

POND X LOBLOLLY HYBRID TEST

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Abstract.--In 1967 controlled pollinations were made with pollen from two loblolly clones on four pond pine clones in the Westvaco Dare County seed orchard. One pond pine failed to set any cones; the other three clones averaged 67 percent cones from strobili pollinated. Seeds per cone averaged 56. Seventy-three percent of seeds sown in the nursery developed plantable 1-0 seedlings. Hybrid height exceeded progeny of the parents in the nursery and has continued in some lines to be equal or better than loblolly through field age 5. Winter coloration in the nursery resembled pond pine. Five replicated tests were planted in 1970 in the South Carolina Coastal Plain and Sandhills, and in west Tennessee and Kentucky. Survival is as good as in the parent lines. Fusiform rust incidence and tip moth damage are intermediate between the parent lines.

Additional keywords: *Pinus serotina*, *Pinus taeda*, controlled pollination, tip moth, fusiform rust

INTRODUCTION

Pond pine (*Pinus serotina* Michx.) and loblolly pine (*Pinus taeda* L.) are viewed taxonomically as members of the *Australes* subsection of the genus *Pinus* (Critchfield & Little 1966). The two species are sympatric through most of the pond pine range, but they apparently maintain their identity by differing flower phenology, the last loblolly pollen usually having flown two to three weeks before the first pond pine strobili are receptive. However, under these circumstances it is not surprising that they will hybridize, and, in fact, both natural and artificial hybrids have been described.

Schmitt (1968) reported two surviving pond x loblolly hybrids in the Harrison Experimental Forest from crosses made by the Southern Forest Experiment Station in the late 1950's.

At this same time Westvaco control-pollinated pond pine with loblolly pollen to produce the hybrid. Several plantings were established at their Experimental Forest in South Carolina and in Dare County, North Carolina. By age 9 hybrid height in South Carolina averaged 32 feet tall, only 3 feet below loblolly included in the test. These plantings further served as a basis for the development of a hybrid index by Ke Won Kang at North Carolina State University. Against this index he identified several natural pond x loblolly hybrids and progeny from hybrid backcrosses to loblolly in eastern North Carolina (Kang 1966).

Natural hybrids and intergrades were recognized in Maryland and Delaware (Little, Little & Doolittle 1967).

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From these initial observations and pollinations it was apparent, first, that the pond x loblolly hybrid could be expected to occur if loblolly pollen were available for pond pine strobili; and second, that most features of the hybrid would be intermediate between the two parent species.

The study reported here was conducted to learn whether the pond x loblolly hybrid produced from parent trees that were selected for their desirable traits would develop into high quality trees themselves that might provide an improved tree for pond pine sites.

HYBRIDIZATION

Westvaco established a seed orchard in Dare County, North Carolina, one part composed of loblolly pine selections from deep organic soils, the other part composed of pond pine selections, all from Dare and Tyrrell Counties. In 1967 controlled pollinations were made with fresh pollen from two loblolly clones applied to each of four pond pine clones. Loblolly clones 11-544 and 11-551 were selected as the pollen source because they were the last two to shed pollen in that orchard and thus were the most likely to generate hybrids during a late spring. Three of the pond pine clones, 11-533, 11-546, and 11-550 were selected for hybrid pollinations because from 1/3 to 1/2 of previous controlled pollinations for the pond pine progeny testing had developed to cones, a cone yield above average performance there. These three clones were among the earliest in flower emergence in the orchard, usually becoming receptive about two weeks after the last loblolly pollen had flown. One other pond pine clone, 11-538, was selected for hybridization on the basis of the excellent form of its ramets, even though controlled pollination success on it had been below average.

Through the remainder of this report the 11- prefix which serves as a company identification in the N. C. State Coop. will be omitted.

Among the eight possible hybrid crosses from 17 to 29 strobili were pollinated in each cross. All 17 of the 538 x 544 cross and all 22 of the 538 x 551 cross failed to develop as far as yearling conelets, thus, the hybrid test proceeded with six hybrid crosses. Pollination success expressed as the percent of control-pollinated strobili that developed into cones that were collected ranged from 47 percent to 95 percent, averaging 67 percent (Table 1). Seeds were extracted by the N. C. State Coop. and a count of total seeds per cross provided. No record was made of the percent of the seeds that were sound. Total seeds extracted per cone averaged 56, ranging by cross from 42 to 75 (Table 1.). No strong clonal effects were evident beyond the failure of 538 to set any cones.

SEEDLING PRODUCTION

Seeds of each of the six crosses were sown in the Claridge Nursery, Goldsboro, North Carolina in 1969. Germination percent was not determined, however, the total number of hybrid seedlings that were planted in test plantings is recorded. Overall, 73 percent of the seeds sown yielded a total of 1283 plantable hybrid seedlings. Again there were no strong clonal effects (Table 1.).

Table 1. -- Pond x loblolly hybrid seed and seedling yields.

Cone yield: cones collected/strobili pollinated

	Pond 533	Pond 546	Pond 550	Loblolly averages
Loblolly 544	17/18, 95%	13/28, 47%	18/24, 75%	48/70, 69%
Loblolly 551	10/17, 59%	16/29, 55%	19/23, 83%	45/69, 65%
Pond Averages	27/35, 77%	29/57, 51%	37/47, 79%	93/139, 67%

Seeds per cone: seeds extracted/number of cones

	Pond 533	Pond 546	Pond 550	Loblolly averages
Loblolly 544	63	75	57	65
Loblolly 551	46	42	56	48
Pond averages	55	59	57	57

Seedling yield: seedlings planted/seeds sown at nursery

	Pond 533	Pond 546	Pond 550	Loblolly averages
Loblolly 544	83%	78%	59%	73%
Loblolly 551	77%	67%	75%	73%
Pond averages	80%	73%	67%	73%

In addition to the six hybrid lines open pollinated progeny from the three pond and two loblolly parent clones, and from one mixture of two other loblolly clones that flowered late enough to have probably been predominantly pollinated by the two loblolly parent clones of the hybrid, were raised. In July, at seedling age 7 to 8 weeks, the hybrids were obviously twice as tall, 4 to 6 inches at that time, as seedlings in any of the parent lots. Height superiority of the hybrids persisted through the first year in the nursery producing 1-0 seedlings 12 to 18 inches tall for planting in spring 1970.

Winter coloration of the hybrids remained green in the nursery like the yellow-green color of pond pine and in contrast to the purple acquired by the loblolly lots. This qualitative color characteristic might be helpful in nursery bed selection of hybrids if they could be produced by mass pollination of the reciprocal cross using stored pond pine pollen.

TEST ESTABLISHMENT

The complete test includes six hybrid lots, three loblolly lots, and three pond pine lots. Using the 10-tree row-plot design, one 6 replication main test was planted on an organic bay soil in the South Carolina Coastal Plain. A 3-replication supplemental test was planted on deep sand in the South Carolina Sandhills, substituting a commercial South Carolina Piedmont loblolly plot for the progeny of loblolly 544. Another 3-replication supplemental test was planted on an upland stony silt loam pasture in west Kentucky, substituting a commercial north Mississippi loblolly plot for the progeny of loblolly 544. Surplus seedlings were arranged in two test designs using 25-tree square plots. One 4-replication test on an upland silt loam pasture in west Kentucky includes four hybrid lines, some of the parent pond and loblolly lots, and commercial north **Mississippi** loblolly. The other test on a sandy loam old cotton field in west Tennessee contains 6 replications balanced to consist each of pond x 544, pond x 551, and north **Mississippi** commercial loblolly.

Survival of the pond x loblolly hybrids is as good as survival of the parent lots. Survival in the main test in the South Carolina Coastal Plain, in the supplemental test in Kentucky, and in the surplus planting in Tennessee averaged 98 to 99 percent. Survival of the hybrids in the surplus planting in Kentucky averaged 85 percent, somewhat better than the 78 and 71 percents of the pond and loblolly parent lots, but not quite equal to the 89 percent of the commercial loblolly. Strong competition from fescue grass sod is thought to be the cause of the lower survival of this test. The severest test of survival occurred in the Sandhills supplemental test in which 66 percent of the hybrids and also of the pond pine survived. Only 57 percent of the loblolly seedlings from the 551 parent survived, yet 80 percent of the commercial Piedmont loblolly survived. Apparently the hybrid deriving from wet site coastal trees does not show any more drought resistance than the natural progeny of these same trees. Nevertheless, in none of the five test plantings is there any indication of a disadvantage in survival of the hybrids in comparison to the parent lines.

GROWTH & FORM

Total tree height was measured in all five plantings at field age 5 last winter. DBH was measured in the three taller plantings. Best growth was attained in the Tennessee surplus planting where the hybrids averaged 16.1 feet, followed by the South Carolina Coastal planting at 13.2 feet, Kentucky supplemental test 10.7 feet, Kentucky surplus planting 8.9 feet, and last the South Carolina Sandhills supplemental test at 7.7 feet. Pond pine was shortest in the four plantings in which it was included. The parent lines of loblolly pine were tallest in the South Carolina Coastal test where the site most nearly resembled that of the original source, and, consequently, all hybrids were intermediate there. In the Kentucky supplemental test progeny of loblolly 551 averaged 11.1 feet, and all three of the hybrid crosses pond x 551 were slightly shorter averaging together 10.7 feet. In the Sandhills supplemental test the progeny of loblolly 551 averages 7.3 feet, and all three of the hybrid crosses pond x 551 were slightly taller averaging 7.8 feet. No similar comparison can be made with the hybrid crosses pond x 544 because of the initial shortage of progeny from 544. However, the average of all hybrids pond x 544

in the main and two supplemental tests is essentially the same as the average of all hybrids pond x 551 suggesting no differing parent tree influence from the two loblolly parents (Table 2.).

The pattern of average height among the hybrids matches the pattern in the pure pond pine lines where the balanced design of the main and supplemental tests facilitates this comparison (Table 2.). Progeny of pond pines 533 and 550 average 8.3 feet tall; progeny of pond pine 546 are 6 percent taller. Hybrids of pond pines 533 and 550 average 10.2 and 10.3 respectively; hybrids of pond pine 546 are 8 percent taller at 11.1 feet.

Four of the test sites were recognized initially as so foreign from the native source that a local or more suitable source of loblolly pine was included in the design as a control. In the Sandhills although the average height of the hybrids is taller than North Carolina Coastal loblolly, the Local South Carolina Piedmont loblolly exceeded the hybrid average by 15 percent. Only one hybrid cross, 546 x 544, equalled the local material.

In the Kentucky and Tennessee plantings the commercial loblolly was reportedly of north Mississippi seed source raised in the Tennessee nursery. This commercial source was inferior in height and form to nearly all plantings of the hybrid crosses and was not consistently better than the North Carolina Coastal loblolly. In the Tennessee planting total volume on a per acre basis equalled 227 cubic feet for the commercial loblolly, 228 cubic feet for hybrids pond x 551, and 182 cubic feet for the hybrids pond x 544. The differences are statistically non-significant. The smaller volume of the hybrids pond x 544 results from four of the six replications containing the consistently smallest hybrid, 533 x 544. The similar volume between the commercial loblolly and hybrids pond x 551 results from a smaller diameter in the hybrids compensating their 0.8-foot taller average height.

Form in the hybrids is noticeably better than in the commercial loblolly and thus seems to reflect some of the qualities for which the parent trees were selected. Stem straightness and crown form were subjectively assessed on a scale of decreasing quality from 1 to 6. Hybrids graded 3.61 for straightness compared to 4.87 for commercial loblolly in the Kentucky supplemental test. Crown form of the hybrids there graded 3.64 compared to 4.43 for commercial loblolly.

Part of the cause of poorer height growth and form in loblolly than in the hybrids in the two Kentucky plantings is preferential infestation of pure loblolly by Nantucket pine tip moth. In the Kentucky supplemental test trees were scored as damaged by tip moth if the main stem was crooked due to larval feeding. From age 3 to age 5 the intensity of damage has decreased but the pattern remains that of lowest damage to pond pine, now 12 percent of the trees showing crook, intermediate damage to hybrids with 24 percent of the trees crooked, and highest damage to loblolly pine with 86 percent of the trees deformed.

Uniformity expressed as the coefficient of variation was calculated for tree heights. Within the 25-tree plots of the Tennessee test the coefficient of variation ranges from 10 to 18 percent in the six plots of commercial

Table 2. Pond x Loblolly Hybrid Height in Feet at Plantation Age 5.

Test Planting	Pond 533	Pond 546	Pond 550	Pond Avg.	Lobs.			Hybrid 533 x 544	Hybrid 533 x 551	Hybrid 546 x 544	Hybrid 546 x 551	Hybrid 550 x 544	Hybrid 550 x 551	Hybrid x 544	Averages x 551
					Lob. 544	Lob. 551	Lob. 516 & Comm. 530								
S. C. Coastal Main Test	10.87	10.39	10.04	10.43	15.35	14.40	13.13	12.56	13.43	13.35	13.46	13.46	12.77	13.12	13.22
S.C. Sandhills Supplemental	6.02	7.26	5.90	6.39		7.28	6.39	8.89	7.15	7.30	8.89	8.68	6.87	7.34	7.77
Kentucky Supplemental	7.95	8.88	8.86	8.56		11.10	10.15	9.83	9.98	10.83	11.32	10.86	10.98	10.46	10.72
Kentucky Surplus		5.06	5.24		6.91	5.92	5.47	6.78	8.82		8.95		9.92	7.90	9.23
Tennessee Surplus								16.1	14.9	16.4	16.9	17.4		17.0	16.9
Average: Main & Supplementals	8.28	8.84	8.27			10.93	9.89		9.90	10.52	11.19	11.00	10.44	10.19	10.57
									Average 533 x Lob.	Average 546 x Lob.	Average 550 x Lob.				
									10.21	11.09	10.31				

loblolly. In the twelve plots of hybrids the coefficient of variation ranges from 8 to 16 percent averaging 10 percent for the hybrids pond x 551. In the Kentucky supplemental test the coefficient of variation of the hybrids ranges from 10 to 17 percent, the two North Carolina Coastal loblolly lots are 15 percent, north Mississippi loblolly 22 percent, and the three pond pine lots from 17 to 26 percent. In general, in these two tests the hybrids are slightly more uniform than commercial loblolly, certainly a reasonable difference between plots of full-sib trees and unrelated trees. The uniformity of the hybrids further confirms the absence of any deleterious effects from hybridization that would be expressed as increased variability in growth.

RUST RESISTANCE

The two South Carolina tests are naturally infected intensely enough with fusiform rust (Cronartium fusiforme Hedgc. & Hunt ex Cum.) to reveal differing degrees of resistance among the parent progeny and hybrid lines. Tree infection was scored on an index of increasing severity from 1 to 5 determined by gall position. In both tests pond pine is least infected, scoring 1.22 in the Coastal Plain and 1.07 with no stem galls in the Sandhills. Progeny of pond pine 533 are the most resistant. The North Carolina Coastal loblolly scored 1.67 in the Coastal Plain and 1.91 in the Sandhills. The high mortality of the North Carolina loblolly in the Sandhills could be expected to bias the score downward there. Piedmont loblolly having the best survival has the heaviest infection score of 2.57 with 39 percent of the stems cankered. Hybrids in the Coastal Plain are intermediate in infection with a score of 1.39 and are better than commercial loblolly in the Sandhills at 2.03.

In both tests the 533 x loblolly hybrids are most resistant indicating some influence from the pond pine parent. Hybrids pond x 551 are somewhat more resistant than hybrids pond x 544 in both tests. The particular hybrid cross 533 x 551 shows the overall best resistance in agreement with the better performance of the progeny of both the parents. Second best in resistance is hybrid 550 x 551 supporting the apparent better resistance of loblolly 551.

CONCLUSION

The hybrids as a group are intermediate between the parent lines in growth rate, rust resistance, and tip moth resistance. However, when removed to exotic and adverse sites the hybrid seems to be less sensitive to detrimental factors than loblolly pine and therefore predominates in growth, survival, and form. Thus, in the Sandhills hybrids pond x 551 exceed progeny of loblolly 551 and hybrid 546 x 544 grows as well as the Piedmont loblolly, and although its survival is 10 percent poorer its rust resistance is so much better that stand volume production might be expected to be better. In Kentucky where tip moth damage is severe on young loblolly pine the hybrids again are favored. Height of all hybrids is better than the customary commercial loblolly source for that region. Even on an exceptionally good site in Tennessee volume of the hybrids is equal to commercial loblolly. Height variability within the hybrid lots is slightly lower than in blocks of unrelated or half-sib trees. Hybrid progeny of particular pond x loblolly

cross pollinations reflect characteristics such as growth rate and rust resistance in a degree comparable to the pure progeny of the parent trees. The combination of desirable traits in three hybrid individuals has led to their recognition as having quality equal to that of loblolly pine trees selected for advanced generation breeding.

Whether the hybrid would provide an improved tree for pond pine sites is still essentially unknown. None of the test plantings could be made on the deep organic acid wet soils of eastern North Carolina that are native for the parent material. At those test sites where the hybrid growth was surprisingly good, its performance still appears to be within the range attainable through selection within loblolly pine alone.

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