MOTHER TREE HEIGHT AND SEED WEIGHT EFFECTS ON A NORTH-CENTRAL MINNESOTA POPULATION OF JACK PINE[1]

Wendy A. Radsliff[2]

Abstract . -- The effect of seed weight and parent height on two populations of two to ten-month old greenhouse grown jack pine seedlings was examined. The first population was derived from natural stand collections in north-central Minnesota. Seed weight was positively correlated to progeny height over the ten month period. The selection for family height was equivalent to selection for seed weight. Evaluation of progeny derived from natural stand collections should be delayed beyond two years of nursery or ten months greenhouse growth if data unconfounded by seed weight is desired.

The second population was derived from a seed orchard. The orchard was established using the tallest families following two years nursery growth from the above natural stand collections. Six-year parent height had a negative effect on seed weight (-.28) and two-month progeny height (-.31) which diminished after this period. Seed weight effects were less pronounced than in the natural stand collections and diminished over the ten month period. Selection evaluated by greenhouse grown progeny was effective when based on one-year nursery growth but not when sixth-year field height was used as a criteria.

Minimizing the testing period is important in all plant breeding efforts but particularly so with forest trees. If relative performances change between the juvenile and mature stages due to varying genetic or environmental stimuli, then selection for mature characteristics must be delayed. With jack pine, (Pinus banksiana , Lamb.,) a 45 year testing period would be needed for evaluation to be based on performance at rotation age. However, if the genetic response is constant over time and the environment can be controlled, then greenhouse, nursery or early field evaluation might be acceptable.

One factor known to influence early performance is seed weight. The endosperm, and seed coat, maternal tissues, are the main contributors and affect the early development of the seedling (Righter, 1945). The temporary

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[2] Research Assistant, College of Forestry, University of Minnesota.

nature of the seed weight effect has been demonstrated by Canavera (1976), Canavera et al. (1973) and Yeatman (1966, 1974) who found its effect on jack pine provenance materials decreased rapidly with age.

The objectives of the present study were to: (1) examine the influence of seed weight on progeny height growth and (2) determine the impact of parent tree height on seed weight and progeny height.

MATERIALS AND METHODS

In 1969 Potlatch Corporation initiated a jack pine improvement project with the collection of seed from 348 selected trees growing in natural stands in north-central Minnesota. A replicated nursery test of these materials was established at Cloquet, Minnesota and height measurements taken after the first and second growing seasons. Following the second seasons growth, 189 families exhibiting superior height were planted at Kallstrom, Minnesota in a replicated progeny test for eventual conversion into a seed orchard containing five replicates of four-tree row plots. Height was again measured in 1976 following the sixth growing season.

Using the data from these three height measurements as a basis for selection, three collections of seed were assembled and used for three open-pollinated progeny tests carried out under greenhouse conditions. The first test used seed remaining from the original single-tree collections and evaluated three groups of five families each. The first group contained the tallest families after two years of nursery testing. Families in the second group were intermediate in height and those in the third group were the shortest.

Seed for the other two tests was collected in 1978 from trees in the Kallstrom plantation. One of these tests used offspring of the five tallest and five shortest families identified using one-year nursery height data. The second, evaluated progeny of trees from three tall, three intermediate and three short families selected using sixth-year field heights. Seed was collected from five individual trees within each of the 19 families selected for the two experiments. The identity of the progeny of the 95 parent trees was maintained throughout the experiment.

The three collections of seed were used in separate progeny tests. These tests will be referred to henceforth as the "first-year-test", "second-year-test" and "sixth-year-test" depending on the data used for selection.

All three tests were carried out in a greenhouse over a ten month period. Seedlings were grown in single-cell containers on Anoka county sand, watered daily and fertilized periodically. A 20-hour photoperiod was maintained.

All three tests utilized a randomized complete block design with four-tree row plots and ten replications. Height measurements were made at two month intervals and the final measurement was taken at ten months of age,

giving a total of five measurements. Seed weights for single-tree collections were determined. Standard Analysis of Variance techniques were used to evaluate the data and simple correlations were computed between pairs of the following variables: seed weight, progeny height and parent tree height.

RESULTS AND DISCUSSION

The tall selection group defined by second-year nursery height had significantly larger seed weights than the short group. In the greenhouse test of these materials, a positive correlation between seed weight and seedling height existed throughout the experiment (Figure 1). In contrast, when selection was based on the first-year nursery or sixth-year field heights, no significant difference in seed weight among selection groups was found. While selection groups in these two tests did not differ in seed weight, a positive correlation between seedling size and seed weight was found. Correlations were initially fairly high (.62 and .46) but decreased over the ten month interval (Figures 2 and 3).

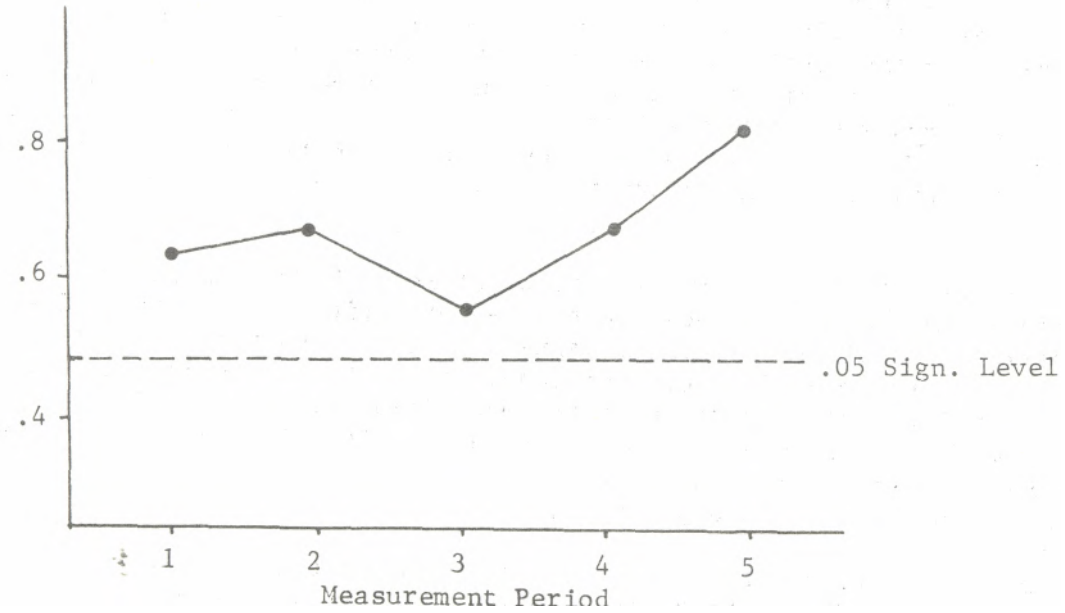

Figure 1. --Correlation between seed weight and progeny height for second-year-test.

Seed weight appears to have had a different impact on progeny height in the natural stand and seed orchard collections; i.e., second-year-test versus first- and sixth-year-tests. One possible explanation is the environments in which the parent trees were growing. Parents from the natural stand collections were growing over a wide range of environments, while those from the seed orchard were confined to one relatively uniform site.

A second factor of importance is selection and the impact it had on the populations sampled. Using second-year height as the criterion for selection,

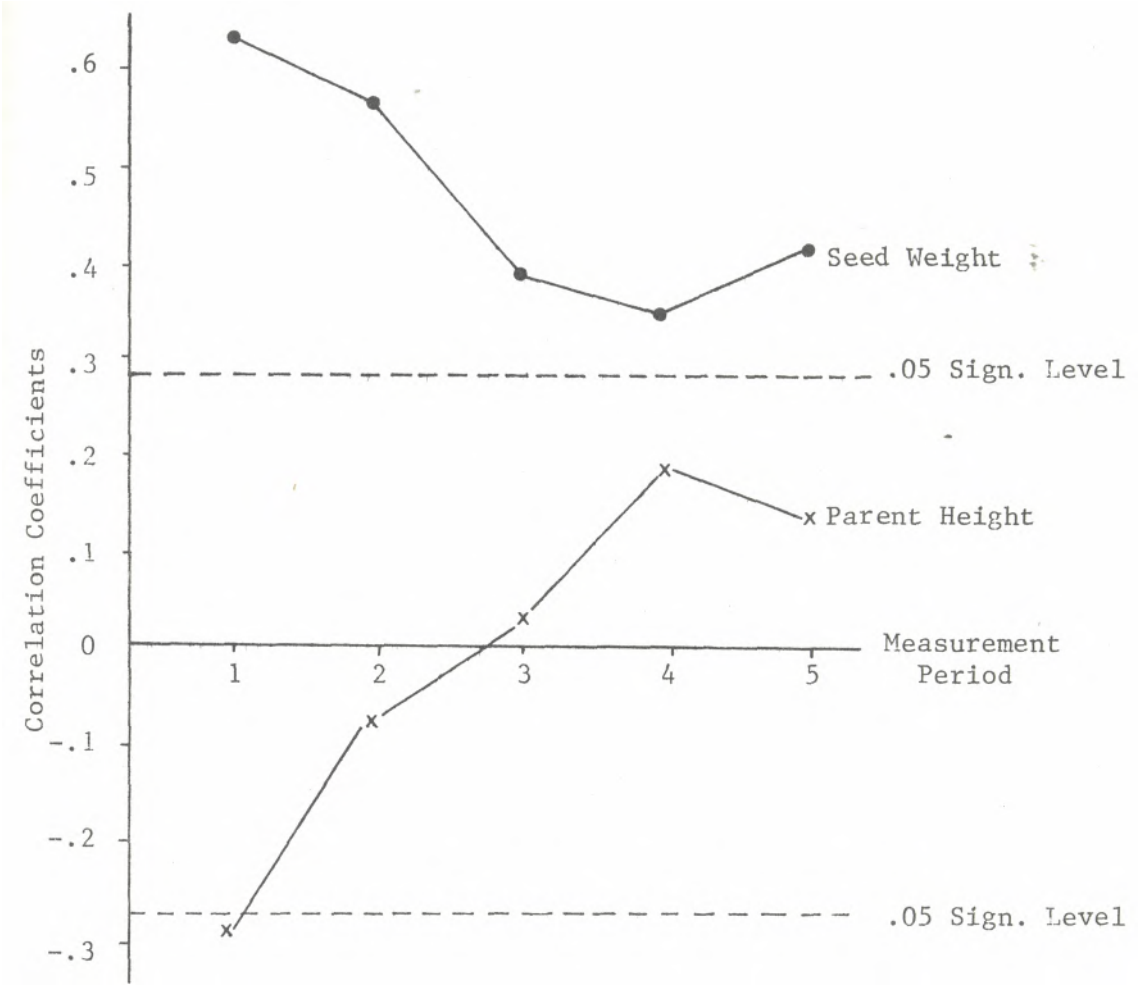

Figure 2. --Progeny height correlation with seed weight and parent tree height for first-year-test.

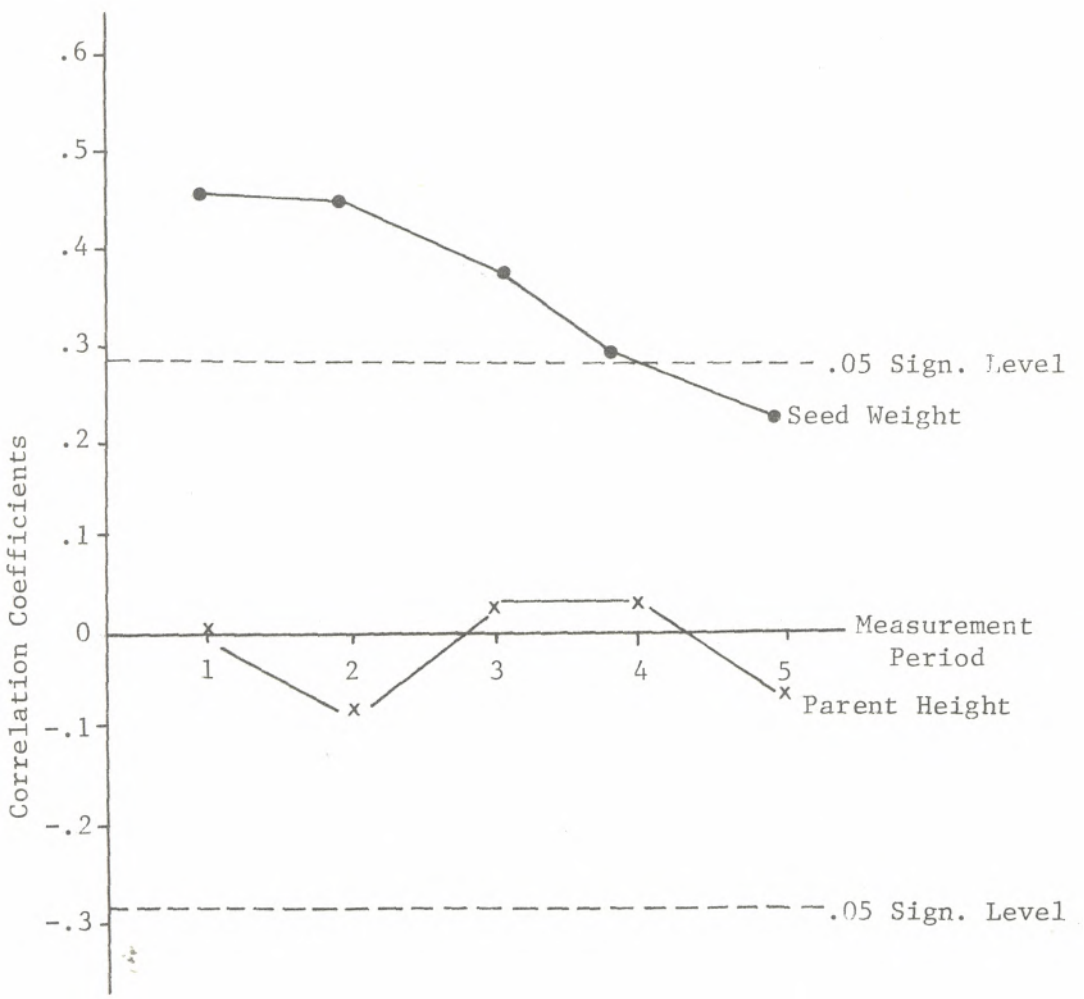

Figure 3. --Progeny height correlation with seed weight and parent tree height for sixth-year-test.

the number of families was reduced from 348 in the nursery to 189 in the seed orchard. Since a positive correlation existed between seed weight and initial seedling height(.56), this selection may have favored large seed weight.

Both the reduction in environmental variation and the nursery selection may have resulted in seed from the seed orchard being heavier and showing more uniformity between seed lots than those from the natural stands. The data show that the Kallstrom collections had larger seeds and fewer lots with very light seed (Figure 4). It is not possible using available data to separate environmental and heritable differences in seed weight. If it is under strong genetic control and nursery culling is practiced, advanced generations would be expected to produce larger seed and larger progeny. However, this early, vigorous growth may not be sustained over the life of the trees.

Parent tree height within the first-year-test was negatively; correlated with both seed weight (-.28) and the two month progeny heights (-.31). The effect on progeny performance may merely be a reflection of seed size since there was a positive correlation between the two (.64) (Figures 2). The sixth-year-test, however, showed no parent height correlation with seed weight or progeny height (Figures 3). The discrepancy between the two results may simply reflect the particular trees sampled in the selected families. Trees within families were chosen with no regard for height. The only criterion was that they were bearing enough seed for the greenhouse tests. As seen in Figure 5, the first-year-test contained a wide range of parent heights and over 20% were less than 155 cm tall. The sixth-year-test on the other hand contained predominantly tall parents and less than 5% were shorter than 155 cm. Thus, the narrower range of materials sampled in the sixth-year-test may have masked this effect.

The initial negative correlation indicate that rapid parent height growth is detrimental to seed weight and early progeny growth. All material in the seed orchard were juvenile and none exhibited an excessively heavy cone crop. A study by Teich (1975) showed that precocious flowering in white spruce tended to limit height growth. It will be interesting as the trees mature, to determine if this trait is shared by jack pine and if heavy cone crops will subsequently be associated with reductions in height growth but increases in seed weight.

The tall families from the natural stand collections which were selected for second-year nursery height were largest during the entire ten month period. However, upon removal of the seed weight effects, selection group differences were no longer detectable. The original selection appears to have been for seed weight differences.

The seed orchard selections in the first-year-test produced significant height differences over the ten month period. However, in this instance selection group differences remained significant at the end of the experi-

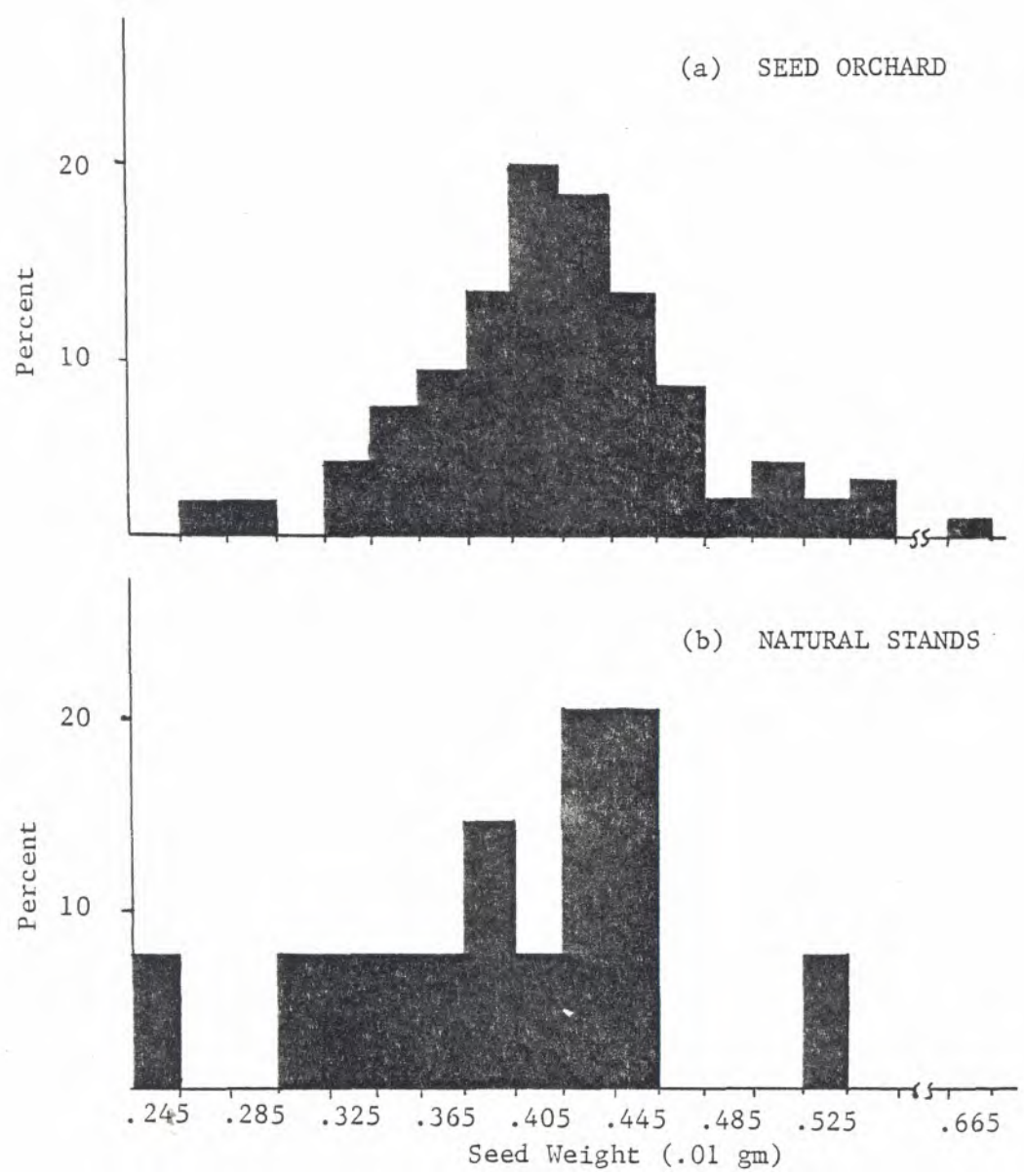

Figure 4. --Seed weight distribution of individual tree collections within (a) a seed orchard and (b) natural stands.

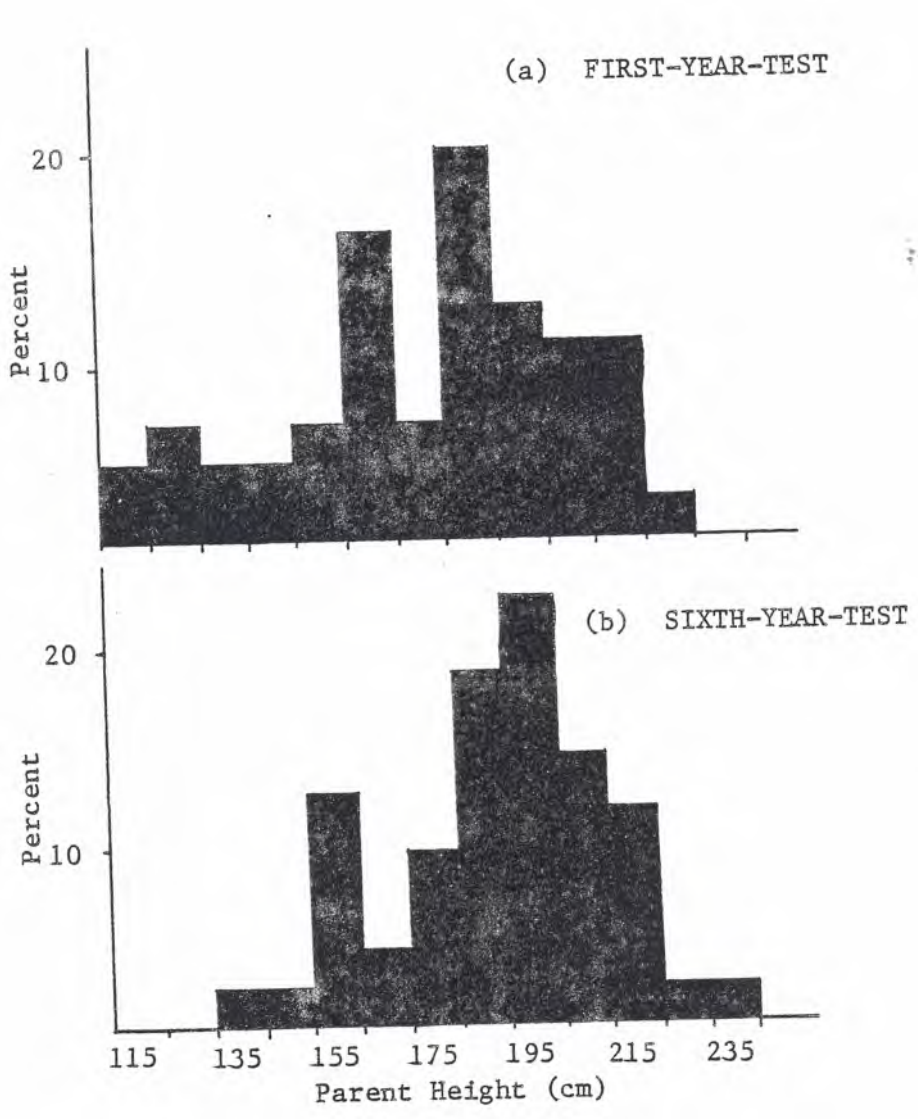

Figure 5. --Parent height distribution within the first- and sixth-year-tests.

mental period after the seed weight adjustment. The nursery culling and the more uniform environment may have reduced the variation within the seed orchard and contributed to the difference between the two tests. As was previously noted, seed lots from the seed orchard appear to be larger and less variable than the natural stand collections.

The final test which selected within the seed orchard based on sixth-year field height showed no significant selection group differences over the duration of the experiment. Ten month greenhouse growth appears to be more representative of one-year nursery growth than sixth-year field growth. Also, the random selection of parents within families may have influenced the results.

CONCLUSIONS

The materials tested could be broken into two distinct populations. The first was composed of the progeny of parents from natural stands and its performance was strongly influenced by seed weight. Selection in this population using two-year family means as a criterion was equivalent to selection for seed weight. These effects still masked any family differences after ten months of greenhouse testing and evaluation of such materials should be delayed to a point beyond this period if seed weight effects are to be minimized. No data is presently available regarding the appropriate age for evaluating such material.

The second population was developed from a seed orchard containing the best families from the previous natural stand collections. Parent height showed a negative correlation with seed weight and initial progeny height. The two negative responses are related and the progeny height correlation may merely be a reflection of the seed weight effect. The negative correlation between parent and progeny height vanished after the fourth month of testing and evaluation after this time should be unconfounded by parent height effects.

When compared to the natural stand collections, both selection and the uniform environment within the seed orchard appear to have reduced the variation in seed weight or at least its effect on progeny height. A positive correlation was present early in the experiment but diminished substantially over a ten month period. After ten months greenhouse growth and removal of seed weight effects, significant selection group differences were present when families were selected for first-year nursery height but not when selection had been for sixth-year field height. The difference may be due to the random selection of parents within each family or a poor correlation between ten month greenhouse growth and sixth-year field height. It appears that evaluation for first or second year growth can effectively be made following ten months growth in a greenhouse but evaluation for sixth-year or older height should be delayed beyond this period.

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