LOBLOLLY PINE IMPROVED PLANTING STOCK-VEGETATION CONTROL STUDY - RESULTS AT AGE 6

Plantation Management Research Cooperative

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The Plantation Management Research Cooperative was established in the mid 1970's with the objectives of (1) developing growth and yield models for the current generation of site prepared slash *(Pinus elliotii* Engelm) and loblolly *(Pinus taeda* L.) pine plantations and (2) designing and implementing experiments which would lead to improved pine plantation management and growth and yield models incorporating variables such as site preparation method and degree of genetic improvement. Most of the cooperator companies in the PMRC were also cooperators with one or both of the tree improvement cooperatives in the Southeast and they had large investments in tree improvement.

A common problem for forest planners was estimating the increase in production they could expect from using genetically improved seedlings. Evidence from progeny test results indicated volume gains ranging from 7% to 19% (Hodge et al 1989, Talbert et al 1985). Progeny tests were typically planted as single row plots and concerns were raised regarding their appropriateness for adjusting growth and yield model results. In addition, progeny tests often received better cultural treatment such as mowing and fertilization than operational plantations. Some researchers expressed concern that these cultural treatments could confound results from progeny tests (Cooper and Ferguson 1977, Duba et al 1984). Also, growth and yield systems now routinely provide breakdowns of stand structure in addition to total yield. This level of modeling sophistication could not be developed using row plot information.

The PMRC established a study in 1986-87 with the following objectives:

(1) evaluate the impact of genetic improvement on yields for planning purposes.

(2) evaluate the impact on yields of combining genetic improvement and vegetation control.

(3) evaluate single family genetically improved plantations versus bulk lot genetically improved plantations.

Yields, as used in these objectives, refers not only to total volume or weight, but also to stand structure and variability. Of particular interest will be the product breakdown and the range and skewness of the diameter distribution. Results from this study should include a growth and yield model for stands planted with rogued first generation genetically improved stock and should provide insight into how to incorporate genetic improvement into future growth and yield models.

Methods

The study was established in Georgia, Alabama, western South Carolina and north Florida. For loblolly pine, the study area was divided into two physiographic regions, Piedmont and Coastal Plain. All slash pine installations were established in the Coastal Plain. The study actually consists of three separate studies, the two loblolly regions which contain different genetic material and are analyzed separately and the slash study. The PMRC membership at the time of study initiation was polled to determine the top ten families by species and region for each company. Those results were compiled and the top six families for each region and species were tentatively scheduled for inclusion in the study. Before final inclusion, the loblolly families were checked by personnel at the North Carolina State University Industry Cooperative Tree Improvement Program and the slash pine families were checked by personnel at the Cooperative Forest Genetics Research Program at the University of Florida. They compared their rankings with those provided and paid particular attention to disease resistance. If the family passed muster and enough seed could be obtained from cooperators for inclusion in the study, the family was included.

The families finally chosen for inclusion are listed in Table 1 by their respective cooperative identification numbers.

Table 1. Families chosen for inclusion in the PMRC Improved Planting StockVegetation Control Study by species and region.

Coastal Plain Loblolly	Piedmont Loblolly	Coastal Plain Slash
7-34	12-12	106-56
10-5	5-5	6-56
17-5	12-9	35-60
10-25	12-7	56-56
7-56	1-14	261-56
7-2	15-42	187-57

In addition to these genetically improved families, unimproved seed was obtained from International Forest Seed in Birmingham, AL. This unimproved seed was obtained in the same regions encompassed by the study and was not obtained from seed orchards or seed production areas. There were three separate lots of unimproved seed corresponding to the three region/species combinations in the study.

Eight treatment plots were included at each study installation:

(1) Unimproved stock, no vegetation control

(2) Unimproved stock, complete vegetation control

(3) Bulk lot improved stock, no vegetation control

(4) Bulk lot improved stock, complete vegetation control

(5) Replicate plot of one of the first four treatments

(6) Single family improved stock, no vegetation control

(7) Single family improved stock, complete vegetation control

(8) Replicate plot of one of the single family treatments Bulk lot improved stock was obtained by mixing equal amounts of the improved stock seed of the six selected families for a particular species and region. The mixed lot was grown together in a common nursery. In addition, some of the seed from each family was kept separate and grown in the nursery beds as single family plantings. All seed came from cooperator owned open pollinated seed orchards. All seedlings were grown in the Union Camp Corporation nursery at Belleville, GA.

Fifty locations of the study were established with 15 Piedmont loblolly, 16 Coastal Plain loblolly, and 19 Coastal Plain slash pine locations. The loblolly studies were established in 1986-87 and the slash plots were established the following year. At each location, treatments 1-4 were randomly assigned to plots and one of the four was randomly selected for replication. In addition, a single family was randomly selected for the location and treatments 6 and 7 were established on randomly selected sites. Either treatment 6 or 7 was randomly selected for replication. In total, there were 8 plots at each location. Locations were treated as replications of the experiment since region wide recommendations were the objective of the study. The replications at a location represented an attempt to quantify the within location error.

Each plot was 0.4 acres in size with a relatively centrally located 0.2 acre measurement plot. Seedlings were hand lifted in January and were planted the same week as lifting at a density of 700-750 per acre. The complete vegetation control treatments were imposed over whatever operational site preparation treatments used by the cooperator at the site. Control was maintained by killing woody vegetation prior to planting with prescribed herbicides, by spraying sulfometuron methyl in early spring of each of the first three growing seasons, and by directed sprays of glyphosate as needed during the growing season. The necessity of the directed sprays declined markedly after the second growing season as planted pines captured the site.

After the third and sixth growing seasons, every other pine on the measurement plots was measured for dbh (0.1 in) and total height (ft). Each tree was checked for evidence of stem cankers of fusiform rust (Cronartium *fusiforme* Hedge. and Hunt).

Two separate analyses were made for each species and region. In one analysis the first four treatments were included and tests were made for significance of vegetation control, genetic improvement, and the interaction of genetic improvement and vegetation control. In the second analysis treatments 3, 4, 6, and 7 were included and tests were made for differences in single family vs bulk lot, vegetation control, and the interaction of vegetation control and type of improved stock (bulk lot or single family). Separate analyses were made for average tree height, average tree dbh, average basal area per acre, and percent cronartium infection. All statements of statistical significance in this report refer to tests made using alpha=.05.

Since slash pine was planted one year later, the measurements of those installations is ongoing in this 1993-94 measurement season. For that reason this report includes only the loblolly analyses.

Results and Discussion

Analysis of unimproved vs bulk lot improved

An analysis of variance appropriate for a factorial design was conducted for average dbh, average total height, average cronartium infection, and basal area per acre at age six. Treatments 1-4 were included in this analysis. The factorial design consisted of two factors, vegetation control and genetic improvement, each at two levels. Vegetation control was either none other than that provided by the operational site preparation or complete control. Genetic improvement was either none (unimproved) or bulk lot improved where the makeup of the bulk lot was an approximately equal mixture of the six families included in the region.

Piedmont Loblolly. Both bulk lot genetic improvement and vegetation control were significant for average dbh, average total height, and average basal area per acre. There was not a significant interaction between vegetation control and genetic improvement. Genetic improvement was significant for percent cronartium infection, but vegetation control was not significant. Means for the four variables are shown in Table 1. The design of the experiment allows for separation of the effects of genetic improvement, vegetation control, and the interaction of genetic improvement and vegetation control(GxV).

Table 1. Average dbh (in), height (ft), basal area per acre (sq. ft.), and percent cronartium infection by treatment for Piedmont loblolly installations.

Treatment	Treatment Code	Average Dbh	Average Height	Average Basal Area	Average Cronartium
1	UNVC	2.73	15.5	29.1	4.3
2	UCVC	3.92	19.5	58.8	5.8
3	INVC	3.08	17.4	37.6	2.6
4	ICVC	4.18	21.8	63.8	2.5

Table 2. Gain in average dbh, average height, average basal area per acre, and cronartium percentage from genetic improvement, vegetation control, and their interaction.

Treatment	Average Dbh	Average Height	Avg. Basal Area/Acre	Avg. Percent Cronartium
Veg. Cntl (V)	1.2	4.0	29.7	1.5
Gen. Imp. (G)	0.4	2.0	8.5	-1.6
GxV	1.5	6.3	34.7	-1.8

On a percentage basis, gains in average dbh from vegetation control were 40% (Figure 1), gains in average height were 27°l0 (Figure 2), and gains in average basal area per acre were approximately 100% (Figure 3). On the downside, gains in cronartium infection were about 35% from the vegetation control treatment (Figure 4). Genetic improvement resulted in gains of 15% for average dbh (Figure 1), 13% for average height, and 29% for average basal area (Figure 3). Genetic improvement resulted in a decrease in cronartium infection of 37% (Figure 4). Differences in growth over the last three years follow the same patterns as for average individual tree characteristics (Figure 5 and Figure 6).

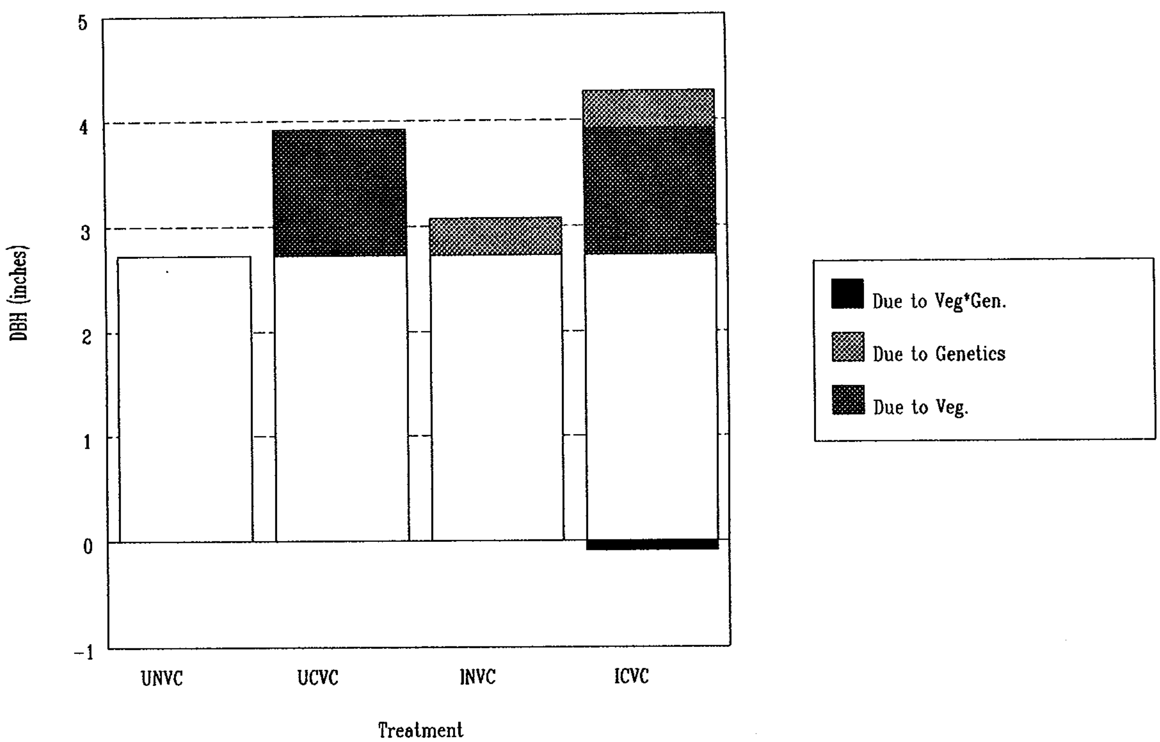

Figure 1. Average DBH vs. treatment for Piedmont loblolly pine at age 6.

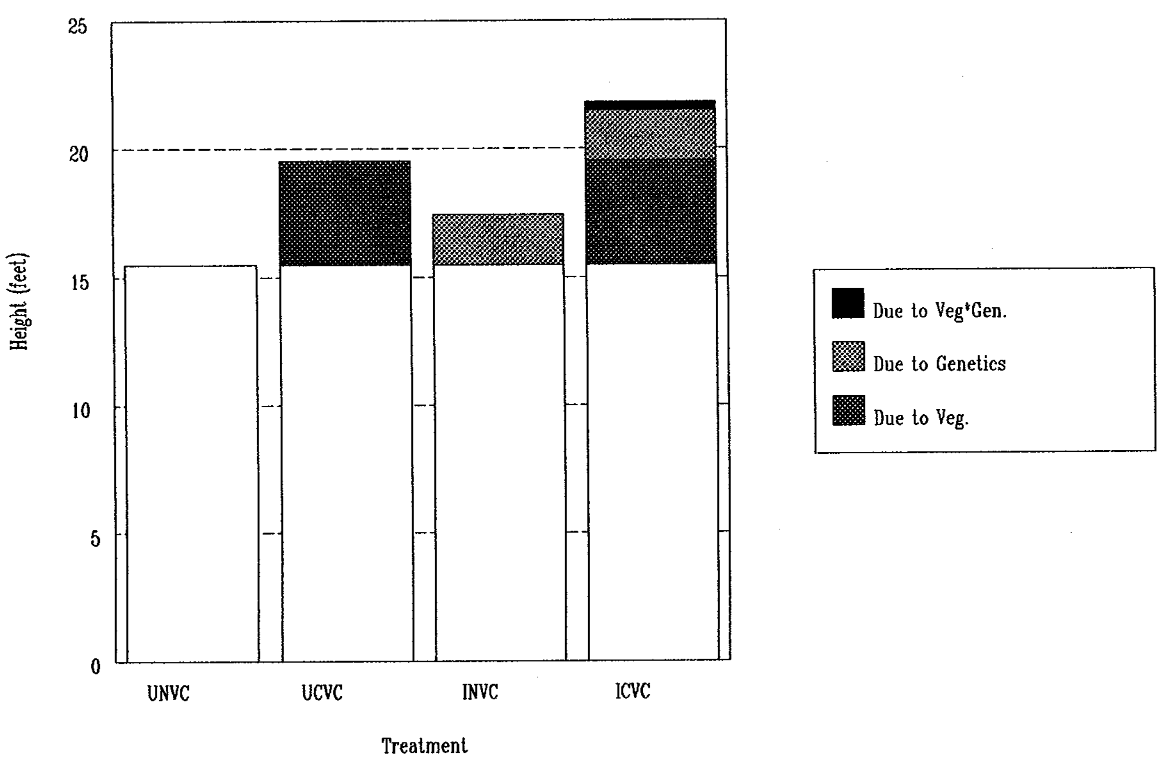

Figure 2. Average height vs. treatment for Piedmont loblolly pine at age 6.

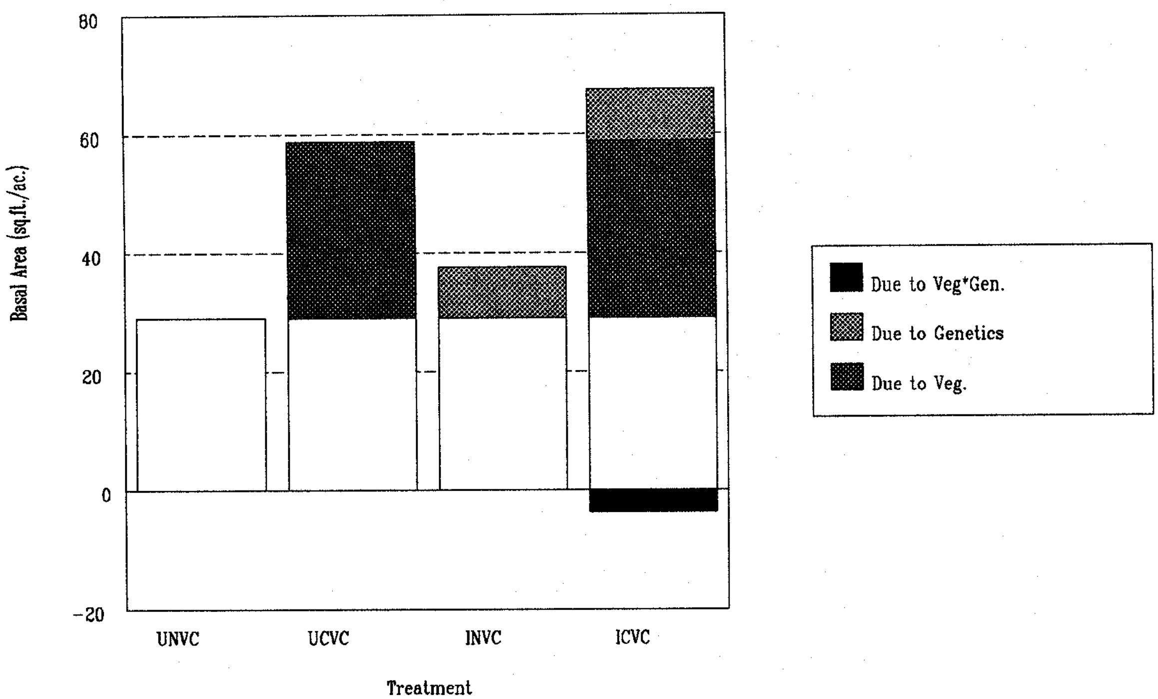

Figure 3. Average basal area per acre for Piedmont loblolly pine at age 6.

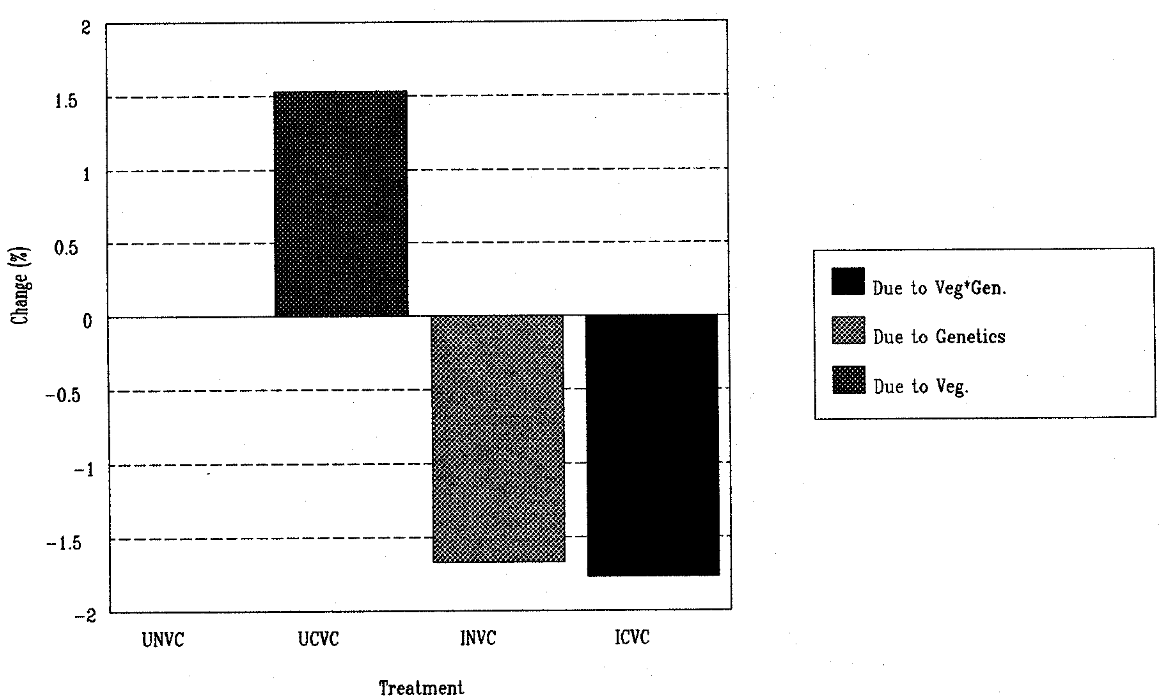

Figure 4. Average change in percent Cronartium infection for Piedmont loblolly at age 6.

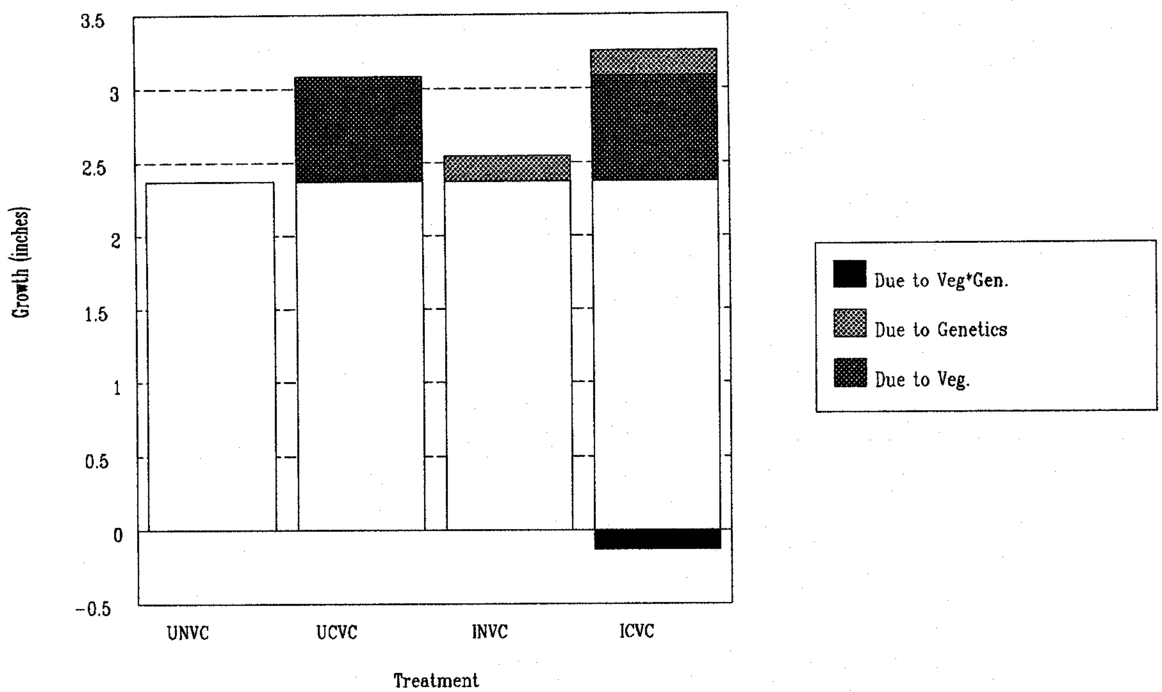

Figure 5. Growth in average DBH from age 3 to age 6 for Piedmont loblolly pine.

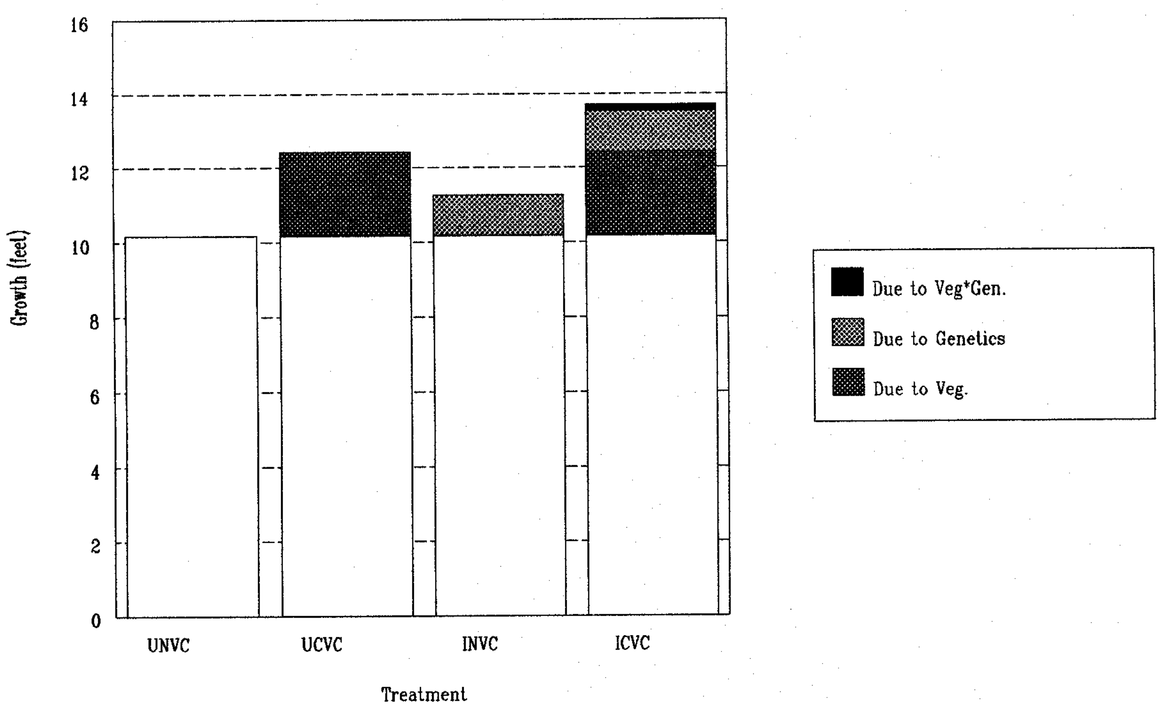

Figure 6. Growth in average height from age 3 to age 6 for Piedmont loblolly Pine.

Coastal Plain Loblolly. Vegetation Control resulted in significant differences in average dbh, average total height, and average basal area per acre for Coastal Plain loblolly pine. Bulk lot genetic improvement resulted in significant differences in average total height and average percent cronartium infection. Differences in average dbh and average basal area due to genetic improvement were not significant in the Coastal Plain. The GxV interaction was not significant for any variable in the coastal plain analysis. Means for the different variables by treatment are shown in Table 3.

Table 3. Average dbh (in), height (ft), basal area per acre (sq. ft.), and percent cronartium infection by treatment for Coastal Plain loblolly installations.

Treatment	Treatment Code	Average Dbh	Average Height	Average Basal Area	Average Cronartium
1	UNVC	2.83	16.4	33.5	6.8
2	U CVC	3.78	19.9	55.3	7.9
3	INVC	2.84	17.4	34.5	3.7
4	ICVC	3.93	22.2	59.0	3.0

Gains from the different treatments are shown in Table 4. Vegetation control resulted in a gain of 0.43 (15°!0) inches in average dbh (Figure 7), 3.5 feet (21 %) in average height (Figure 8), 21.8 sq. ft. (65%) in basal area per acre (Figure 9). Genetic improvement resulted in gains of 1.0 foot (6%) in average height (Figure 8) and a decrease of 3.1 % in average cronartium infection(Figure 10). The GxV interaction was not significant for any variable. Differences in loblolly growth over the last three years in the Coastal Plain closely followed the pattern of treatment differences of individual tree characteristics (Figure 11 and Figure 12).

Table 4. Gain in average dbh, average height, average basal area per acre, and cronartium percentage from genetic improvement, vegetation control, and their interaction for Coastal Plain loblolly installations.

Treatment	Average Dbh	Average Height	Avg. Basal Area/Acre	Avg. Percent Cronartium
Veg. Cntl (V)	0.43	3.5	21.8	1.1
Gen. Imp. (G)	-.07	1.0	1.0	-3.1
GxV	0.42	5.8	25.5	-3.8

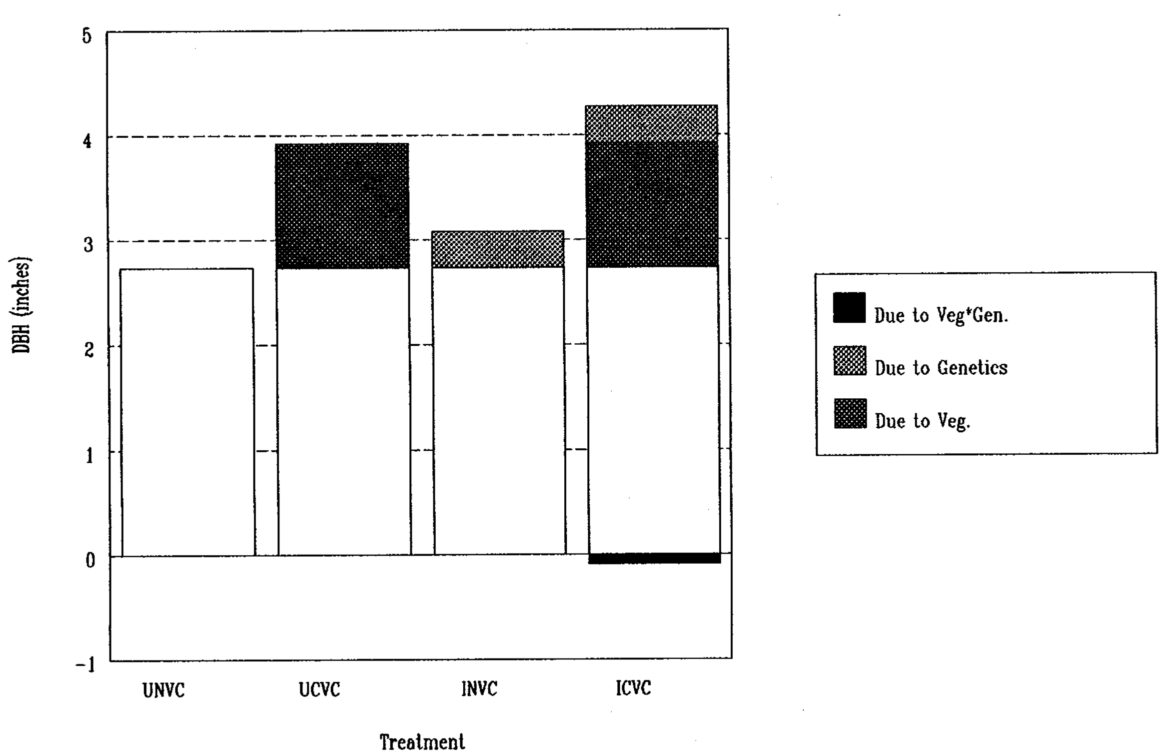

Figure 7. Average DBH vs. treatment for Coastal Plain loblolly pine at age 6.

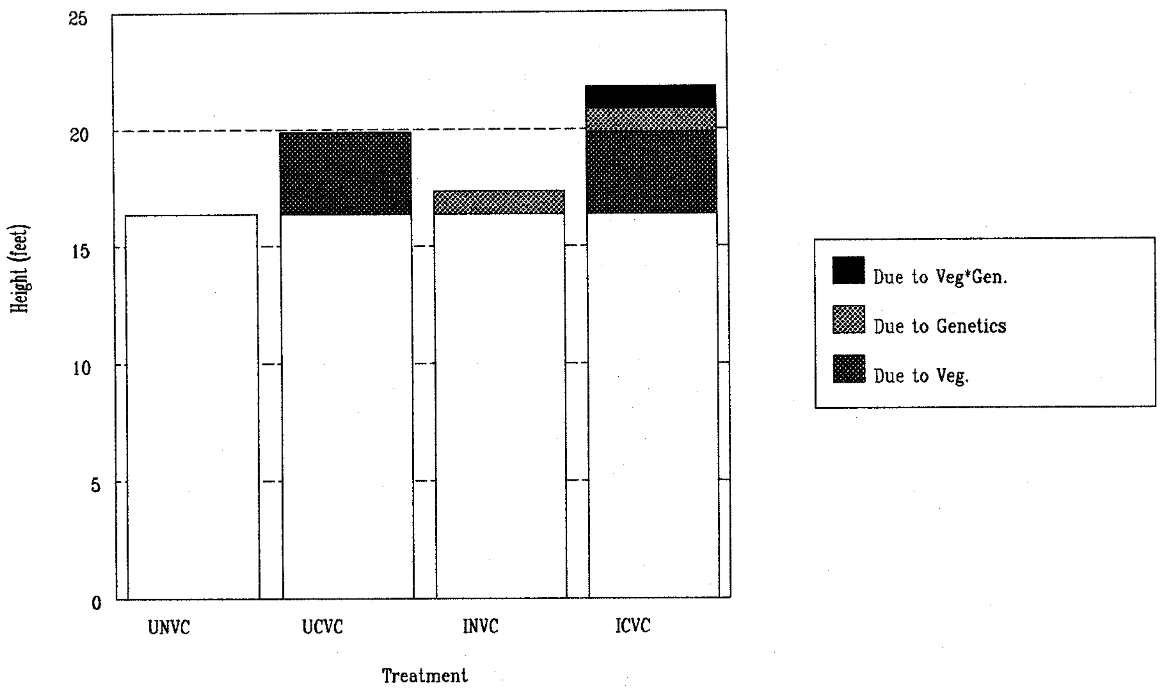

Figure 8. Average height vs. treatment for Coastal Plain loblolly pine at age 6.

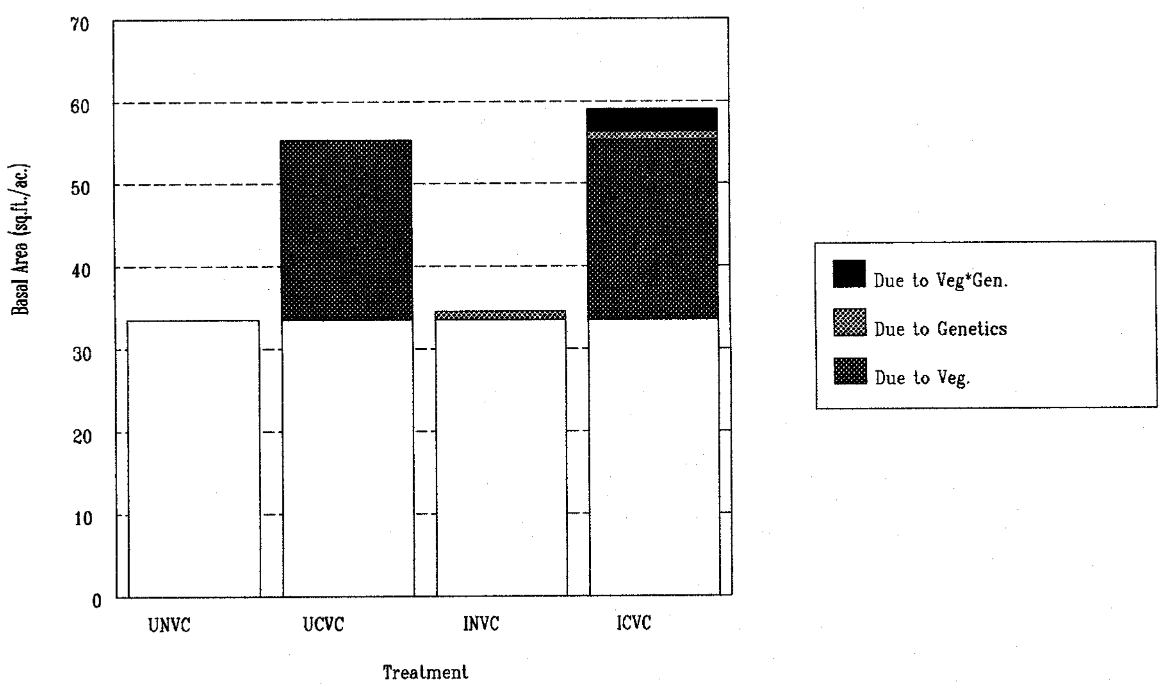

Figure 9. Average basal area per acre vs. treatment for Coastal Plain loblolly pine at age 6.

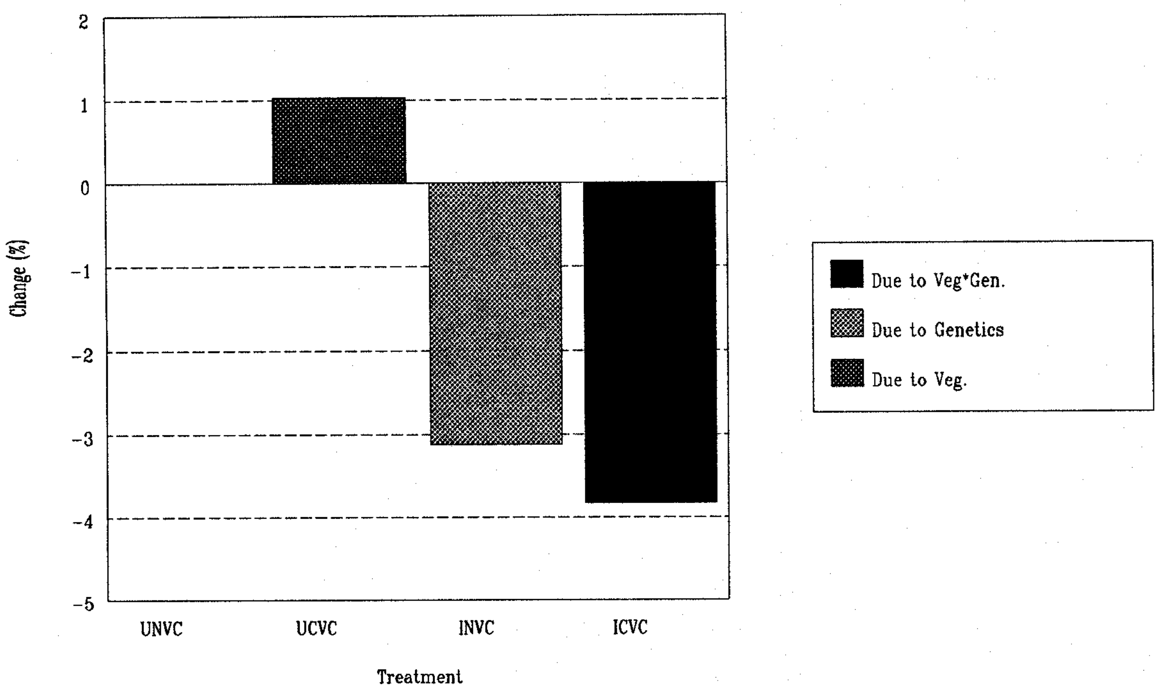

Figure 10. Change in percent Cronartium infection vs. treatment for Coastal Plain loblolly pine at age 6.

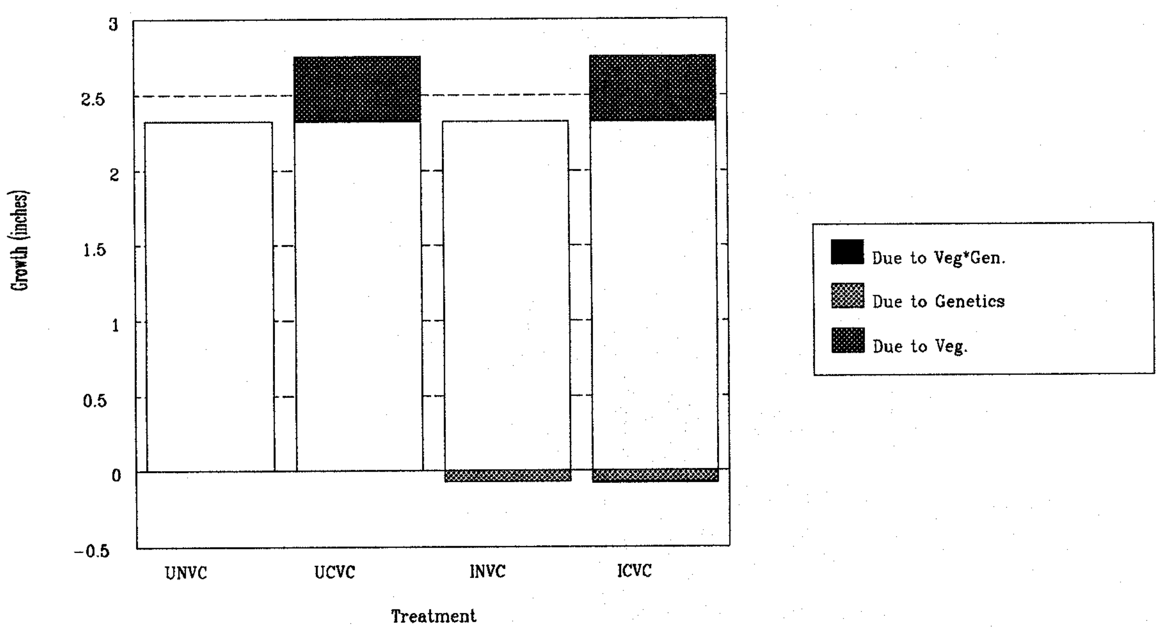

Figure 11. Average DBH growth from age 3 to age 6 vs. treatment for Coastal Plain loblolly pine.

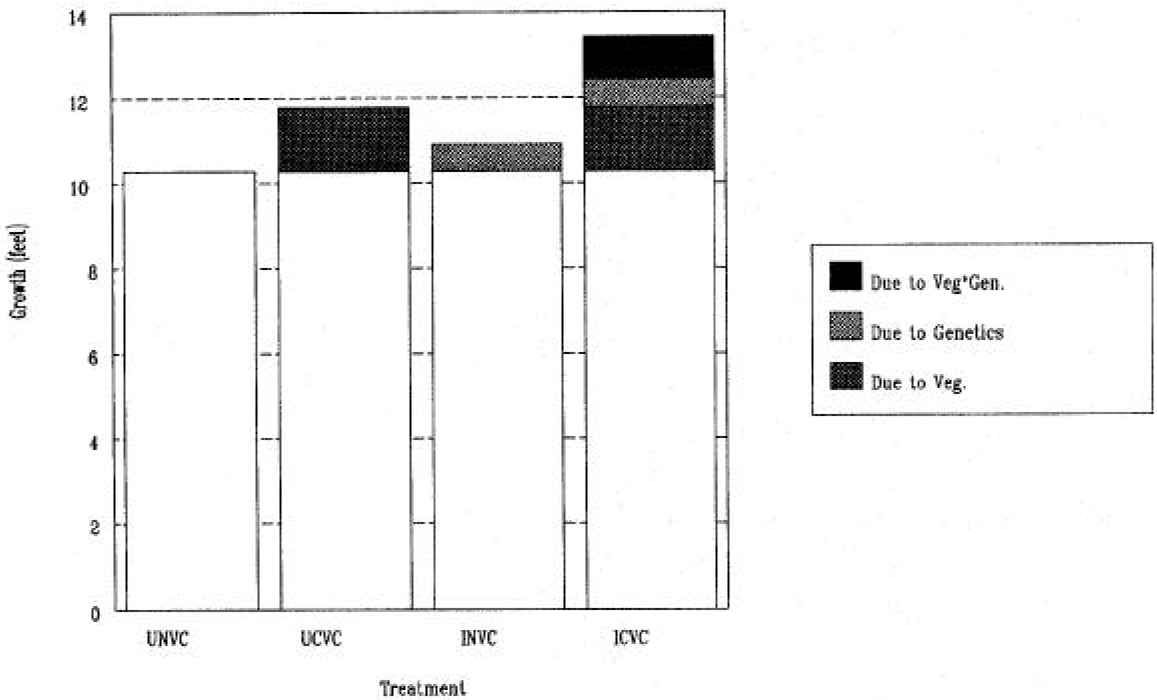

Figure 12. Average height growth from age 3 to age 6 vs. treatment for Coastal Plain loblolly pine.

Single Family vs Bulk Lot Improved Analysis

This analysis involved only genetically improved treatments, two bulk lot improved treatments and two single family plantings. The analysis of variance was conducted for a factorial arrangement of treatments as before. The factors in the experiment were vegetation control at two levels, none and complete, and genetic improvement at two levels, bulk lot and single family. The analysis was carried out across all installations and separately by family. The separate analyses involved only 2-3 installations for each analysis.

Piedmont Loblolly. The analysis across all installations resulted in no significant differences between single family and bulk lot improved means for any variable. This is not too surprising since the single families make up the bulk lot.

The analysis by single family resulted in only one significant difference between single family and bulk lot plantings (Table 5). Family 5-5 had significantly higher cronartium infection (3.2% vs 1.1 %) than did bulk lot plantings on the two installations where 5-5 was planted in the single family treatment. All other significant differences in these 6 analyses were the result of vegetation control (Table 5). After six growing seasons, there is little reason to prefer single family plantings over bulk lot plantings examining only their field performance.

Table 5. Significant factors in the single family vs bulk lot analyses for Piedmont loblolly installations. G=Genetic, V=Vegetation control.

Family	# of Inst.	Avg. Dbh	Avg. Ht.	Avg Cron%	BA/Acre
1-14	3	V	V		V
12-12	3	V	V		V
12-7	2				
12-9	3	V	V		V
15-42	2				
5-5	2	V			G

Coastal Plain Loblolly. The same analyses were performed on the Coastal Plain loblolly data. Again, the analysis over all installations resulted in no significant differences between bulk lot and single family plantings. The results of the single family analyses are summarized in Table 6. Only one family, 7-2, had significant differences in treatment means due to genetics. Family 7-2 had an average dbh after six years of 3.0 vs 2.6 for the bulk lot on those installations where 7-2 was the single family planting. The average height for 7-2 was 16.6 feet compared to 14.9 for the bulk lot planting.

Table 6. Significant factors in the single family vs bulk lot analyses for Coastal Plain loblolly installations. G=Genetic, V=Vegetation control.

Family	# of Inst.	Avg. Dbh	Avg. Ht.	Avg Cron%	BA/Acre
10-25	3	V	V	V	V
10-5	3	V	V		V
17-5	2	V	V		V
7-2	3	V, G	V, G		V
7-34	2	V			V
7-56	3				V

Summary

For Piedmont loblolly pine both vegetation control and genetic improvement significantly increased average tree characteristics and basal area per acre. For Coastal Plain loblolly pine, vegetation control significantly increases virtually all individual tree characteristics and basal area per acre, but genetic improvement has very little effect on tree size other than average height. In both regions, genetic improvement had a positive effect of reducing average cronartium infection, even with faster growth rates.

Analysis of differences between single family plantings and bulk lot plantings resulted in very few significant differences. At age six there is no growth response reason to prefer either single family or bulk lot plantings to the other.

Future work on this study will examine variability in addition to yield. There will also be an attempt to correlate growth with quantity of vegetation present on the plots.

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