TWENTY-THIRD ANNUAL REPORT

N. C. State University-Industry
Cooperative Tree Improvement Program

School of Forest Resources
North Carolina State University
Raleigh

June, 1979

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EXECUTIVE SUMMARY

1. Execptionally good seed orchard production was enjoyed for the second successive year. In 1978 the Cooperative orchards collectively produced 23.5 tons of improved loblolly pine seed.

   a. Orchard management activities have again been shown to greatly improve orchard production.

   b. At full production, well-managed Coastal source orchards have produced 56 pounds of seed/acre while Piedmont orchards produced 64 pounds/acre.

   c. Self-fertilization in seed orchards was shown to be less than 1.5%, which is great news since selfing generally results in substantial inbreeding depression.

2. A milestone is approached as the progeny testing program for the first-generation seed orchards moves rapidly toward completion. Resources will soon be turned toward breeding and testing for advanced-generation improvement.

   a. A new system of progeny test evaluation has been developed which results in more effective use of the Cooperative's large data base.

   b. Genetic improvement of 10 to 15% has been reconfirmed as a result of the new performance level analyses. An equal improvement has been realized for quality traits.

   c. Special projects designed to improve fusiform rust resistance continues to provide useful results.

3. A total of <u>1722 new select trees</u> have been graded in plantations. These new select trees <u>average 19.3% volume superiority</u> over the comparison check trees, which are the five next best in the stand.

   a. Established second-generation orchards in the Cooperative now exceed 350 acres. Breeding second-generation selections has begun.

   b. The Cooperative's proven clones, <u>good general combiners</u>, <u>have been widely tested</u>, with the first results now in hand. Certain families show excellent performance over a wide geographic area.

   c. In a recent study of the mechanical properties of solid wood it was found that <u>low-density juvenile wood was much weaker</u> than mature wood. Young, fast-grown trees have a very high proportion of juvenile wood. Therefore, if a strength reduction is to be countered <u>we must exercise the option of breeding for higher-gravity juvenile wood</u>.

Dr. Bruce J. Zobel

A TRIBUTE TO BRUCE ZOBEL

Bruce John Zobel "retires" effective June 1, 1979 from his full-time responsibility with N. C. State University. However, those of us who know Bruce are well aware that the word "retire" is totally inappropriate. Bruce will receive a half-time appointment at N. C. State University to teach (four courses) and to work with graduate students (he is chairman or committee member for at least 30 students). To most, this would constitute a full-time work load but not for a man as extraordinary as Bruce. He will spend an additional 5 to 6 months a year working internationally as a consultant in forest regeneration and silvicultural practices. Indeed, this is a major transition in the career of a most remarkable man. We feel it is appropriate to pause and take note of the tremendous inspiration, great leadership, and simply overwhelming contribution Bruce has made to both the Cooperative and to applied tree improvement worldwide.

First we can say that Bruce is a pioneer who recognized the potential to the South and to the nation of increasing forest land productivity through selection and breeding. Many capable scientists before and since have recognized the potential, but to Bruce's credit he was the first to imaginatively translate potential into a functional and active program on a scale surpassed by none.

Bruce is a recognized world authority in his special discipline, the genetic improvement and variation of wood properties. He received worldwide acclaim for his fundamental research contribution in this field when in 1975 he was the first forester to be awarded the TAPPI Gold Medal for "outstanding contributions to the technical progress of the pulp and paper industry." The list of awards Bruce has received goes on and on.

Bruce has been and continues to be a teacher comparable to none. Over 100 graduate students feel fortunate to have studied in association with him. Many of these students hold positions of substantial responsibility in universities, governments, and industries throughout the world. The true mark of excellence in teaching is the ability to teach thinking and independent reasoning; Bruce is unsurpassed in this capacity.

Teacher, pioneer, scientist, leader . . . and the accolades go on. Yet those of us working with the Cooperative feel especially fortunate for our association with Bruce. Through his relentless, untiring efforts he conceived of, molded, and directed this program to the tremendous success enjoyed today. Bruce accomplished this through wholehearted dedication, uncanny perception, and boundless energy which allowed translation of an ideal into practical worth for the benefit of all. We all enjoy and fully appreciate these benefits and, as we do, we say a heartfelt "Thank you, Bruce. You are without peer in Cooperative Program development."

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INTRODUCTION

Happiness is a second year of bumper cone and seed production in the Cooperative. In general, orchards are producing well, in certain instances far above normal expectations. Loblolly seed supplies are substantial and, in fact, some sales of improved loblolly seed are pending. All associated are truly enjoying the atmosphere surrounding the "payoff" after long years of development effort. This major success story for the Cooperative occurs in conjunction with optimistic economic outlook for the industry. Year-end profits for 1978 were excellent, as were first-quarter earnings for 1979. The long-suspected decline in the housing market has yet to materialize, and paper prices are again on the rise. The uncertainties of inflation's impact are a slight damper to morale, as are the memories of the unsettled financial climate of just a year ago. Yet, when contrasted with the recent and projected economic successes, healthy attitudes prevail.

The industry has literally exploded into a new round of nursery expansion and new nursery development. As many as eight new forest tree nurseries are currently planned or under development in the Southeast. We believe at least a portion of the rationale behind these particular capital investments to be the desire to "control" the destiny of the very valuable improved seed now being produced in quantity. Experienced nurserymen are in great demand at this time.

Research and technical program support continues to be strong. Several organizations are involved with or are currently evaluating substantial expansions of research and/or technical programs. As intensive forest management receives more and more recognition among the top financial managers of the industry, the pressure for new technology and efficient use of existing technology grows. Tree improvement programs are due and are justifiably receiving a proportional share of these investment increases.

One factor having a rather negative repercussion on the forest management segment of the industry is the less-than-satisfactory plantation survival experienced by more than a few organizations in the last few years. Adverse weather has no doubt been the proverbial "straw" that pushed the situation past one of being a concern to a full-fledged problem. Extensive efforts by many organizations are being focused on unraveling the complex of contributing factors. We are concerned that the problems be solved, for no amount of potential genetic gain can be exploited if the seedlings grown from improved seed fail to survive and grow.

Increased accountability for investments in the forest management sector is very evident. We are conscious of this trend and are seeking to move the Cooperative toward the most efficient strategies available. Major efforts to wrap up first-generation developmental efforts and to redirect resources toward advanced-generation improvement are underway. This is the beginning of a new and exciting era for the Cooperative. We look forward to many additional years of steady progress.

CONE AND SEED PRODUCTION

Yields

The production of genetically improved seed for operational planting is the major focal point of the Cooperative effort. We are delighted to report a second successive huge harvest of improved pine seed from Cooperative orchards. The 1978 harvest of loblolly cones approached 38,000 bushels which yielded 23.5

Full cone sacks everywhere you turn--what a delightful sight!
Shown are storage racks outside Weyerhaeuser's Washington, N. C. seed extractory. This is part of their 10,500-bushel crop in 1978.

tons of improved seed. Assuming 8000 plantable seedlings per pound and 600 trees planted per acre, enough improved loblolly seed was produced to regenerate 625,000 acres of forest land. This is substantially in excess of the estimated 500,000-acre annual regeneration effort by Cooperative members. However, as in 1977, some organizations with older orchards have surplus seed while members with younger orchards are still short of their needs.

While we are indeed encouraged by two bumper cone crops in as many years, improvement is possible. Relative to 1977, a rather substantial drop in pounds of seed produced per bushel of cones was experienced in 1978 (Table 1). Loblolly cone production was actually greater by nearly 6000 bushels in 1978, yet approximately 2700 fewer pounds of seed were produced. Note also in Table 1 that bushels of slash pine cones harvested were less in 1978 than in any of the previous years. This is not because the orchards failed to produce well; in fact, slash cone production was estimated to be at an all-time high. However, because of the tremendous quantities of improved slash seed harvested in 1977 and the great surplus created, many cooperators harvested only a portion of the available crop.

It is not entirely clear why both loblolly and slash pine poundage yields per bushel were reduced below 1977 levels. Successive summers of very hot, very dry weather have been suspected. The fact that irrigated orchards such as Catawba's in Rock Hill, South Carolina maintained yields of 1.6 to 1.8 pounds per bushel through these hot, dry summers lends credence to our suspicion. In addition to the direct effect of heat and drought on yields, the dry soil conditions are known to reduce the effectiveness of the widely used systemic insecticide Furadan.(R) To be effective it must go into "soil solution" and be taken up through the tree roots. The Cooperative will continue to monitor seed yields and to evaluate insect control strategies such as combination treatments of systemic Furadan(R) and contact sprays of Guthion(R).

Seed orchard irrigation has substantially improved production in some orchards. How best to utilize irrigation is, however, not well known. Graduate student Dave Harcharik is studying irrigation as part of his Ph. D. program.

Table 1. Cone and seed yields within the Cooperative over the past nine years

	Loblolly		Slash	
Year	Bushels of Cones	Lbs. Seed/ Bushel	Bushels of Cones	Lbs. Seed/ Bushel
1969	1769	1.10	317	0.42
1970	5146	1.36	1744	0.88
1971	6478	1.14	3795	0.80
1972	6807	0.98	1684	0.60
1973	11853	1.09	2779	0.58
1974	8816	0.99	4088	0.74
1975	16348	1.31	5516	0.93
1976	14656	1.21	5233	0.79
1977	32152	1.54	12880	1.17
1978	37977	1.24	4789	0.54

Although the N. C. State Tree Improvement Cooeprative is largely concerned with loblolly pine seed production and, to a lesser extent, slash pine, orchards have been developed with selected trees of many other coniferous species. These various species by comparison have limited commercial interest; yet in localized areas or for specialty application such as Christmas trees, improved seed is in great demand. Such is particularly true for Fraser fir seed. A first in 1978 was the production of significant quantities of white pine and Fraser fir seed. Orchard production levels for 1977 and 1978 are compared for loblolly, slash and six other conifer species in Table 2.

Table 2. Comparison of the cone and seed yields for 1977 and 1978

	Bushels of Cones		Pounds of Seeds		Pounds of Seed/ Bushel of Cones	
	1977	1978	1977	1978	1977	1978
Loblolly Pine-- Coastal Source	22769	25443	36692	31156	1.61	1.22
Loblolly Pine-- Piedmont and Mountain Source	9383	12534	12947	15810	1.38	1.26
Slash Pine	12880	4789	15024	2571	1.17	0.54
White Pine	60	2429	9	856	0.15	0.35
Virginia Pine	321	669	292	418	0.91	0.62
Longleaf Pine	588	260	622	146	1.06	0.56
Fraser fir	0	66	0	156	0	2.36
Shortleaf Pine	22	46	14	35	0.64	0.76
Pond Pine	18	22	11	5	0.61	0.23
Total	46041	46258	65611	51153		

Orchard Management Increases Yields

Cooperative staff members are accused of an almost fanatic belief in high standards for orchard management, but with good reason. A well-managed orchard that receives properly timed and applied cultural treatments, including fertilization, thinning, insecticides, subsoiling and regular mowing, will outproduce orchards receiving less attention. Ample evidence of this was recently furnished by Jake Stone, Orchard Supervisor/Nurseryman for Union Camp in Virginia. Jake compared yields of three well-managed 13-year-old orchard blocks with an adjacent block also 13 years old that had received no fertilizer, no insect control, and only an occasional mowing for the last several years. The lack of management was associated with a reduction in yield to less than 20% of the potential (Table 3).

Table 3. Effect of orchard management on cone production in Union Camp's Murfreesboro seed orchard

Block	Bu./Acre	Age	Culture
9	23.90	13	Intensive
10	26.31	13	Intensive
11	15.15	13	Intensive
12	3.53	13	None for several years

James Hodges of Brunswick reports a similar example of reduced yields resulting from the omission of insect control. James wrote the following: "I have some encouraging results to justify our continued use of Furadan(R). We again had better than a pound per bushel of slash seed on our treated orchard. Our bushel yield was over 3200 on 43 acres. On our seven-acre rust orchard we did not put out Furadan(R) and managed only 200 bushels of cones and .42 pounds of seed per bushel." Need we say more? ORCHARD MANAGEMENT PAYS!

Reaching Full Production

It is of interest to examine how quickly young orchards develop and reach commercial production levels. Occasionally very young orchards, ages 3 to 5, will flower heavily; however, because crowns are small, cone crops are always very limited. Meaningful production usually begins between ages seven and ten. Commercial production levels have been experienced generally between 10 and 15 years following orchard extablishment. Recently we determined average per-acre seed yields for a number of older cooperative orchards (Table 4). Orchards that encountered problems related to location, e. g., site too wet, frost pockets, too far north, etc., have yet to meet these production standards.

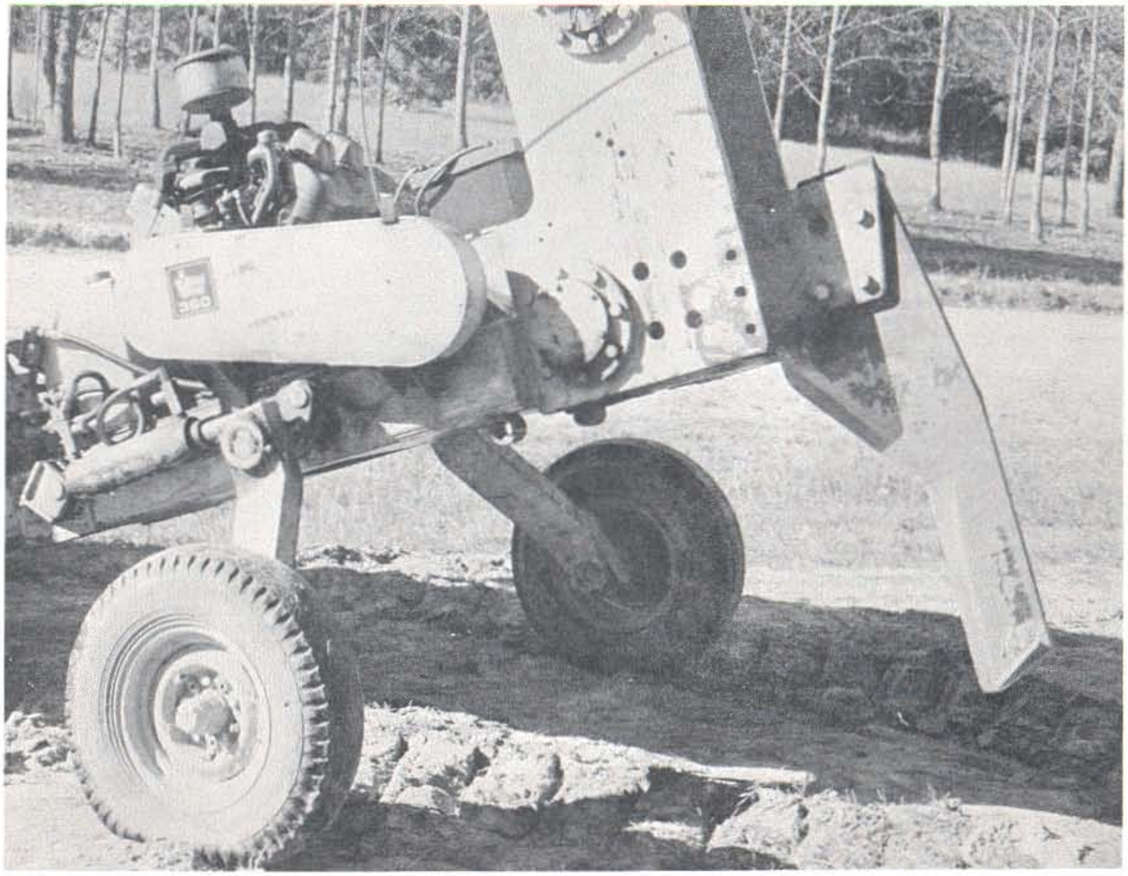
Ice and snow storms in the winter of 1978-1979 brought problems of all types. These two (above) were lucky, they were on their way after a fashion. Those orchards (below) damaged by ice will in some cases take years to recover fully.

Piedmont source orchards routinely produce heavier crops at younger ages than do coastal orchards. This is a characteristic inherent in the select trees and is exhibited no matter where orchards are located.

Table 4. Average production of seed in pounds per acre for 19 Cooperative orchards

Geographic Source	Number of Orchards	Average Age	Seed (Lbs./Acre)
Piedmont	9	14	64.3
Coastal Plain	10	15	56.0

An example of orchard production increasing over time is shown for Georgia Kraft's Briar Patch orchard (Table 5). Note there are some peaks and valleys in production levels from year to year. This is normal variation attributed to weather influences; however, the trend is a steady increase as the orchard gets older. Increases occurred despite several thinnings in older orchard blocks. Georgia Kraft has over the years produced 10,000 seedlings per pound of orchard seed. This is an excellent seedling-to-seed ratio. The normal expectation for most Cooperative members is 8000 plantable seedlings per pound of seed.



A vibrating subsoiler such as the one above does an excellent job of fracturing compacted soil and enhances the vigor of seed orchard trees.

Table 5. Production data for Georgia Kraft's Briar Patch seed orchard. Data are for 155 acres established between 1965 and 1973.

	Seed Orchard Production			Outplanting of Seed Orchard Seed	
Year	Cones (bu.)	Seed (Lbs.)	Seed/Bu. (Lbs.)	Lbs. Seed	M Seedlings
1969	1	0.8	0.80	-	-
1970	15	12.5	0.83	-	-
1971	40	47.5	1.19	12.5	10
1972	87	52.0	0.60	47.5	393
1973	218	222.8	1.02	52.0	426
1974	211	122.0	0.59	222.8	2035
1975	942	1142.0	1.21	122.0	1220
1976	820	970.0	1.18	1142.0	11,765
1977	2350	3232.0	1.38	959.0	9587
1978	3758	4050.0	1.08	1632.0	17,120

Seed Crops Have Few Selfs

Southern pine seed orchards produce seed crops as a result of relatively random wind-pollination. It has always been a concern whether or not self-pollination and eventual self-fertilization occurs and, if it does, with what frequency. Many orchard trees are self-incompatible or have a built-in self-avoidance mechanism; yet when self-pollination is forced, the resulting progeny generally grow very poorly. Selfing is a severe form of inbreeding. In a selfing study being maintained by the Eastern Carolina Region of Champion International Corporation, a reduction in growth rate of 50% was observed for selfs at age 10. Such a severe amount of growth depression cannot be tolerated even in modest amounts in commercial seed production programs.

In the late 1960's Bob McElwee examined pollen flight patterns and determined that the likelihood of self-pollination could be minimized if separate grafts of the same tree were spatially separated by approximately 90 feet. However, until this year we did not know just how effective such spatial separation was in reducing the frequency of self-fertilized seed. As the result of studies by Tom Adams, we now know that selfed seeds are very uncommon in orchard seed crops.

Lift vehicles are essential equipment in older orchards. Shown is a JLG lift in use at the North Carolina Forest Service longleaf orchard. Lift vehicles are used in cone harvest, control-pollination work, production inventories, and research activities.

Tom Adams and associates at the University of New Hampshire[1/] have used the relatively new technology of electrophoretic analysis of isozymes to quantify selfing rates. This technique involves first identifying the "genotype" of each tree in the seed orchard by studying fifteen gene loci that code for variants in ten enzyme systems. With orchard genotypes known, the sampling of large numbers of seed embryos from a single clone allows the determination of the genetic makeup of the pollen pool, i. e., the pollen effective in fertilization, for that clone. The proportion of wind-pollinated progeny that have resulted from selfing can be estimated.

In a paper soon to be published by Adams and Joly the following is reported: "Based on a sample of 513 seeds from five clones with unique alleles, the proportion of selfed progeny was estimated at only 1.2 percent. This indicates that selfing probably has little effect on the genetic makeup of the seed crops in these orchards." This work was conducted in two first-generation orchards of Champion International Corporation, Newberry, South Carolina. The estimated frequency of selfs in these orchards is close to the average estimate of 1.75 percent reported for a natural loblolly pine stand by Carlyle Franklin in his Ph. D. thesis here at N. C. State University. There seems to be no evidence for increased self rates in seed orchards due to pollination among ramets of the same clone. Present orchard designs that stress wide separation between ramets of the same clone are satisfactory.

Orchards in South Africa

Several cooperators have contracted with South African forest industries to have orchards established and seed produced. These South African orchards are being justified by most as a means of providing insurance production and by some as a way to get commercial production in less time. Neville Denison,

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1/ Dr. W. Thomas Adams is now Associate Professor of Forestry, Oregon State University, Corvallis, Oregon.

project leader, wrote in a recent letter that growth and health of grafts for U. S. orchards was good. The Cooperative staff has been active recently preparing orchard layouts for proper graft espacement in these South African orchards.

A couple of photographs of the South African orchard work are included in this report for your information.

PROGENY TESTING

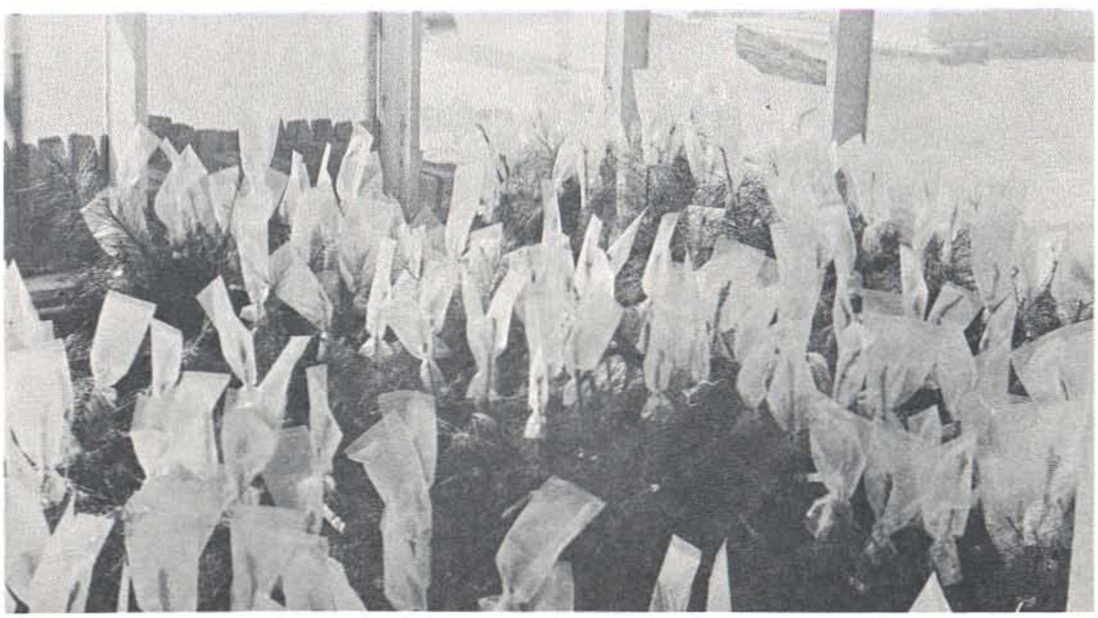
Progress to Date

A major activity of Cooperative members from virtually the start of tree improvement work has been progeny testing. The breeding and testing of trees selected in the wild serves two functions, (1) the determination of breeding values or genetic worth of parent trees in the orchard, and (2) the creation of a base population of progeny from which second-generation selections can be drawn. The progeny testing program is a very large undertaking. To date, Cooperative members have established 991 control-pollinated tests on over 3612 acres (Table 6). One cooperator has estimated the cost of progeny testing to be 36% of the total program cost.

Table 6. Acreages planted and number of progeny tests by species of type test in the N. C. State Cooperative as of May 1, 1979.

Species or Type Test	Acreage	Number of Tests
Coastal Loblolly	1321	384
Piedmont Loblolly	870	263
Slash Pine	522	99
Virginia Pine	214	71
Shortleaf Pine	33	9
Pond Pine	34	12
Other (Mountain, Longleaf, Hybrids, etc.)	145	45
Good General Combiner	360	80
Disease Diallel	113	28
Total	3612	991

A 2-year-old graft of a cooperator's loblolly selection in a South African seed orchard.



Grafts made in March, 1978 for use in cooperator's orchard in South Africa.

There is indeed reason for pride among Cooperative members as we approach a plateau of accomplishment, the wrapping up of first-generation progeny testing. The first control-pollinated progeny tests were established in 1964. Sixteen years later the breeding and testing of the first-generation trees is drawing to a close. Most of the charter members of the Cooperative have completed control-pollinations and outplanting of their crosses, several are about halfway, and newer organizations are just starting. The newer companies will not do a tester system on their first-generation material but will begin with the partial diallel mating scheme to be used with plantation breeding work.

There are 48 loblolly orchards in the Cooperative which have been or are being progeny tested. Of these 48, crossing and outplanting of progeny has been completed on 15 of the orchards. Another 6 orchards have crossing completed and only have one or two outplantings left. Eleven orchards have 70 to 80% of the crossing done; four have 50 to 65% of the crossing completed, and ten have only 10 to 50% done. In total, approximately half of these orchards have the crossing and outplantings completed. It is estimated that before 1985 all first-generation progeny tests will have been outplanted.

The progeny test data base from which decisions are made continues to grow rapidly. Each year more tests reach measurement age and a great many tests are now old enough for their second (age 8) assessment. As of May, 1979, age 4 (or 5) data are available from 40% of the loblolly tests established, while both age 4 and 8 data are available for an additional 36% of the tests (Table 7). The Cooperative members now measure about 250 tests each year.

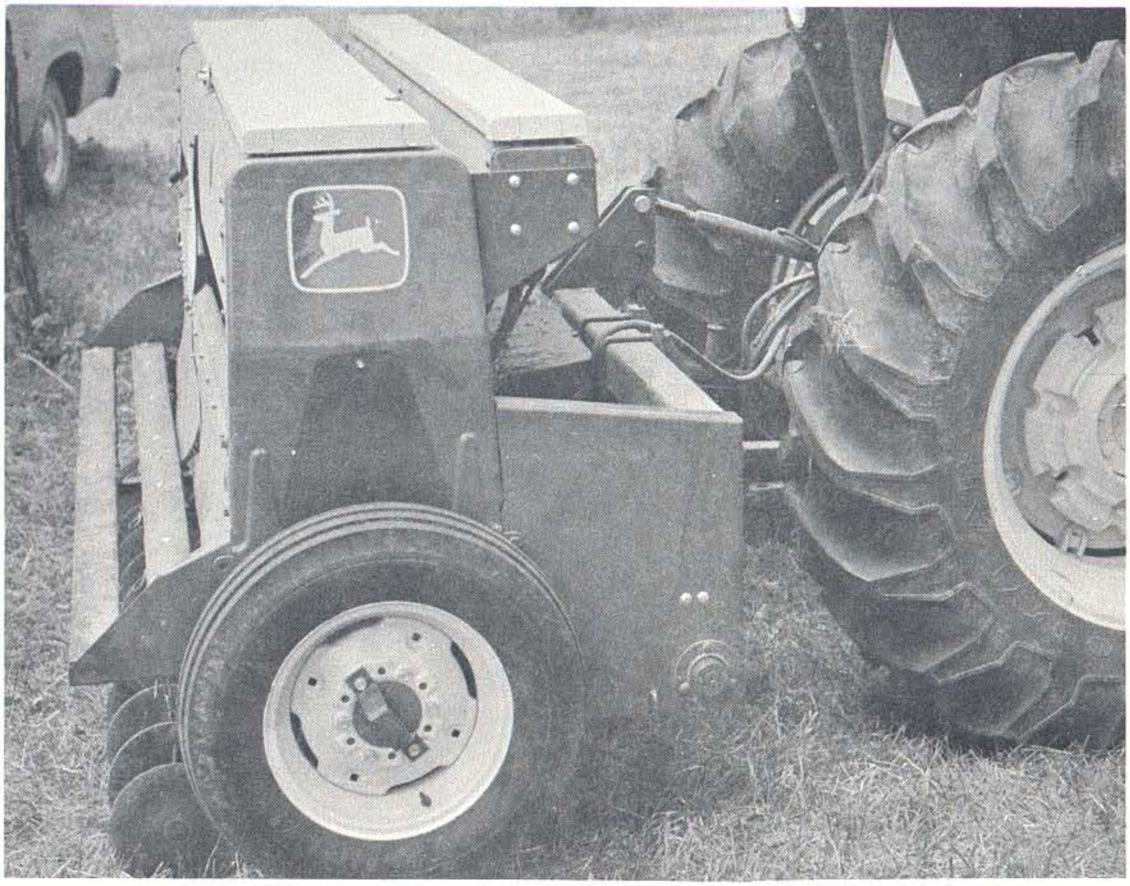
Table 7. Measurement status of Coastal and Piedmont loblolly tests as of May 1, 1979

	Number of Tests	
	Piedmont	Coastal
Not measured to date	70	91
Fourth-year measurements only	104	156
Eighth-year measurements completed	89	137
Total	263	384

Progeny Test Evaluation

A major effort was made by the Cooperative staff during the past year toward more meaningful and efficient analysis of progeny test data. An evaluation procedure can be highly efficient only if it uses all of the available information. Since all crosses are not planted in the same year and/or location, the information from progeny tests must be placed on a comparable basis prior to combining over years and locations. Our evaluation procedure to date has been based on the use of genetic checks (crosses resulting from a half-diallel of the tester parents and planted in each progeny test) to remove year and location effects prior to pooling the information from several tests. As we gained more experience in the use of genetic checks and the resulting evaluation procedure, some shortcomings in the system were recognized. Briefly, the concerns centered around the following four points:

1. Even though a concentrated effort was made to insure the establishment of genetic checks in each progeny test, we too often encounter tests without these common crosses (especially true with respect to supplemental tests). When this situation occurs, the information must be segmented into several groups and each group analyzed separately. An evaluation based on segmented analysis is less than desirable.



The Power Till Seeder, when appropriately modified, does an excellent job of incorporating Furadan(R) into the soil. Proper incorporation of this systemic insecticide gives better insect control and reduces the hazard to nontarget wildlife.

2. The second area of concern involved the possibility of genotype-by-environment interaction among the genetic checks. If such an interaction should occur, the adjustment factor calculated from genetic checks could be incorrect, resulting in a biased evaluation.
3. The numbers obtained using the old system were meaningless in terms of absolute value. Thus the assessment of worth for clones or crosses was reduced to a subjective rating.
4. Finally, the procedure assumed homogeneity of variances when pooling the information from several plantings. In some instances the evaluation of clones and crosses was found to be biased, since tests with the largest variances were weighted heaviest in the evaluation.

After investigating a number of alternatives, a procedure was developed which minimizes the concerns expressed above. The evaluation utilizes the test mean and standard deviation to place the information from different progeny tests on a comparable basis prior to pooling. The actual calculation of performance levels is done as follows:

1. Calculate a standard deviation for each progeny test.
2. A range of expected values is defined as those values falling within plus or minus two standard deviations of the test mean.
3. A performance level is calculated to reflect the position of a specific cross within the defined range. The performance level is determined by subtracting the minimum value of the range from the cross average, dividing by the range, and multiplying by 100. Any cross average falling below or equal to the minimum value of the range is assigned a performance level of zero. Any cross average exceeding or equal to the maximum value of the range is assigned a performance level of 100.

4. The performance level for a specific cross is the average of all the individual test performance levels for that cross.
5. The performance level for a clone is the average of the performance levels for the specific crosses involving that clone.

The performance levels generated by the above procedure are easily interpreted. The range of performance level values is from 0 (poorest) to 100 (best). A performance level of 50 indicates that the cross or clone is an average performer. As the value of the performance level decreases to zero, the cross or clone's average performance falls farther and farther below average. As the values increase to 100, the performance increasingly exceeds the mean performance of all crosses or clones, whichever the case may be.

Evaluations are obtained for all assessed traits (height, volume--when diameter is assessed, crown, straightness, Cronartium score, and percent rust infection). In addition, a performance level is calculated for form (a combined assessment for crown and straightness) and for rust resistance (a combined assessment using Cronartium score and percent infection). The form value is calculated with straightness weighted twice as heavily as crown. This weight, although arrived at arbitrarily, appears reasonable from the standpoint of both economic value and measurement reliability. The performance level for rust resistance is calculated using a value obtained by multiplying the percent infection by the Cronartium score (essentially this combined score represents the level of infection weighted by the severity of the infection). When pooling information from age 4 and age 8 tests, it was felt that the older tests should be weighted heaviest in the evaluation. In our evaluations, age 8 tests carry twice as much weight as age 4 tests.

Through the performance level evaluation, an estimate of percent gain over the commercial check can be obtained. We would caution that this is a rough estimate only. The accuracy of the estimate depends upon (1) the degree to which the commercial check used is representative of commercial material in general, and (2) the quality of the testers used in the progeny test program.

Use of Performance Level Information

Performance level values are being used in several ways. Values obtained from Westvaco's 1973 South Coastal loblolly main test are shown in Table 8. Second-generation selections would be expected to come from those crosses with performance level values greater than 50 in both height and rust.

Clone evaluations derived from performance level information are more meaningful than with the genetic check system. Numerical values can now be attached to a clone's performance for any given trait (Table 9). Those clones with high performance levels would be favored during orchard roguing. Numerical descriptions of a clone's overall rating await more detailed information for the relative economic values of the individual traits.

Note the seed lots in Table 9 with an LP prefix. These five lots are Livingston Parish seed sources. In general, Livingston Parish seed shows excellent rust resistance, but in this test growing in the Coastal Plain of South Carolina the growth rate of these Livingston Parish sources is quite inferior. This has been generally true when Livingston Parish seed is moved this far north.

Table 8. Performance levels for crosses in 1973 Westvaco South Coastal loblolly main test

Cross	Height	Crown	Straight-ness	Form	Cronartium Score	Percent Infection	Rust Resistance
CC 1	14	30	2	11	53	63	63
7-02 x 11-23	77	66	61	62	15	11	10
7-56 x 11-10	75	58	71	66	74	70	70
7-56 x 11-20	55	72	83	79	77	82	77
7-56 x 11-23	64	56	59	58	23	37	36
11-09 x 11-10	21	62	61	61	86	92	82
11-10 x 11-23	37	93	98	96	78	81	76
11-20 x 11-23	56	52	50	50	25	21	23
11-23 x 11-16	52	51	38	42	28	21	24
11-51 x 11-02	5	40	45	43	39	39	43
7-02 x 11-10	55	66	61	62	69	66	68
11-09 x 11-23	67	75	50	58	49	55	57
7-56 x 11-02	91	74	76	75	41	42	45
11-08 x 11-20	52	3	44	30	43	40	45
11-14 x 11-16	51	0	0	0	66	56	61
11-20 x 11-16	43	51	63	59	56	56	59
11-23 x 11-23	71	54	53	53	0	2	0
11-51 x 11-23	54	44	50	48	7	0	0
11-02 x 11-20	43	70	66	67	58	58	60
11-10 x 11-10	21	57	54	55	78	77	74
11-14 x 11-10	21	24	21	22	77	82	77
11-14 x 11-20	8	0	0	0	59	51	56
11-19 x 11-20	34	3	5	4	67	61	64
11-25 x 11-23	90	56	49	51	13	7	5
11-41 x 11-16	80	24	26	25	83	86	79
18-102x 11-20	31	49	51	50	73	67	68
18-102x 11-23	31	66	76	72	13	16	13
11-03 x 11-16	84	53	45	47	50	46	51
7-52 x 11-20	35	68	68	68	45	60	60
7-53 x 11-20	16	69	62	64	56	59	61
11-13 x 11-10	26	54	51	52	73	67	69
11-26 x 11-16	57	29	26	27	33	29	33
11-28 x 11-20	29	23	40	34	70	68	69
11-61 x 11-10	73	86	90	88	76	72	71
11-61 x 11-16	93	93	73	79	47	43	48
11-61 x 11-23	72	50	61	57	31	36	38

Table 9. Performance levels for clones in Westvaco's South Coastal loblolly orchard

Clone	Performance Levels: Height	Volume[1/]	Form	Rust Resistance	Number of Crosses	Overall Rating	Estimate of Percent Gain (Height)
7-56	74	74	63	62	6	Good+	11.4
7-2	71	53	43	58	4	Good+	10.6
7-52	66		61	50	5	Good	9.4
11-19	65		34	57	5	Good	9.1
11-25	62		35	48	4	Good	8.4
LP-B53	62		26	61		Good-	8.4
11-16	61	53	44	45	25	Good	8.1
11-13	60		53	45	3	Good	7.8
11-03	59	34	57	52	4	Avg.+	7.6
11-23	57	48	52	27	24	Avg.	7.1
Fla. Lob.	56		31	42		Avg.+	6.8
7-53	53		62	33	4	Avg.	6.1
11-61	53		69	53	4	Avg.	6.1
11-02	49	57	49	47	9	Avg.	5.1
18-99	48		51	31	4	Avg.	4.8
11-10	46	49	62	64	25	Avg.	4.3
11-09	46	64	48	70	6	Avg.	4.3
11-41	46	22	51	75	3	Avg.	4.3
11-21	46		64	14	4	Avg.-	4.3
11-22	44		47	50	4	Avg.	3.8
11-08	44	35	41	51	5	Avg.	3.8
SPA	43	51	15	53		Avg.-	3.5
11-28	44		49	41	4	Avg.	3.8
LP-B57	43		42	69		Avg.-	3.5
11-26	42		40	39	4	Avg.-	3.3
18-102	42		49	61	4	Avg.-	3.3
11-14	38	32	18	51	5	Avg.-	2.3
11-88	38		33	82	1	Avg.-	2.3
LP	36		31	64	5	Avg.-	1.8
LP-B18	35		18	57		Avg.-	1.5
11-20	34	34	46	58	26	Avg.-	1.3
7-22	32	82	65	65	4	Avg.	.8
11-51	30	28	59	44	6	Poor	.3
CC	29	32	19	54		Poor	
LP-B14	28		33	76		Poor	-.3
LP-B23	12		38	57		Poor	-4.3

[1/] Performance level values are shown for only those parents with progeny in age 8 tests.

Progeny testing on representative sites and with current management practices is essential. Shown is a newly planted progeny test of Masonite Corporation. Plots are planted across excellent beds.

Rust Resistance Work

Special efforts to breed and test for resistance to fusiform rust continue on a variety of fronts. The first of some 28 disease diallel plantings were assessed this past year at age 4. A more detailed (9-point) scoring system was used to allow better determination of the rust severity. As usual, rust infection will also be assessed by determining the percentage of trees infected in each control-pollinated family. The disease diallel plantings are comprised of families created by control-pollinations among the most rust-resistant first-generation parents in the Cooperative. The families resulting from mating the best with the best provide an excellent base population from which to select for future generations.

Many Cooperative members have screened seed lots for fusiform resistance at the Resistance Screening Center run by the U. S. Forest Service, State and Private Forestry, in Asheville, North Carolina. This service has held great promise for early testing of rust resistance potential in our select trees. However, as might be expected with a new service, the center has had some difficulty in producing reliable results in the early stages. We are most encouraged, though, by the quality control improvements recently made at the center. We are now encouraging Cooperative members to take full advantage of the services available. We hope to screen the many hundreds of new plantation selections identified and to concentrate early breeding efforts on those trees showing the greatest rust resistance potential.

A joint project to examine the correlation between field and screening center test results has been undertaken. Dr. van Buijtenen at Texas A & M has spearheaded the effort which utilizes the data base from the three major tree improvement cooperatives in the South--Western Gulf, Florida, and N. C. State--as well as data from the U. S. Forest Service Region 8 Improvement

Program. While results are very tentative at this time, a reasonable correlation was evident in the preliminary work. The agreement between field and center data seems to be about as good as the agreement among different field tests.

A study complementing the abovementioned work has been undertaken at N. C. State by graduate student Tim Adams. This study will assess the correlation or agreement in results between Screening Center tests and the results obtained from several of the disease diallel and good general combiner field plantings located in high rust areas. Tim's experiments at Asheville are being conducted subsequent to the quality control improvements mentioned previously.

Some interesting data were reported by Marvin Zoerb of Union Camp regarding the rust infection on a planting of Screening Center "survivors." Survivors are uninfected trees from seed lots inoculated at the Asheville Center. Marvin reports that, after four years in the field, only 7% of the survivors were infected compared to 52% of the trees in a nearby 4-year-old planting of bulked seed from the orchard. These results were for slash pine and would suggest that meaningful improvement can be made by selecting fast-growing trees from the survivor population. Most of these trees appear to be truly resistant rather than merely escapees. The survivor planting included 77 trees from slash parent 18-22, of which none were infected to date.

Problems and Solutions?

An annual report is normally a place to report highlights of the past year and is customarily filled with details of positive accomplishment. However, sometimes it is useful to identify problems, however painful they may be to relate. Such is the subject of this final section on progeny testing.

Progeny test measurement has routinely included an assessment of form (crown characteristics and straightness). In 1976 we discovered that this aspect of progeny test evaluation had in fact become a bit too routine. Measurement crews were not properly utilizing the subjective rating system developed for form assessment. All too frequently, too many trees were given very poor scores or, in some instances, scoring was much too generous (Table 10). As a result, members of the Cooperative staff invested considerable time in progeny measurement training schools. We are happy to report that 1977 and 1978 results showed marked improvement which we believe is the direct result of the extra training effort. Additional improvement can be made, however, so training in this vital aspect of tree improvement work will continue.

A second and potentially more serious problem was uncovered during the last year concerning the integrity of control-pollinated seed lots. A special study involving the biochemical verification of parental genotypes conducted for seed lots in one breeding program of the Cooperative, uncovered evidence of contaminated control-pollinated seed lots. In short, a cross labeled A x B was found instead to be A x C. While the contamination discovered was not extensive, it was in several seed lots and enough to cause some concern. There are many places where such a mix-up might occur, e. g., a mislabeled graft used in the crossing, collection of pollen from the wrong tree, mixing pollen inadvertently, mislabeling or mixing of cones at harvest, mixing of cones or seed during extraction, and the list goes on.

The importance of careful, accurate work during the production of control-pollinated seed cannot be stressed enough. Accuracy is essential if we are to progress in the development of pedigreed progeny populations. Errors will seriously limit the efficiency and progress to be made in realizing genetic gain in future generations. While errors are inevitable, each cooperator must check and recheck the company's work to insure that errors are kept to an absolute minimum.

Table 10. A comparison of form assessment effectiveness for progeny tests measured in 1976, 1977 and 1978

	Crown Scoring	
	% of Tests Acceptable	% of Tests Unacceptable
1976	32.8	67.8
1977	76.4	23.6
1978	72.9	27.1
	Straightness Scoring	
	% of Tests Acceptable	% of Tests Unacceptable
1976	50.0	50.0
1977	87.5	12.5
1978	80.0	20.0

ADVANCED-GENERATION PROGRAM

A section describing activities and progress related to "advanced-generation" efforts has been included in this report for several years. We use this terminology to broadly describe a number of distinct activities such as second-generation selections, plantation selections, establishment of second-generation orchards, good general combiner breeding, etc. Much of the work described here is developmental in nature, with the payoff expected in the second generation or in some cases even farther down the road. For example, the real payoff to be derived from plantation selection work is in the third generation of improvement. We cannot stress enough the importance of such developmental work if the Cooperative Tree Improvement Program is to have a sound base on which to build for the long term. Yet we are ever mindful of the requirement that the program pay a return on investment at each and every stage. Currently the large effort by Cooperative members on second-generation orchard establishment is expected to produce the next major increment of genetic improvement.

The Cooperative has been very busy in the last year defining plans for the advanced-generation work. A major decision was made concerning which mating scheme to be employed. Based on the work of John Talbert and others, a decision was made to use a six-parent, disconnected half-diallel scheme for breeding second-generation and plantation selections. Work continues to determine, on the basis of existing test results, the field design best suited for the advanced-generation testing. The question is how many replications, how many locations, and what plot size is best for future generation progeny tests. This is a decision that will greatly affect the efficiency and cost of the breeding and testing program planned for the Cooperative.

Plantation Selections

Through March, 1979, in unimproved loblolly plantations, 1722 new select trees have been graded. Five members of the Cooperative have reached their goal of 100 plantation selections. Congratulations are in order for the following: Hiwassee Land Company, Virginia Division of Forestry, Weyerhaeuser (Miss.-Ala.), Kimberly-Clark, and Catawba Timber Company; all have 100 or more graded plantation selections. Another 12 members of the Cooperative are well over halfway toward the target number of 100 trees per orchard program, i. e., a member with both Coastal and Piedmont orchards would have a goal of 200 trees.

This intensive selection program was kicked off in 1975 and is scheduled for completion in 1980. It is important to meet this time schedule if delays in developing third-generation production orchards are to be avoided. Several members in the Western and Gulf Coast area will be granted time extensions because programs are phased several years behind those on the Atlantic Coast due to a later start in the Cooperative. Also, many of these members do not have in their area sufficient acreage of 15+-year-old loblolly plantations to complete the work by 1980.

We have recently summarized data for the 1700+ select trees and for the five check trees against which each was graded. We found a difference of .008 for specific gravity between the checks and the select tree, which is no difference at all. The average height superiority of select trees over checks was found to be in excess of 5%. The select trees showed average cubic foot volume superiority over the checks of 19.3%. We have indeed made substantial volume gains in this round of selections with no apparent regression for quality traits. The volume superiority is particularly striking when it is noted that the check trees are the next five best crop trees in the stand. The average difference in volume between the select trees and the stand average would be tremendous!

The correlation between select tree specific gravity and select tree percent volume superiority over checks was found to be -.081. While this is ever so slightly negative, it is so close to zero that we can safely say that growth rate and wood density are entirely independent! This is not a new discovery but it is encouraging to confirm that the complete independence of density and growth is evident in young, fast-grown plantation trees just as it was for trees selected in older stands. *

The work to locate and grade hundreds of plantation selections is a very large and costly undertaking. Estimating the cost of one graded plantation selection to be approximately $400, the total expenditure to date by Cooperative

Shown is one of more than 1700 new select trees graded in plantations. Select trees have averaged 19.3% volume superiority over checks, which are the five next best trees in the stand.

members has been in excess of $680,000. We anticipate that an investment of over a million dollars will have been made by Cooperative members before this program is completed. While the cost is high, it is an investment worth making. This has been shown to be true numerous times by the various economic evaluations of tree improvement. The fact that such an investment is being made by the Cooperative is a credit to the membership and a measure of commitment to this long-term developmental program.

Second Generation

Twenty-three cooperators have continued development of second-generation production orchard acreage through 1978, and grafting work for new acreage in 1979 was extensive. Over 350 acres have been established to date with second-generation selections identified in first-generation progeny tests. A listing of loblolly second-generation selection totals by cooperator is shown in Table 11.

Economic pressures dictate moving to second-generation production orchards as soon as possible. However, gains will not be made if the select trees chosen for inclusion in these new orchards are "losers." Because these orchards are often started with rather young selections from the progeny tests (aged 5 to 9 years) it is of continued interest to monitor how many trees used in these orchards are maintaining superiority over time.

Table 11. A listing of second-generation selections of loblolly pine in the Cooperative

	Number of Selections
Hiwassee	141
Catawba	48
Union Camp (Va.)	77
Champion--Western Carolina Division	63
Chesapeake	86
Continental Forest Industries (Ga.)	73
Champion--Eastern Carolina Division	110
International Paper	87
Weyerhaeuser (N. C.)	192
Weyerhaeuser (Miss.-Ala.)	30
Federal	92
Union Camp (Ga.)--Loblolly Only	46
Westvaco	126
Kimberly-Clark	120
Continental Forest Industries (Va.)	76
Georgia Kraft	57
N. C. Forest Service	4
American Can	29
S. C. Commission of Forestry	36
Tennessee River	54
Virginia Division of Forestry	46
Georgia-Pacific	7
Masonite	1
Total	1601

Table 12 shows the proportion of trees recommended for use that were later rejected. The overall rejection rate of 18.5% is quite tolerable. The greatest rejection rate seems to occur with those organizations located in areas of high rust hazard. We have recently undertaken a rather detailed study of why apparently good second-generation selections are subsequently rejected. Understanding the primary causes of rejection should allow selection efforts to be more effective in the future. However, as long as the rejection rate is less than about 20% we are in good shape. We suspected some inefficiency of this sort since we were working with selections that were very young; therefore, a large number of trees and clones have been used in each acre of these new orchards to allow roguing of rejected trees. With this strategy it is possible to rogue rejected trees and still maintain a satisfactory orchard of high-quality trees.

Table 12. Summary of second-generation orchard clonal recommendations and rejection rates, 1972 to 1979

	Number of Clones Recommended for Orchard	Percent Rejected
Hiwassee	71	23.9
Catawba	89	22.5
Union Camp (Va.)	78	28.2
Champion	95	30.3
Chesapeake	83	31.3
Continental Forest Industries (Ga.)	57	22.8
Champion International-- Eastern Carolina Division		
Coastal	54	11.1
Piedmont	58	3.4
International Paper		
Coastal	79	21.5
Piedmont	31	0.0
Weyerhaeuser		
N. C. Coastal	111	28.8
Federal		
Coastal	61	16.4
Piedmont	99	33.3
Union Camp (Ga.)	78	30.8
Westvaco	83	26.5
Kimberly-Clark	51	29.4
Continental Forest Industries (Va.)	66	15.2
Georgia Kraft	47	4.3
American Can	55	9.1
S. C. Commission of Forestry		
Coastal	34	0.0
Piedmont	62	8.1
Tennessee River	56	16.1
Georgia-Pacific	69	18.8
Masonite	41	7.3
Container	42	4.8
Rayonier	66	10.6
Brunswick		
Piedmont	61	3.3
Coastal	32	0.0

Overall rejection rate of 18.5%

Heavy flowering has occurred in several second-generation orchards for the first time in the spring of 1979. Breeding of second-generation selections, both in the production orchards and the breeding orchards (clone banks) will commence in a meaningful way in the spring of 1980. Weyerhaeuser has already completed several six-parent diallel blocks on grafts of second-generation selections located in their flower acceleration facility in Hot Springs, Arkansas. Many cooperators have sent pollen from early-flowering second-generation selections to be stored in the pollen bank at N. C. State for future breeding work. A new generation of improvement is indeed upon us.

Good General Combiner Open-Pollinated Tests

During the past winter many cooperators made fourth-year measurements on the good general combiner tests established in 1975. The tests, consisting of proven superior open-pollinated families, were established to assess the potential for wide movement of seed from superior clones and to obtain more exact information on the magnitude and extent of genotype-environment interaction. Over 60 tests have been established throughout the South and overseas; nearly 30 were scheduled for measurement this year.

Detailed analyses await more complete processing of the data, but upon examination of a few early test results some trends become apparent. Some families appear to behave uniformly, regardless of the environment in which they were planted. Other families do well in some environments but not in others. An example of these contrasting situations is shown in Figure 1. Family 7-56 is a good grower relative to other families in the test at both locations analyzed. Stated simply, it is a high-yielding clone and stable across environments. Family 1-14 is an unstable family, *i. e.*, it does well in the North Carolina test but rather poorly in Georgia. Similar examples can be found for rust resistance.

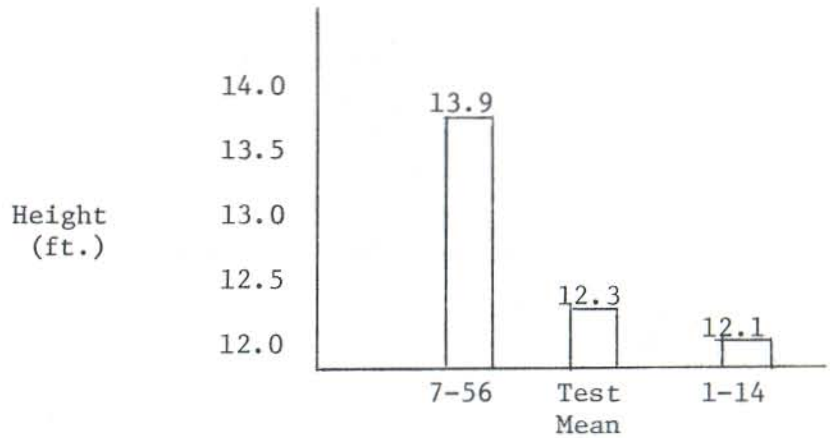
A particularly pleasing aspect of the data examined thus far is that some clones do well in all traits in all environments. International Paper Company family 7-34, for instance, appears to be a winner in both height growth and rust resistance. Also included in the tests were bulked seed lots from Livingston Parish, La., Eastern Shore, Maryland, Marion County, Florida. The Maryland Eastern Shore source is resistant to rust in all environments but grows poorly when planted south of its range. Livingston Parish material ranks high in height up into the Coastal Plain of Georgia. More definitive information on wide movement of superior families will be available shortly.

Good General Combiner Crossing

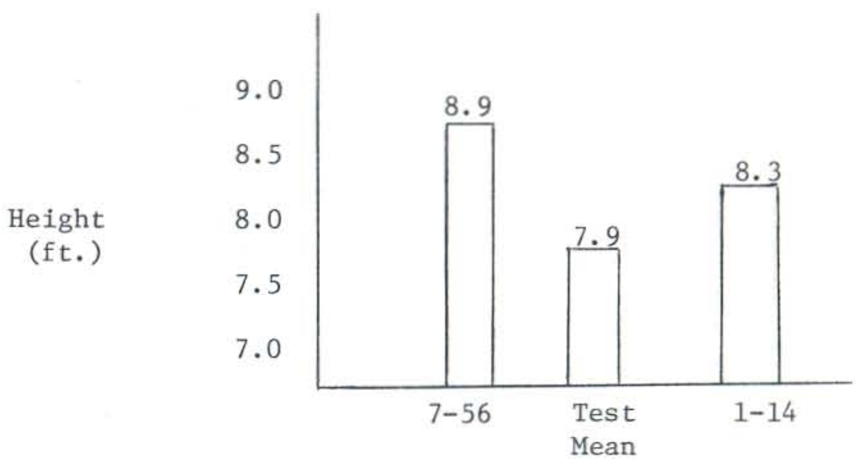
The purpose of the good general combiner crossing is twofold, (1) to create new genetic combinations among the best good general combiners, which were not made during the regular progeny testing of the orchards, (2) to make some wide crosses between breeding regions to see how they will perform in different environments. Plans are to incorporate selections from this material into future generations of improvement.

Controlled crossing of good general combiners began in the spring of 1975. Several of the very best were identified for each organization, and crosses within regions and between regions were made. Most of the crosses were within regions. Between-region crosses are considered to have less potential for payoff and therefore the effort is limited in scope. As of January, 1979, a total of 889 crosses from the 7 breeding regions were requested, and presently 265 crosses have sufficient seed for outplanting. Of these 265 with enough seed, 181 were nursery-planted in the spring for field planting in 1980. A total of 10 tests will be established. Future plans for this study are to finish crossing the 889 and to outplant them whenever there are enough in a region to make a test. No new crosses will be added for older organizations, but

Figure 1. Performance of two loblolly pine families when planted in different environments



Burke Co., Georgia (Union Camp)



Richmond Co., N. C. (Catawba)

additional crosses will be made when more progeny test data becomes available from younger orchards, allowing identification of new good general combiners. The heaviest crossing of this material in the future will be in the western area where most of the newer companies operate.

Improvement of Wood

Through the years Cooperative policy has been to sample wood specific gravity of every first-generation select tree and every second-generation selection eight years or older. In addition to the many special studies done by the Cooperative, wood samples have been obtained from many families during progeny test thinnings. All told, a massive amount of specific gravity information has been accumulated from progeny tests.

Heritability estimates for loblolly pine wood specific gravity based upon family differences in progeny tests have consistently been high, often in the range of .5 to .6. Heritability values can also be calculated from parent-offspring regression or correlation techniques. Recent analyses of Cooperative data using these procedures show that the heritability of wood specific gravity based upon correlation of second-generation selection and midparent values of first-generation parents is approximately 0.5, quite close to previously reported estimates. These results are pleasing because they indicate that substantial gains for wood specific gravity can be made by selecting trees for second-generation seed orchards based solely upon individual performance. Meaningful gains can also be made by selecting on the basis of midparent value when second-generation selections have not reached an age where their wood properties can be reliably and safely sampled.

These results suggest that there is no need to intensively sample for specific gravity as was being done in progeny test thinnings. As a result of these findings, a major revision of policies pertaining to long-term rust maintenance, thinning and wood sampling is possible. These changes in policy will result in reduced work loads for test maintenance over time, without a loss of useful data. By wrapping up work with first-generation tests, resources will be freed for the second-generation breeding and testing activities that are just beginning.

Recently a study of solid wood strength properties was completed in the N. C. State Wood and Paper Science Department. The study by Ron Pearson and Bob Gilmore will soon be published; however, Ron and Bob graciously allowed us to report highlights of their work below. Because the study examined strength properties of a 15-year-old open-pollinated progeny test of Westvaco, it is of considerable interest to the Cooperative. The abstract of this report follows:

"Static bending, compression parallel to the grain, and toughness tests were done on clear wood from the inner (juvenile wood) and outer zones of 143 trees from three populations of loblolly pine grown in South Carolina. The populations differed in age and rate of growth. They comprised a naturally regenerated forest 41 years old, a plantation of ordinary commercial stock 25 years old, and a research plantation of 15-year-old trees from parents selected for fast growth rate and good form. In general, the older the tree, the higher its mechanical properties. The juvenile wood from all populations was much lower in density and mechanical properties than the wood from the outer zones. Owing to its fast growth rate, the 15-year-old trees had a much higher proportion of low-density, low-strength juvenile wood than the older trees. The main significant difference between the populations was the difference in density of wood.

"The wide variation in the density of juvenile wood from different trees and localities indicates that it should be feasible to breed pines with juvenile wood of higher specific gravity than the present average value, with a substantial gain in the mechanical properties."

Work recently reported by Zobel, et al. (Zobel, B. J., J. B. Jett and R. Hutto, 1978, "Improving wood density of short-rotation southern pine," Tappi 61(3):41-44.) demonstrates that breeding for high specific gravity juvenile wood is possible. We now know that this is important, not only for increasing pulp yields as reported by Zobel, et al., but also for strength properties of solid wood products. The Cooperative is currently reviewing strategies so that greater emphasis can be placed on breeding for high-gravity juvenile wood. Note Table 13 from Pearson and Gilmore's report showing the very high proportion of juvenile wood (43%) in young merchantable fast-growing trees from the progeny test. Any cultural practice that results in faster-growing trees harvested at younger ages, whether it be fertilization, site preparation, genetics or other, will have the same effect. While breeding for high-gravity juvenile wood can help, it cannot completely overcome the inevitable reduction in average wood density resulting from the harvest of increasingly younger trees. Those Cooperative members that require low-gravity wood because of their product specifications will still be in good shape despite increased emphasis on high gravity by many in the Cooperative. We always have the option of selecting and breeding for either high or low wood density.

Table 13. Characteristics of 41-, 25-, and 15-year-old trees tested for wood strength properties by Pearson and Gilmore

Property	Units	Natural Forest (41-yr.)	Plantation Trees: Unselected (25-yr.)	Plantation Trees: Genetically Selected (15-yr.)
Diameter breast height (over bark)				
Average	in.	11.2	11.7	10.6
Minimum	in.	10.4	9.9	9.2
Maximum	in.	12.1	14.3	12.9
Number of rings per inch				
Inner specimens	no.	8.3	3.9	2.6
Outer specimens	no.	8.0	6.2	4.7
Summerwood				
Inner specimens	%	36	27	20
Outer specimens	%	42	40	37
Average diameter of juvenile wood in tree (estimated)	in.	2.5	4.9	6.3
Juvenile wood as percentage of area of wood cross-section of test trees	%	6	21	43

MISCELLANEOUS

Supportive Research

Substantial progress toward strengthening our supportive research effort has been made in the last year. The Tree Improvement Program with the Forestry Department and the Agricultural Research Service at N. C. State University have entered into a cooperative agreement with the U. S. Forest Service. Most noteworthy in this agreement has been the placement by the Forest Service of Dr. Floyd Bridgwater on our campus to work in collaboration with the Cooperative. Floyd has considerable experience with Weyerhaeuser in the West and the South, both in research and in tree improvement operations. His strength in the quantitative genetics area could be a great asset to the Cooperative.

Attractive seed orchards are always pleasant and popular places to visit. An excellent public relations effort such as this sign at Virginia's New Kent Seed Orchard pays dividends many times over.

A major research effort by Floyd will involve a thorough examination of advanced-generation selection strategies. Floyd will also be working with our graduate students, which will be most helpful.

The cooperative agreement with the Forest Service has also resulted in a substantial grant of research monies. The major objective for work with these monies is to establish a small breeding orchard to be used for studying the effects of inbreeding in the second generation. Grafting for this orchard was nearly completed this spring. Additional grant monies may be available to the Cooperative through this agreement; however, this must await decisions by Congress on the federal budget. Overall, the cooperative agreement with the Forest Service portends a very beneficial collaborative effort.

Students

The Cooperative continues to work with approximately 15 graduate students at both the Master's and Ph. D. level. The burden of this work largely falls to Bruce Zobel, with much interaction with students by Bob Weir and Floyd Bridgwater. All staff members of the Cooperative spend some time assisting students and guiding their research program activities. Student research is an integral part of the Cooperative's supportive research program. Currently, students are working on projects such as the economics of seed orchard irrigation, hybrid vigor from outcrossed selfed lines, genetic variation in stand carrying capacity, variation in natural Fraser fir stands, and on various aspects of breeding for rust resistance. Financial support for students comes from a variety of sources--the Cooperative Programs, the School of Forest Resources, the N. C. State University Agricultural Research Service, the U. S. Forest Service, and special industry-sponsored fellowships.

Staffing

While the Cooperative staff has grown to a degree over the years, we continue to operate a "lean" program. The fact is the membership, and thus the level of activity, has also grown in a commensurate manner. It is also evident that the intensification of advanced-generation activity places a heavier burden on the Raleigh staff as well as on each cooperator. One new position has been added to the data-processing section of the program. The position currently held by Maude Hardee was approved and budget for initiation July 1, 1979; however, we were able to move a bit faster on this as a result of the grant monies available.

Faculty-level staff are well known to cooperators because of their nearly constant travel to work with members in the field. Laboratory, secretarial and data-processing staff are not nearly so visible, yet their work is of equal importance and contributes vitally to the smooth and effective operation of the Cooperative. Our complete staff is currently as follows:

Faculty-Level Staff

Bob Weir, Director
J. B. Jett, Associate Director
Jerry Sprague, Liaison Geneticist
John Talbert, Liaison Geneticist
Bruce Zobel, Professor, Forest Genetics (only part-time with Cooperative)

Support Staff

Laboratory and Field Technicians:

*Vernon Johnson, Coordinator
*Martha Matthias
*Addie Byrd
*Ray Mann
*Rob Wilson (part-time student)

Secretarial:

*Martha Holland, Coordinator
*Kathy Hughes
*Margaret Funderburg

Data Processing:

Alice Hatcher, Coordinator
Maude Hardee
*Vernedia Hunter

*Individual's time and financial support shared by Tree Improvement and one or more other cooperative programs

MEMBERSHIP OF TREE IMPROVEMENT COOPERATIVE

Organization	States Where Operating
American Can Company	Ala., Miss.
Brunswick Pulp Land Company	S. C., Ga., Tenn.
Bowaters	Catawba Timber Co.--S.C., N.C., Va., Ga. Hiwassee Land Co.--Tenn., Ga., Ala., Miss., N. C.
Champion International	Alabama Region--Ala., Tenn., Miss. East Carolina Region--N.C., Va. West Carolina Region--S.C., N.C., Ga.
Chesapeake Corporation of Virginia	Va., Md., Del., N.C.
Container Corporation of America	Ala.
Continental Forest Industries	Savannah Div.--S.C., Ga. Hopewell Div.--N.C., Va.
Federal Paper Board Co., Inc.	N.C., S.C.
Georgia Kraft Company	Ga., Ala.
Georgia-Pacific Corporation	Va., N.C., S.C., Ga., Fla.
Great Southern Paper Company	Ga., Ala., Fla.
Hammermill Paper Company	Ala.
International Paper Company	Atlantic Region--N.C., S.C., Ga. Gulf Region--Miss., Ala.
Kimberly-Clark Corporation	Ala.
MacMillan-Bloedel Corporation	Ala., Miss.
Masonite Corporation	Miss.
North Carolina Forest Service	N.C.
Rayonier Inc.	Fla., Ga., S.C.
Scott Paper Company	Ala., W. Fla., Miss.
South Carolina State Commission of Forestry	S. C.
St. Regis Paper Company	Ala., Miss., W. Fla., Ga.
Tennessee River Pulp and Paper Co.	Tenn., Ala., Miss.
Union Camp Corporation	Savannah Div.--Ga., S.C., Ala. Franklin Div.--N.C., Va.
Virginia Division of Forestry	Va.
Westvaco Corporation	South--S.C. North--Va., W.Va., Ohio, Tenn., Ky., Miss.
Weyerhaeuser Company	N. C. Div.--N.C., Va. Miss.-Ala. Div.--Miss., Ala.

PUBLICATIONS BY OR OF SPECIAL INTEREST TO MEMBERS OF THE COOPERATIVE

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