

TESTS OF REALIZED GENETIC GAIN FROM A COASTAL VIRGINIA
LOBLOLLY PINE FIRST GENERATION SEED ORCHARD

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Abstract:--Percent volume gain observed in the performance of improved loblolly pine (Pinus taeda L.) mix seedlots at five locations ranged from -3 to +6 compared to the volume growth of commercial check seedlots. The improved mix seedlots were obtained from several seed collection years in a first generation seed orchard containing clones that originated from the Coastal Plain of southeastern Virginia and northeastern North Carolina. The data were obtained from eight- and four-year-old block plot tests in which the objective was to determine realized genetic gain from seed orchards.

INTRODUCTION

Realized genetic gain from seed orchards can be determined only by using appropriately designed field tests. Meaningful estimates of gain on a per acre basis can only be calculated from block plot tests of improved and unimproved seedlings (Zobel and Talbert, 1984). After thirty years of active tree improvement involving many industrial corporations and government agencies in the Southeast, there is surprisingly few published reports of block plot estimates of realized genetic gain. A volume gain of 20 percent in a rogued first generation loblolly seed orchard mix (origin: Coastal Georgia and South Carolina) was reported by Lowerts (1986) in a six-year-old test of realized gain. This paper will describe the gain in volume observed in eight- and four-year-old block plot test of realized genetic gain from a first generation loblolly pine seed orchard containing clones selected from natural stands in the Coastal Plain of Virginia and northeastern North Carolina.

EXPERIMENTAL METHODS

1979 TEST OF REALIZED GENETIC GAIN

In March, 1979, three locations of a loblolly pine test of realized genetic gain were established on a moderately well drained Goldsboro soil in Prince George and Isle of Wight Counties, Virginia (location 1 and 2, respectively) and on a moderately well drained Duplin soil in Hertford County, North Carolina (location 3). Eight replications of six or seven seedlots were planted (bareroot seedlings) at each location in 25-tree-block

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(5 x 5) plots at a spacing of 10 x 6 feet. The seedlots were:

1. An unimproved commercial check seedlot collected in 1975 by the North Carolina Forest Service (CCNCF), origin unknown.
2. An unimproved commercial check seedlot collected in 1967 by the Virginia Division of Forestry (CCVDF), origin known.
3. An unimproved commercial check seedlot collected by Union Camp Corporation (CCUCC) on Company lands in southeastern Virginia.
4. Three unrogued first generation seed orchard mix seedlots collected from the Murfreesboro Seed Orchard, Hertford County, North Carolina in 1973, 1975, and 1976 (SOM73, SOM75, SOM76), respectively. The clones in the orchard originated from wild stand selections in Southeast Virginia and Northeastern North Carolina.
5. A seed orchard mix seedlot collected in 1976 from a rogued block of the Murfreesboro Seed Orchard (SOMR76). Spacing and seed production were the primary considerations for roguing.

Because of a shortage of plantable seedlings, the SOM75 seedlot was not planted in location 1 and the CCVDF seedlot was not planted in location 2.

Site preparation of all locations consisted of KG and rake. Each seedling at each location of the 1979 test received six grams of Furadan, 10g and four ounces of 8-40-0 fertilizer. Seven years after planting (1986), herbicide (Velpar, L, 0.75 lb./acre) was applied to each location. Each location was mowed in 1981 and 1985.

1983 TEST OF REALIZED GENETIC GAIN

In February, 1983, two additional locations of a test of realized genetic gain from the Murfreesboro Seed Orchard were also established on a somewhat poorly drained Augusta soil in Isle of Wight County (location 1) and on a well drained Wagram soil in Southampton County (location 2), Virginia. Each location contained six replications of two different seedlots planted (bareroot seedlings) in 49-tree-block (7 x 7) plots at a spacing of 9 x 9 feet. The two seedlots were: 1. an unimproved commercial check mix seedlot, and 2. a first generation improved mix seedlot, Murfreesboro 1979 Group A. The commercial check mix seedlot was composed of seed obtained from the CCNCF, CCUCC, and CCVDF seedlots. The Murfreesboro Group A seedlot is a mix of the seed from the best performing clones in the seed orchard based on the 1978 North Carolina State University - Industry Tree Improvement Cooperative performance levels. The Murfreesboro Group A seedlot is not representative of an orchard rogued for genetic quality since the Murfreesboro orchard still contained many inferior clones in 1979. The seed from these poor performing clones was collected as Group B.

Site preparation of all locations consisted of KG and rake. Each seedling of each location received 10 grams of Furadan, 10G at the time of planting. Fertilizer was not applied to either location. Two years after planting, herbicide (Velpar, L, 0.75 lb./acre) was applied to each location. Location 1 was mowed in 1984 and 1986 and location 2 was mowed in 1986.

In the winter of 1987, total tree height, diameter (at breast height), and fusiform rust incidence were measured on the nine (3 x 3), and twenty-five (5 x 5) interior trees of the 1979 and 1983 tests, respectively. A meaningful estimate of diameter was unavailable in location 1 of the 1983 test of gains because of small tree size.

Statistical Procedure

Seedlot mean total height, diameter (DBH), percent fusiform rust infection, and percent survival were determined for each replication at each location using individual tree measurements. The incidence of fusiform rust was very low among all seedlots at all locations of both tests and was not considered for further analysis. Seedlots were analyzed on an individual basis or as the mean of improved and commercial check seedlots. The percent data was transformed by the arcsine procedure prior to the analysis of variance. Individual tree volume was calculated using the formula: $\text{Volume} = 0.03371 + 0.001961128 * (\text{Dia.} * \text{Dia.} * \text{Height})$ (Goebel and Warner, 1962). The total seedlot volume for each replication and each location was determined by summing the individual tree volumes. Total volume of each seedlot was adjusted for differences in survival. The combined analysis of variance for the 1979 and 1983 tests used location, seedlot, location*seedlot, and replication within location as the source of variation. For both tests, the results of the combined analysis revealed a highly significant ($p=0.01$) location effect for all variables except survival. In the 1979 test, height was the only variable that displayed a significant ($p=0.01$) difference among seedlots in the combined analysis. The location*seedlot interaction of any variable measured was not significantly different for either test. Mean height, and diameter, individual tree volume, and percent survival were then analyzed by location for each test using replication and seedlot as the source of variation.

RESULTS

1979 Test of Realized Genetic Gain

Seedlot mean height and individual tree volume were significantly different at location 1 (Table 1), all other variables at each location were not significantly different among seedlots. At each location, the improved seedlots displayed a slightly greater height than the commercial check seedlots (Table 2). The mean diameter of the improved and commercial check seedlots at each location was very similar. Percent survival was very uniform among the three locations.

Percent mean height gain of the improved seedlots compared to the average performance of the commercial check was +3, +2, and +1 at location 1, 2, and 3, respectively (Table 3). Percent volume gain of the average of the improved seedlots at each location versus the average of the commercial check seedlots was +6, -1, and +1 at locations 1, 2, and 3, respectively. The performance of the improved seedlots varied with the check seedlot used as a comparison. Volume gains of SOMR76 ranged from +2 to +12 percent when compared to CCUCC, and from -10 to +6 percent when compared to CCNCF (Table 4).

Table 1. Analysis of variance for height, diameter, individual tree volume, and percent survival for each location of the 1979 and 1983 tests of realized genetic gain.

Source of Variation	D.F.	-----Mean Square for-----			
		Height	Dia.	Ind. Tree Volume	Percent Survival
1979 TEST OF GAIN, LOCATION I					
Seedlots	5	5.1088**	0.1057 ^{ns}	0.0289*	0.0060 ^{ns}
Reps.	7	4.8599**	0.1433*	0.0423**	0.0225*
Error	35	1.2214	0.0569	0.0104	0.0092
1979 TEST OF GAIN, LOCATION II					
Seedlots	5	1.2569 ^{ns}	0.0190 ^{ns}	0.0029 ^{ns}	0.0035 ^{ns}
Reps.	7	3.1178*	0.2112*	0.0314**	0.0021 ^{ns}
Error	35	1.3592	0.0791	0.0099	0.0019
1979 TEST OF GAIN, LOCATION III					
Seedlots	6	1.7982 ^{ns}	0.0924 ^{ns}	0.0264 ^{ns}	0.0009 ^{ns}
Reps.	7	4.0849**	0.1635*	0.0436**	0.0183*
Error	42	1.1065	0.0618	0.0130	0.0079

1983 TEST OF GAIN, LOCATION I					
Seedlots	1	0.0428 ^{ns}	n.a.	n.a.	0.0012 ^{ns}
Reps.	5	0.1175 ^{ns}	n.a.	n.a.	0.0005 ^{ns}
Error	5	0.1714	n.a.	n.a.	0.0002
1983 TEST OF GAIN, LOCATION II					
Seedlots	1	0.1520 ^{ns}	0.0091 ^{ns}	0.0001 ^{ns}	0.0012 ^{ns}
Reps.	5	2.1686 ^{ns}	0.1876*	0.0014*	0.0018 ^{ns}
Error	5	0.6875	0.0389	0.0002	0.0050

where ** = significant at the one percent level of probability
 * = significant at the five percent level of probability
 ns = not significant

Table 2. Improved and commercial check mean height, diameter, and percent survival at each location of the 1979 and 1983 test of realized genetic gain, age 8 and 4, respectively.

Seedlot	Height (ft.)	Diameter (in.)	Percent Survival
1979 TEST OF GAINS, LOCATION I			
CHECK ^{1/}	22.4	4.0	97
IMPROVED	23.2	4.0	94
1979 TEST OF GAINS, LOCATION II			
CHECK	18.9	3.6	99
IMPROVED	19.2	3.6	97
1979 TEST OF GAINS, LOCATION III			
CHECK	22.7	4.1	95
IMPROVED	23.0	4.1	96

1983 TEST OF GAINS, LOCATION 1			
CHECK ^{2/}	6.8	N.A.	99
IMPROVED	6.7	N.A.	97
1983 TEST OF GAINS, LOCATION 2			
CHECK	10.4	1.7	96
IMPROVED	10.2	1.6	94

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Improved seedlot in the 1979 test of gains is the average performance SOM73, SOM75, SOM76, AND SOMR76 and the check seedlot is the average performance of CCUCC, CCNCF, and CCVDF.

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Improved seedlot in the 1983 test of gains is the Murfreesboro 1979 Group A mix and the check seedlot is a composite of seed from the CCNCF, CCUCC, and CCVDF seedlots.

N.A. = Not Available

Table 3. Percent volume and height gain of the average total volume and height of the improved seedlots compared to the average total volume and height of the commercial check seedlots at each location of the 1979 (age 8) and 1983 (age 4) tests of realized genetic gain.

Age	Test	Location	% Volume Gain	% Height Gain
8	1979	I	+6	+3
8	1979	II	-1	+2
8	1979	III	+1	+1
4	1983	I	N.A. ^{1/}	-1
4	1983	II	-3	-2

N.A. = Not Available

Table 4. Percent volume gain from SOMR76 compared to the CCUCC, and CCNCF commercial check seedlots at each location of the 1979 test of gains.

Location	% Volume Gain Vs. CCUCC	% Volume Gain Vs. CCNCF
I	+11	+ 6
II	+ 2	- 3
III	+12	-10

where CCUCC = Union Camp Commercial Check
 CCNCF = North Carolina Division of Forestry Check
 SOMR76 = Seed Orchard Mix Rogued 1976

1983 Test of Realized Genetic Gain

The improved and commercial check seedlot mean height, diameter (location 2), individual tree volume (location 2), and percent survival were not significantly different at either location (Table 1). The performance of the commercial check exceeded that of the improved seedlot for all variables measured at each location (Table 2). Survival at each location was excellent. Percent mean height gain of the improved over that of the commercial check seedlot was -1 and -2 percent at location 1 and 2, respectively (Table 3). A 3 percent volume loss in the improved seedlot occurred at location 2. The percent volume gains observed in this study should be interpreted with caution since gain estimates at age four and eight years could be influenced to a large extent by the presence of a few big trees (Zobel and Talbert, 1984).

DISCUSSION

Talbert (1982), using row plot data and growth and yield modeling estimated 15- and 25-year-old volume gains from a rogued and unrogued first generation seed orchard to be 20.0 and 12.5, and 10.0 and 6.5 percent, respectively. Realized plantation volume gain from the first generation of tree improvement was estimated by Weir (1973) to be between 10 and 20 percent. These and other theoretical estimates of volume gain have been supported by the 20 percent gain in volume observed in a rogued first generation seed orchard mix seedlot (origin of clones: Coastal Georgia and South Carolina) in a six-year-old block plot test of realized genetic gain (Lowerts, 1986). The volume gains observed in the 1979 and 1983 tests of realized genetic gain are low (-3 to +6 %) when compared to the theoretical gain estimates and previously reported realized volume gains for loblolly pine. The individual improved seedlots in the 1979 test contained seed from many clones which have been rogued from the orchard and approximately 25 percent of the total seed volume in the seedlots could have been supplied by a very poor performing but prolific seed producing clone (2-40) (Stone, 1987). Also, 57 percent of the clones represented in the 1979 Murfreesboro Group A seedlot (1983 test) have been rogued from the orchard. Today, only the 12 best performing of the original 48 clones remain in the Murfreesboro seed orchard and the genetic quality of the seed greatly exceeds that of the seed in the improved seedlots of the 1979 and 1983 tests of realized genetic gain. The presence of seed from the poor performing clones in the improved seedlots in both the 1979 and 1983 tests of gain probably contributed to the relatively low level of observed volume gain.

The results of the 1979 and 1983 tests of realized genetic gain have not clearly established the level of genetic gain achieved by the first generation of tree improvement in the Coastal Virginia area. Also, the results clearly suggest the level of genetic gain observed is dependent on the choice of the commercial check seedlot. The SOMR76 seedlot performed well when compared to the CCUCC seedlot but the volume performance of SOMR76 was not as good when compared to the commercial check seedlot from the North Carolina Forest Service (CCNCF). The CCNCF seedlot performed very well at each location of the 1979 test and probably influenced the growth of the

commercial check mix seedlot in the 1983 test. Unfortunately, the origin of CCNCF in North Carolina cannot be established (Zoerb, 1985). If CCNCF were collected in the southeast coastal area of North Carolina, it would probably possess excellent growth characteristics as displayed in this study since the Onslow County, North Carolina source of loblolly pine was identified by Wells (1983) as a source with good growth potential. The long term adaptability of CCNCF to the environment of Virginia has not been determined. However, through age eight, the CCNCF is performing better than virtually all other seedlots and has displayed excellent survival at each test location suggesting that CCNCF may be adaptable to the environment of Coastal Virginia.

Although positive volume and height gains in the first generation improved seedlots did occur at some locations of the 1979 test, the results of this study suggest the absolute level of genetic gain achieved by the first generation of tree improvement in the coastal region of Southeast Virginia and Northeast North Carolina may not approach the level of genetic gain observed or predicted in other breeding regions. Union Camp Corporation's lands in Virginia and North Carolina are located near the northern fringe of the natural range of loblolly pine. Although experimental evidence is lacking, the opportunity to select outstanding trees for growth characteristics in this region could be reduced because the variation in growth near the northern fringe of the species may be less than that of the southern range. The shorter growing season and harsher winter of Virginia may restrict the expression of growth characteristics, whereas the mild, moist environment of the Atlantic Coast Region of South Carolina and Georgia, where many outstanding selections have occurred, may allow for considerable variation in growth characteristics. The results of this study also suggest that various sources of loblolly pine from North Carolina may perform well in the Coastal Virginia area. A future test of realized gain containing a seed orchard mix of the 12 best remaining clones in the Murfreesboro orchard will provide an estimate of the level of genetic gain achieved when all poor performing clones are rogued.

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