# Influence of Size and Portion of Cone on Seed Weight In Eastern White Pine[1]

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The data presented in this article indicate that in eastern white pine the fresh weight of the seed increases significantly in progressing from small to large cones and from the apical to the basal portion of the cone. While the results are clear cut for eastern white pine, the author warns against applying to other species without further corroboration.

THE increasing interest in the physiology and genetics of forest trees in recent years makes it desirable to have further information on some of the factors governing seed size. In the fall of 1938, cones were collected from six eastern white pine trees (*Pinus strobus* L.) in the vicinity of Petersham, Mass., which had been felled by the hurricane of that year. The trees ranged from 56 to 86 years in age, and from 17 to 30 inches in diameter.

The cones from each tree were grouped into three length classes—small, medium, and large. For each class, which differed from tree to tree, the average length was determined from a sample of 50 cones. Each cone was then cut into three equal portions—apical, middle, and basal. The seeds were separately extracted and weighed for each of the 54 tree-length-portion cone classes. Empty seeds were blown out in an upward moving air stream.

Two sets of weighings were obtained for each of the 54 lots of seed. In the first set, 10 groups of 50 seeds each were weighed to an accuracy of 0.2 mg. on an analytical balance. These group weighings are the basis of Table 1. In the second set, which furnish the basis for Tables 2 and 3, 50 seeds were weighed individually to an accuracy of 0.02 mg. on a torsion balance.

## Weight of Seed

Table 1 shows that within portion classes for each of the six trees there was a constant increase in seed weight with increasing cone size; the seed from the large cones averages 2.9 mg. heavier than that from the small cones. Presumably the nutritional and other factors governing cone size also have a large influence on seed size. There was no constancy in seed weight in cones of the same length from the different trees.

Within the size classes there was a significant, though not constant, increase in seed size from the apical to the basal portion of the cones. In every case, the difference between the seeds of the apical and middle portions was much greater than was the difference between the middle and basal portions.

There were also highly significant differences in seed weight between the different trees. In an effort to determine whether seed size or cone size was correlated with any obvious character of the parent, measurements of diameter, current growth rate, and age were made for five of the six trees. There proved to be no apparent relation between cone or seed size and any of these variables.

## Germination of Seed

Some 5,400 of the seeds were weighed individually and grouped in 2-mg. classes for germination tests. Half of the seeds were stratified for 3 weeks in cool moist peat prior to germination, and half were left unstratified. The results are presented in Table 2. The low average germination of the stratified seed indicates that the stratification should be continued longer than 3 weeks. The medium-sized seeds showed higher germination percentages than either the large or small seeds in both cases. The differences between the medium (14.1-16 mg.) and the heavy (18.1-20 mg.) stratified seeds were significant; so also were the differences in germinative behavior between the medium and the light (10.1-12 mg.) unstratified seeds. Other differences were below the level of significance.

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TABLE 1.—MEAN WEIGHT OF SEED FROM SIX WHITE PINE TREES BY SIZE AND PORTION OF CONE FROM WHICH DERIVED. EACH ITEM IS BASED ON 10 RANDOMLY SELECTED GROUPS OF 50 FULL SEEDS[1]

| Tree number | Cone length | | Portion of cone | | | |
|---|---|---|---|---|---|---|
| | Relative | Absolute | Apical | Middle | Basal | Average |
| | | *Cm.* | *Mg.* | *Mg.* | *Mg.* | *Mg.* |
| I | Small | 9.1 | 11.3 | 13.3 | 13.5 | |
| | Medium | 10.8 | 12.8 | 14.8 | 14.8 | |
| | Large | 12.8 | 13.8 | 15.3 | 15.9 | 14.0 |
| II | Small | 8.6 | 12.7 | 15.0 | 15.4 | |
| | Medium | 10.3 | 14.6 | 16.4 | 17.1 | |
| | Large | 11.8 | 15.3 | 18.2 | 19.0 | 16.0 |
| III | Small | 9.4 | 14.4 | 16.2 | 16.6 | |
| | Medium | 10.9 | 15.6 | 17.9 | 17.9 | |
| | Large | 12.1 | 17.0 | 18.4 | 19.3 | 17.0 |
| IV | Small | 7.9 | 12.7 | 14.1 | 15.2 | |
| | Medium | 10.0 | 14.7 | 16.4 | 17.3 | |
| | Large | 11.9 | 16.6 | 18.5 | 19.2 | 16.1 |
| V | Small | 8.4 | 11.2 | 12.7 | 12.9 | |
| | Medium | 9.7 | 11.9 | 13.8 | 14.1 | |
| | Large | 10.9 | 13.7 | 15.8 | 15.9 | 13.6 |
| VI | Small | 8.4 | 13.2 | 15.1 | 15.7 | |
| | Medium | 9.4 | 14.4 | 16.0 | 16.4 | |
| | Large | 10.7 | 15.1 | 17.1 | 17.8 | 15.7 |
| All trees | Small | 8.6 | 12.6 | 14.4 | 14.9 | 13.9 |
| | Medium | 10.2 | 14.0 | 15.9 | 16.3 | 15.4 |
| | Large | 11.7 | 15.2 | 17.2 | 18.0 | 16.8 |
| | Average | ---- | 13.9 | 15.8 | 16.4 | 15.4 |

[1]An analysis of variance showed that the variation attributable to tree was very highly significant, as was that attributable to cone size and portion of cone.

These results may be compared with those of Perry and Coover[3] and Eliason.[4] The former reported higher viability percentages for seeds from small cones of pitch pine and for seeds from large cones of shortleaf pine. Eliason found that in Scotch pine germination percent, tree percent, weight per seed, and weight of the resultant seedlings were all higher for the seeds from the large cones.

## EFFICIENCY OF CONE SORTING AS A METHOD OF SEED SORTING

In experiments on growth it is desirable to have the material as homogeneous as possible. A very large portion of the variability in the size of first-year and second-year tree seedlings may be eliminated by starting with seed of uniform size, as Gast[5] and others have shown.

TABLE 2.—GERMINATION OF FULL WHITE PINE SEED OF DIFFERENT WEIGHTS, BASED ON 5,400 FULL SEEDS

| Size class | Germination | |
|---|---|---|
| | Stratified | Unstratified |
| *Mg.* | *Percent* | *Percent* |
| 10.1-12 | 26.7±16.2 | 2.0±0.6 |
| 12.1-14 | 44.4± 6.3 | 5.2±1.3 |
| 14.1-16 | 53.3± 6.9 | 8.2±1.6 |
| 16.1-18 | 39.4± 7.2 | 7.3±1.2 |
| 18.1-20 | 30.2± 7.8 | 7.2±3.5 |

In order to determine the relative efficiency of the seed sorting done by collecting seed from certain portions and sizes of cones, the calculations summarized in Table 3 were made.

The means and standard deviations were derived from the individual weighings of 50 seeds of each portion-size class. The size of sample

[3]Perry, G. S. and C. A. Coover. Seed source and quality. Jour. Forestry 31:19-25. 1933.

[4]Eliason, E. J. The size of Scotch pine cones as related to seed size and yield. Jour. Forestry 38:65-66. 1940.

[5]Gast, P. R. Studies on the development of conifers in raw humus, III. The growth of Scots pine (*Pinus sylvestris* L.) seedlings in pot culture of different soils under varied radiation intensities. Medd. f. Statens Skogsförsöksanstalt 29:587-682. 1937.

TABLE 3.—EFFECT OF SORTING CONES FOR SIZE AND WEIGHT ON VARIANCE IN SEED WEIGHT

| Seed source | Mean weight | Standard deviation | Size of sample needed to have S.E. of mean equal to 1 percent of mean |
|---|---|---|---|
| | *Mg.* | *Mg.* | *Seeds* |
| All trees, all cones | 15.2 | 2.9 | 367 |
| I, all cones | 13.8 | 2.4 | 306 |
| II, all cones | 15.9 | 2.8 | 305 |
| III, all cones | 16.9 | 2.4 | 208 |
| IV, all cones | 15.9 | 3.0 | 354 |
| V, all cones | 13.4 | 2.6 | 368 |
| VI, all cones | 15.4 | 2.7 | 306 |
| I S.B.[1] | 13.4 | 1.7 | 166 |
| II S.B. | 15.4 | 1.9 | 146 |
| III S.B. | 16.9 | 1.6 | 85 |
| IV S.B. | 15.1 | 1.8 | 148 |
| V S.B. | 13.0 | 1.6 | 144 |
| VI S.B. | 15.4 | 2.0 | 166 |
| I M.B., II S.M., III S.A.,[1] IV M.A., V L.M., VI S.M. | 14.8 | 2.2 | 216 |
| I L.B., II M.M., III M.A.,[1] IV M.M., V L.B., VI M.M. | 16.0 | 2.2 | 199 |

[1]The first letters, S., M., L., denote respectively small, medium, and large cones; the second letters, A., M., B., denote respectively apical, middle, and basal portions of the cone.

necessary to obtain a standard error of the mean equal to one percent of the mean was calculated by the formula

$$N = \frac{(\text{standard deviation})^2}{(\text{S.E. of mean})^2}, \text{ since S. E. of mean} = \frac{\text{standard deviation}}{\sqrt{N}}.$$

For the unsorted cones taken from all trees the variability in seed size was so great as to necessitate a sample of 367 seeds to obtain a mean with a standard error equal to one percent of itself. When seeds were taken from one instead of several trees, the size of sample necessary to obtain the same accuracy was reduced not at all (Tree V) to 43 percent (Tree III). When the seeds were extracted from cones sorted as to tree, portion, and size, the size of sample was reduced by 50 to 75 percent.

Such preliminary sorting would substantially reduce the amount of weighing necessary to obtain a sample of seeds all of which were within required weight limits. Where larger quantities of seed are needed, some reduction in sample size may be gained by the grouping of seed lots with similar mean weights (I M. B., II S. M., etc.). The reduction amounted to 40 percent for the two lots for which calculations were made.

Correlation coefficients were calculated between relative cone size (expressed as —1, 0, +1) and mean seed weight (expressed as percent of the tree mean). The values of $r$ were found to be .955, .944, and .970 respectively for the apical, middle, and basal portions of the cones. Such astonishingly high correlation coefficients—rare in biological material—indicate that little increase in the efficiency of sorting could have been gained by accurate measurement of the cones prior to sorting.

While these results are clear cut for eastern white pine, it is probably unwise to extend them to other species at the present time. The summary given by Baldwin[6] indicates that the trend toward the production of large seed in the basal portion of large cones is by no means universal even in the pines.

## SUMMARY

1. Cones were collected from six eastern white pine trees. The seeds were extracted and kept separate according to tree and to portion and size of cone.

2. The fresh weight of the seed was found to increase significantly in progressing from small to large cones and from the apical to the basal portion of the cone.

3. There were also significant differences in seed weight between trees. There was no obvious correlation between seed or cone size and the age, diameter, or growth rate of the parent.

4. The sorting of seeds according to portion and size of cone and tree may be effectively used to reduce the number of seeds which it is necessary to handle in order to obtain a seed sample with an average weight of a given accuracy.

[6]Baldwin, H. I. Forest tree seed. Chronica Botanica Co., Waltham, Mass. 1942.