test 6 Mean	Test 6 Rank	Test 7 Mean	Test 7 Rank	Combined Mean	Tests Rank
4	6.70	2	6.78	1	5.37	1	4.26	2	5.78	2
5	6.77	1	6.60	2	5.31	2	4.53	**1**	5.80	1
6	6.46	4	6.33	4	4.59	5	4.06	4	5.36	5
12	6.35	6	5.87	6	4.50	6	3.86	6	5.14	6
13	6.58	3	6.24	5	5.41	3	4.22	3	5.61	3
14	6.38	5	6.39	3	5.05	4	4.16	5	5.50	4
Mean	6.53		6.36		5.08		4.13			

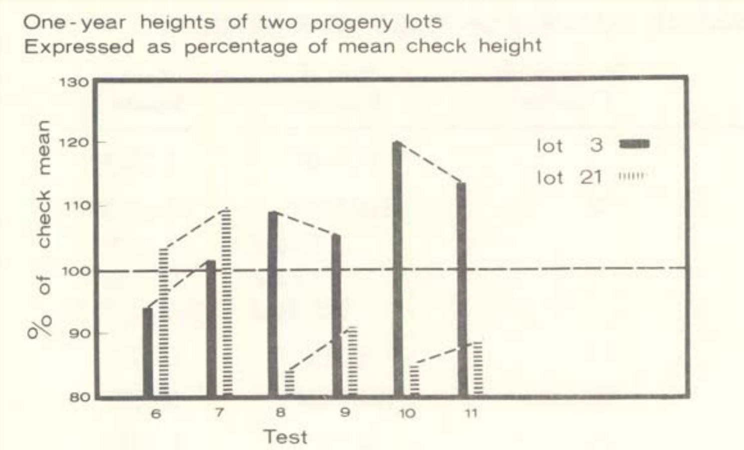


FIGURE 2

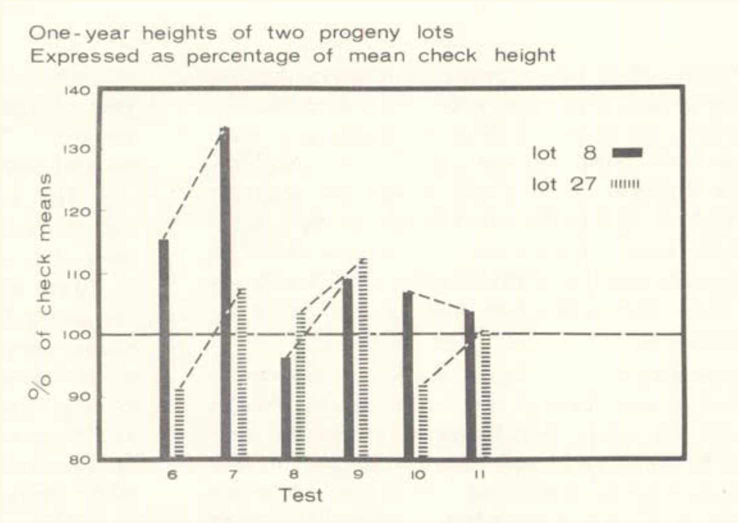


FIGURE 3

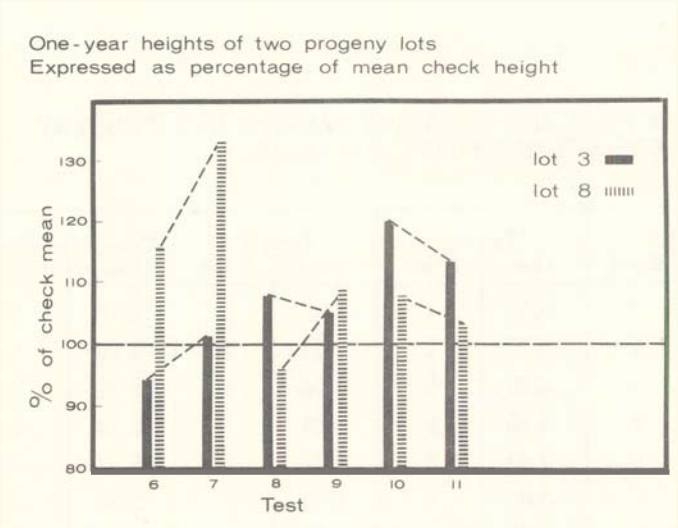


FIGURE 4

sites typical of those of most common occurrence in an area should be sufficient to evaluate the improvement potential of seed orchard clones for planting average sites. For indications of variaation in adaptibility to environmental conditions, it will probably be necessary to establish tests over a greater geographic range on sites of more diversity than those employed in these tests.

SUMMARY

Height measurements one and three years after establishment were analyzed for eight slash pine progeny tests established on different sites from 1963 to 1966.

Growth at both ages was significantly different on the various test sites. One year after establishment, the interaction of progeny lots and environments was highly significant. Results suggest a variable response to seasonal weather conditions 'and to site factors in early growth.

The progeny lot and environment interaction was not significant for height at three years. Possibly, more diverse sites should be tested to determine variation in response.