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Height Growth of Ponderosa Pine Progenies

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Research at the Institute of Forest Genetics at Placerville, California since its inception in 1925, has been concerned with the variation in individual trees of a speices. We are interested in this variation as a guide to selection of outstanding individuals. Western forests have considerable diversity in soils, topography, species composition, and distribution of age classes in stands. All of this variability is reflected in the phenotype of the tree and tends to make field selection of genetically superior individuals difficult. Is an outstanding tree genetically superior, or is it just the product of a succession of favorable environmental conditions? Progeny testing of selected individuals is a means of estimating their genetic worth, but such tests for any number of trees require considerable land area and many years using present methods of measuring older trees. Can juvenile characters of progenies be used to estimate inherent superiority of seed trees? This and the preceding question were posed by Lloyd Austin, formerly in charge of the work at the Institute.

He resolved to learn whether one tree would produce better progenies than the next and whether he could find progeny differences in the nursery. He organized a colossal study of 729 progenies of trees growing in the locality of the Institute. To our knowledge, no study before or since has encompassed this many progenies of individual trees.

How did Austin go about this undertaking? First he sent scouts into the field in 1934 to search for cone-bearing trees. Any tree bearing ten cones qualified for admittance. Infrequently, when many cone-bearing trees were found together, just the best looking trees were chosen. The cones were collected from the tagged trees by crews of climbers. When all of the seed had been extracted, lo and behold, seed had been collected from only 400 progenies. Austin felt more were needed.

He waited for the next cone crop, but nature failed in 1935. The remainder of the trees were not selected and brought into the study until the 1936 cone crop. To enable assessment of the difference between the '34 and '36 crops, Austin made collections from 67 trees in both years. A total of 627 ponderosa and 33 Jeffrey pine seed trees were represented in the 729 progenies.

Finally in the spring of 1937 all was in readiness. The cubic volume of 200 seeds from each progeny, as an expression of seed size, had been measured. The nursery beds were prepared, and progenies were sown in an intricate triple lattice design reported by Day and Austin.[2] For each progeny 6 seeds were sown at each of 6 spots in each of 9 replications: 324 seeds in all. Each of 236,196 seeds was planted individually in a depression in the soil.

Numerous records were made of nursery performance to answer the second of Austin's questions. The germination of the seeds was observed, and the number of days required for germination was recorded. When germination was complete, all but the most westerly seedling at each spot were thinned. Growth of the remaining 40,000 seedlings was measured at one and two years. Part of these data are the concern of this paper. Other records on characters of branching, needles, and secondary shoot growth are presently under analysis.

All of the seedlings grown in the nursery could not be outplanted to observe subsequent growth and development. After much debate and calculation, Austin decided on 81 progenies; each was represented by 48 seedlings, 3,888 in all. Most of the progenies were selected for their superior growth in the nursery. Others were selected to show the effects on subsequent growth of: (1) crop year of seed collection; (2) seed size; (3) germination time; (4) progenies which made the most and least nursery growth from elevational zones; (5) progenies from isolated possible self-pollinated trees; (6) progenies from trees growing in close association in the field.

At the suggestion of an eminent statistician, Dr. F. Yates, the plantation was laid out in a 9 x 9 double lattice design with 3 replications. Insects rendered one of the replications useless, leaving 2 replications intact. Sixteen trees of each progeny were planted in a 4 x 4 arrangement in each replication. Thus, 32 trees of each progeny were available for measurement of height and diameter after 15 growing seasons.

The measurements and compilation of data were supervised by J. W. Duffield, formerly geneticist at the Institute. K. R. Nair, Forest Research Institute, Dehra Dun, India, subjected the compiled data to statistical analysis. We have conducted further statistical analyses.

What kind of general information have we gleaned from these piles of data? Briefly, our first multiple regression analyses bring out several important relationships (Fig. 1).

(1) Seed size and germination time were related to crop year; 1934 seed

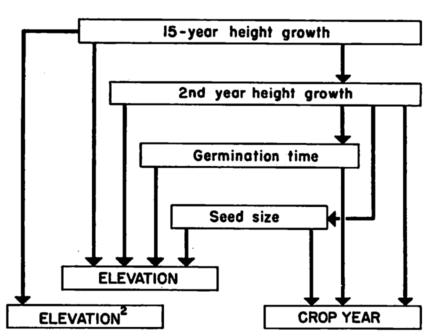

Fig. 1.—Analyses made and significant relationships found.

[1]Maintained at Berkeley, Calif. by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California.

[2]Day, Besse B. and L. Austin. 1939. A three-dimensional lattice design for studies in forest genetics. Jour. Agr. Res. 59(2): 101-120, illus.

was smaller and germinated slower than 1936 seed.

(2) Seed size and germination time were related to elevation of the seed source; seed from lower elevations in both crop years was larger and germinated faster than seed from higher elevations.

(3) Height growth in the second year and the volume of 2-year-old seedlings were related to seed size, germination time, elevation of the seed source, and crop year of the seed; greatest second-year-growth was found in large-seeded, fast-germinating, low-elevation progenies from the 1936 crop; 50 percent of the variation in second-year height growth was associated with variation in these variables.

(4) Height growth at 15 years was related to height growth in the second year, elevation of the seed source, and elevation-squared; progenies growing most in the second year and arising from middle elevation (2000-3000 feet) sources were tallest at 15 years; 49 percent of the variation in 15-year height was accounted for by variation in these 3 variables.

(5) Height growth at 15 years could not be associated with other factors; crop year of the seed, seed size, and germination time all had lost their significant influence on growth.

We have applied our general finding to the practical problem of predicting from seedling measurements the 15-year performance of progenies. Selection of the progenies growing tallest in their second year, which requires only one direct measurement, is efficient. If in addition, the elevation of seed source is known, the accuracy of the prediction of 15-year height will be improved. Second-year height growth and its square accounts for 38 percent of the variability in 15-year height; second year height growth in combination with elevation and elevation squared accounts for 49 percent. In practice, if seed collection is restricted to trees growing in the zone of optimum elevation of seed source, selection of prospectively superior progenies can be based solely on second-year height growth.

We also have found that the growth of some progenies at 15 years deviates significantly from what we would have expected for that seed tree on the basis of nursery performance and elevation. These seed trees and their neighbors deserve further study. Some offer promise for increasing growth; other seed trees probably should be avoided because of progressively poorer performance of their progenies. These latter trees were isolated individuals where self-pollination was likely.

The most important product of this long-term piece of research is the relationship established between the juvenile and later growth of progenies. Hereditary differences in terminal elongation show through as early as the second year of growth. If comparable studies of other species substantiate this finding, the length of time and the land area required for progeny testing may be dramatically reduced in the future. Only the most promising progenies in the nursery bed would have to be plantation tested.