Variation in Nursery Grown Seedlings From Individual Mother Trees in a Seed Production Area

By C. L. Brown and R. E. Goddard 1/

In 1955, the Texas Forest Service established a seed production area on the I. D. Fairchild State Forest near Maydelle, Cherokee County, Texas, The area consists of six acres of loblolly-shortleaf pine, with loblolly pine predominating. It is an even-aged stand which averaged 44 years of age at time of establishment, and before thinning supported over 14, 000 bd. ft, (Scribner) per acre. Presently the stand has an average of 18 trees per acre, with a volume of approximately 4,000 bd. ft.

The primary objectives underlying the establishment of this area were: (1) to determine what degree of genetic improvement in quality and growth might be expected in the progeny from such areas, (2) to study methods of increasing cone production on large trees, and (3) to determine the economic feasibility of permanent seed producing areas where individual trees must be climbed for cone collections. This last objective has been realized and has been previously published upon by Zobel et al (1956) and. Goddard (1958). The second objective, that of increased flower stimulation and cone production, is still under investigation.

For deriving objective (1), that of determining the genetic validity of seed production areas, several long range studies are currently in progress. These consist of established replicated field plantings of open pollinated progeny from: (a) individual mother trees in the seed production area before the area was rogued, (b) the same individual mother trees after roguing, (c) extremely poor phenotypes from an adjacent area (large crowned, poorly pruned trees of the type many cone collectors prefer) and (d) commercial seedlings, i. e. , average nursery run seedlings from the Texas Forest Service Indian Mound Nursery near Alto, Texas. During the 1958 growing season seedlings from these four sources were grown under standard nursery practices and outplanted to the field for future observations and measurements on growth and form.

Because so little is presently known about juvenile characteristics of pine seedlings and their expression of growth and form in later years, it seemed pertinent to make rather detailed observations on the one-year-old seedlings from these different sources at the time of lifting. Such information would provide a basis for making comparisons of the same seedlings as they

---

1/ Silviculturist and Associate Silviculturist, respectively, Texas Forest Service, College Station, Texas.

became older under uniform spacing on a given site. Secondly, every nurseryman in the South that has produced loblolly pine seedlings in commercial quantities recognizes the wide variations in size and grade common to this species, and the factors contributing to this variation is of primary importance.

The purpose of the present paper is to point out some of the observed variations in growth and form of the progeny from different mother trees and to compare the variation in height growth of seed production area seedlings with commercial seedlings produced from local seed obtained from cone collectors in East Texas. The data reported here were obtained from detailed measurements on 14,000 one-year-old seedlings and included approximately 140, 000 recorded observations.

Experimental Procedures

Seed from 75 individual loblolly pine mother trees in the Fairchild Seed Production Area were machine graded, by the use of sieves, into large, medium, and small size classes and stratified for 30 days at 5 C prior to planting. The seed from each mother tree were sown separately by the three size classes in standard nursery beds. Each seed source was replicated twice in adjacent nursery beds. Records of germination rates were kept for each tree by seed size for a 4 week period after planting. At this time all seedlings were thinned, by hand, to 30 seedlings per square foot which corresponded to the average density of commercial loblolly pine seedlings growing in the same nursery. Throughout the growing season the experimental seedlings received the same care and irrigation schedules as the adjacent commercial seedlings.

During late December the seed production area seedlings and the related check seedlings were lifted for grading and planting° A sample of 30 seedlings were taken from each seed size class for each mother tree, in both replications, giving a total of 180 seedlings from each source for detailed measurements. In addition, twenty random samples of commercial seedlings, totaling 30 seedlings each, were also measured and outplanted for comparison. The following measurements and observations were recorded" (1) stem diameter at ground line by 4 sizes in, 1, .2, .3, and .4 inche classes, (2) total seedling height to the nearest inch, (3) length of first flush (juvenile growth) to nearest inch, (4) total number of flushes (shoot extensions), (5) number of lateral buds or branches at distal end of each flush, (6) the presence or absence of a distinct terminal bud, and (7) the number of adventitous branches on the basal portion of the stem near the ground line.

Results

During the initial separation of seed into small, medium, and large size classes by the use of round-hole sieves graduated in successive units of 1/64 inch in diameter, it immediately became apparent that the average size of seed from different mother trees was highly variable. Because of this it was impossible to adopt two standard sieve sizes for all trees, therefore, it was necessary to shift the size of the sieves used for different mother trees. To standardize the relative grading process for each tree, sieve sizes one unit above and below the mean seed size were consistently used to separate the largest and smallest seed, e. g. , if the bulk of the seed from any one tree passed through a #12 sieve (12/64 inch) then a #13 and #11 sieve were used to collect the large and small seed respectively. A frequency distribution of average seed size among the 75 mother trees is shown in Figure 10 From such a distribution it appears likely that the common process of grading bulk commercial seed collected from numerous trees into small, medium, and large seed sizes, to some extent, separates trees as well as seed of varying size within the same tree.

The primary purpose of grading seed by size classes is, of course, to reduce variation in seedling size or yields because seedling size is known to be related to size of seed, as has been previously shown by several workers (Spurr, 1944: Righter, 1945; Fowells, 1953; and Mitchell, 1939). In the present study, an analysis of variance of the mean heights of all seedlings from the seed production area showed that the mean heights of seedlings from the large and medium sized seed were significantly greater at the 1% level than the mean heights of seedlings produced from small seed (Table 1). There was no significant difference in mean seedling heights between large and medium size seed.

A further interpretation of the data is made possible by grouping all mother trees together which possess the same average seed size, and comparing the mean seedling heights of each group. When this is done as shown in Figure 2, there is no strong correlation between absolute seed size and seedling heights. Stated somewhat differently, the greatest influence of seed size on seedling size is found within and not between individual mother trees.

With regard to other measurable characteristics of seedlings as related to seed size the following statements hold true for this study:

(1) There is a slight trend toward smaller stem diameters with seedlings from small seed as indicated by the greater proportion of seedlings in the .1 inch diameter class as shown in Table 2. This data was not statistically analyzed.

(2) There is no significant difference in length of first flush (juvenile growth) in seedlings from different seed sizes; however, there is a trend in this direction. The average length of the first flush was 7. 1, 7.3, and 7.4 inches for small, medium, and large seed sizes respectively. There is, nevertheless, a strong correlation between mean total height of seedlings and mean length of the first flush regardless of seed size. A correlation analysis of these data show a correlation coefficient of .85 which is highly

significant. This obviously indicates that the variation in length of the first flush accounts for most of the variation in total height.

(3) A close review of the data indicates that no real differences exist between seedlings from different seed sizes in the number of successive growth flushes.

(4) There was a slight trend toward more rapid germination with an increase in seed size, e. g. , at the end of the third week the germination percentage was 42, 45, and 47 per cent for small, medium, and large seed respectively. After these considerations on the influence of seed size on seedling growth and development, it is now possible to discuss seedling variations of an apparent inherent nature.

Because one-year-old nursery grown loblolly pine seedlings from graded seed usually show considerable variation in total height, it becomes of primary interest to compare the mean heights and range of variation in seedlings from the seed production area with standard nursery seedlings from focal seed sources in East Texas (Table 3). A modified chi-square test homogeneity of variance of heights indicates that the variances are heterogeneous, i. e. , the variance of standard nursery seedlings is significantly higher than that of seedlings from the seed production area. These data are not at all surprising, however, when one stops to consider that one-half of the total heritable variation in each progeny group from the seed production area was contributed by individual mother trees, in contrast to the sample groups of nursery seedlings coming from an undetermined number of mother trees. Therefore it is not inferred, in any sense, that the total variation in height of the progeny from all 75 trees in the seed production area would be any less than that encountered among 75 other trees randomly selected in any local area.

There are also real differences between progeny from different mother trees in the following characteristics: (1) total height, (2) length of first flush (juvenile growth), (3) number of growth flushes per seedling, and (4) formation of terminal buds.

Seedlings from some mother trees tend to be short regardless of seed size, while others are consistently tall. The same was true for total length of the first growth flush as shown in Figure 3.

The progeny from some of the 75 mother trees possessed almost 100% well-formed, terminal buds at lifting time (late December) whereas the majority of seedlings from other trees were caught in various stages

---

2/ Bartlet's test of homogeneity of variance. Snedecor, G. W. Statistical Methods. Fifth ed. pp. 285-289. Iowa State College Press, Ames. 1956.

of shoot elongation late in the fall season (Figure 4).

Although the majority of all seedlings produced by each of the 75 mother trees possessed two flushes of growth, there were also certain trees that produced a higher percentage of seedlings with three, or even four growth flushes, while other trees consistently produced seedlings with only one and two flushes.

There were no consistent differences in the number of lateral buds produced at the top of each successive growth flush by the progeny from different sources; neither did the number of adventitious branches at the base of the stems conform to any set pattern within or between progeny groups.

Conclusions and Summary

The observations reported here are of practical as well as theoretical importance. In essence, the study confirms some of the same conclusions reached by Righter (1945) on the relationship of seed size and seedling size to inherent vigor, and in addition it points out that one-year-old progenies from different trees possess inherent differences in patterns of growth and development.

These findings may be summarized as follows:

(1) Seed size is positively correlated with seedling size within the progeny of individual trees, but not between progenies from different trees.

(2) The variation in seed size within a progeny is non-heritable, and accounts for part of the total height variation in one-year-old loblolly pine seedlings. This indicates that subjective selection of seedlings for inherent vigor within any progeny group will not necessarily result in genetic improvement. If, however, the seed of any one progeny are graded and sown at wide spacing in a uniform environment, followed by statistical selection above the mean in each seed size-class, then one should expect to select inherently vigorous seedlings with more than 50 per cent accuracy. Furthermore, it seems valid to say that a comparison of different mother tree progenies on a similar basis could assist one in the early "'weeding out" of undersirable "strains" in a program of controlled breeding designed toward strain building.

(3) A large part of the variation in seed size between progenies from different trees is heritable, but these inherent differences in seed size per se do not form a genetic basis for selecting inherently vigorous seedlings.

(4) In nursery practice the grading of bulked seed into size classes results in the production of more uniform seedlings because it separates seeds within progenies thereby reducing the non-heritable variation. At the same time, and to a greater extent than one might think, it separates individual

trees possessing inherent differences in seed size which reduces the number of trees and possibly seedling variation. Grading bulked seed is, therefore, a desirable cultural practice, but is of no consequence genetically in either direction.

(5) There are inherent physiological differences in the rates and duration of growth between progenies from different trees which result in marked differences in growth patterns and morphological expression of several seedling characteristics. The most obvious of these were the average length of the juvenile growth flush, the number of successive shoot extensions, and terminal bud formation. Although these differences were clearly distinct, nothing is virtually known about the degree of heritability of these traits, or even of more importance from the practical standpoint, whether these early differences are strongly correlated with later growth, form, and quality.

The greatest value of this study will come several years hence when these same progeny can be compared with their seedling characteristics. Until this is done, we will not know what extent or what degree of genetic improvement may be expected quality-wise in seedlings from seed production areas as compared to other local sources. It must be kept in mind that we are working with selected phenotypes whose genetic value is presently unassesed, and for this reason there is no real evidence upon which to draw generalizations.

Literature Cited

Fowells, H. A. 1953. The effect of seed and stock sizes on survival and early growth of ponderosa and Jeffrey pine. Jour. For. 51. 504-507.

Goddard, R. E. 1958. Additional data on the cost of collecting cones from a seed production area. Jour. For. 56: 846-848.

Mitchell, H. L. 1939. The growth and nutrition of white pine (Pinus strobus L.) seedlings in culture with varying nitrogen, phosphorus, potassium, and calcium, with observations on the relation of seed weight to seedling yield. Black Rock Forest Bull. 9, 135 pp. , illus.

Righter, F. I. 1945. Pinus: the relationship of seed size and seedling size to inherent vigor. Jour, For. 43: 131-137.

Spurr, S. H. 1944. Effect of seed weight and seed origin on the early development of eastern white pine. Jour. Arnold Arboretum 25: 467-480.

Zobel, B. J. , F. C. Cech, and R. E. Goddard. 1956. Cost of seed collection from a pine seed production area. Jour. For. 54: 750-755.

Table I. Mean Height of Seedlings Grown From Three Size Classes of Seed

Seed Size	Height (inches)
Small	10.7 ± .42 *
Medium	11.1 ± .40
Large	11.2 ± .33

* Significant at the 1% level.

Table II. Percent Seedlings in Each Stem Diameter Class Grown From Seed of Three Size Classes.

Seed Size	Stem Diameter Class (tenths of inches)			
	.1	.2	.3	.4
Small	25.6	70.3	4.0	.7
Medium	17.1	76.2	5.5	1.2
Large	16.5	75.7	6.8	1.0

Table III. Comparison of Variance of Seed Production Area Seedlings With Ordinary Nursery Seedlings Grown From Seed of the Same Size Class.

Source	Total Height (inches)	Mean Variance $\bar{s}^2$	Range in $\bar{s}$
Seed Production Area	10.7	5.36	1.0 - 3.2
Nursery	10.4	11.87*	2.7 - 4.2

* Highly significant.

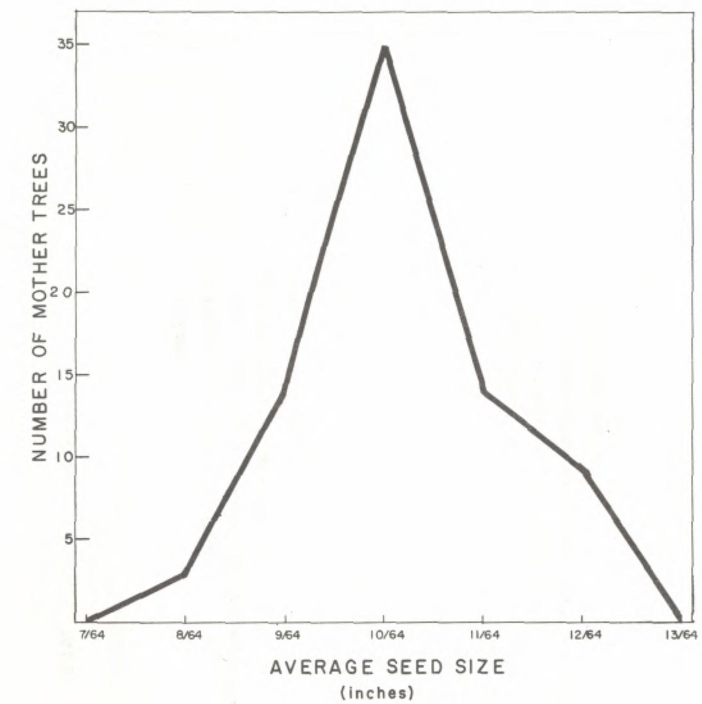

Figure 1. Frequency distribution of average seed size among the 75 loblolly pine mother trees in the seed production area.

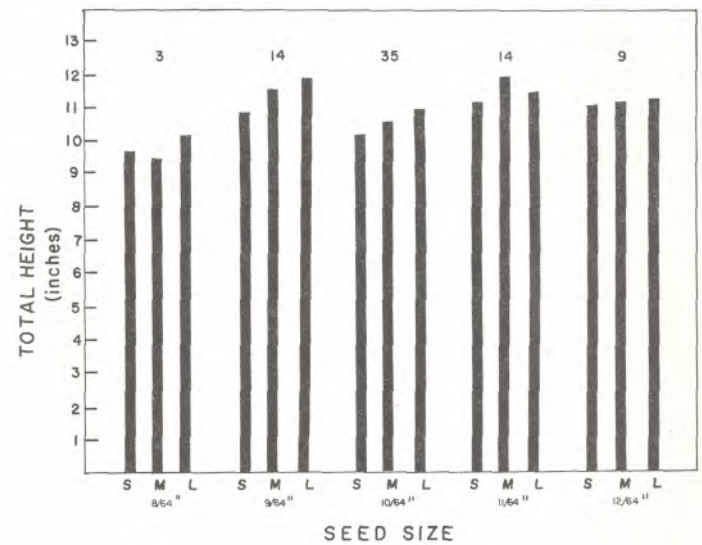

Figure 2. Total heights of one-year-old seedlings grouped by mother trees possessing the same mean seed size. (S M L denotes small, medium, and large seed within each group. Figures at top denote number of mother trees in each group).

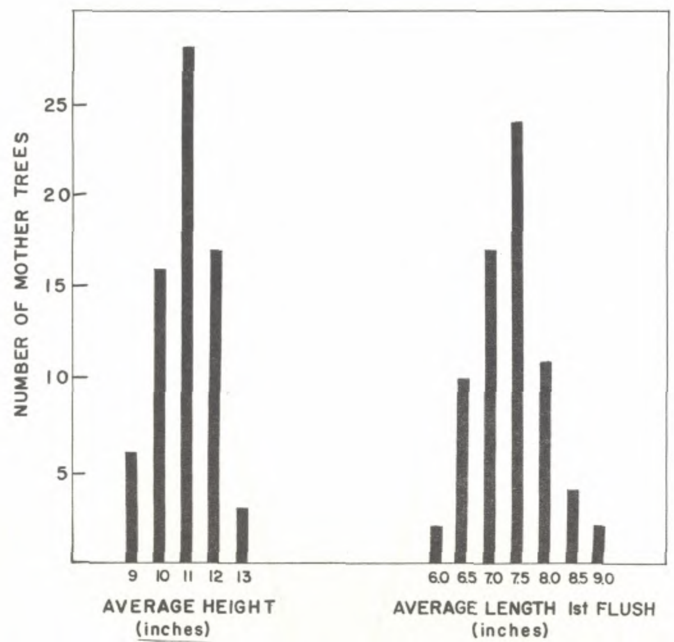

Figure 3. Frequency distribution of average seedling heights (left) and average length of first flush (right) of the progenies from each of the 75 mother trees in the seed production area.

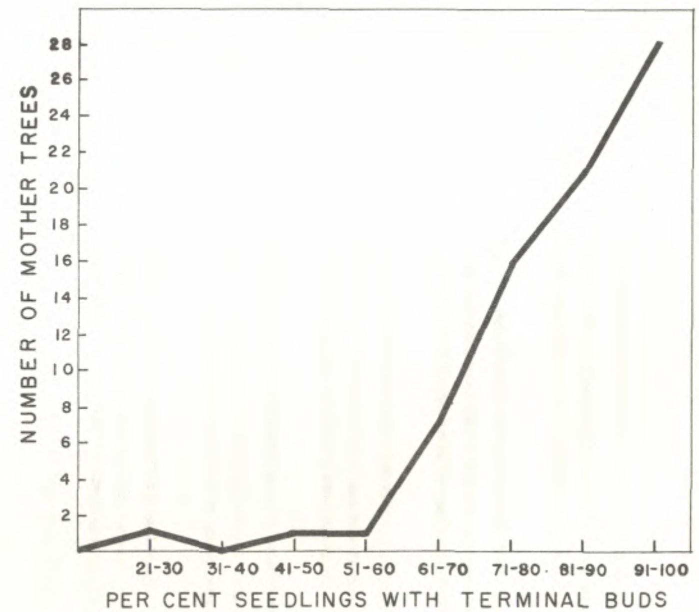

Figure 4. Frequency of terminal bud formation in the progenies from 75 mother trees in the seed production area.