# SOME CONE AND SEED RELATIONSHIPS FOR EASTERN WHITE PINE FOR THE 1971 AND 1973 SEED YEARS FROM THE UNIVERSITY OF NEW HAMPSHIRE BREEDING ARBORETUM[1]

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Through an understanding of cone-seed relationships, estimates can be made of seed quality, quantity and production efficiency for a seed year. Furthermore, control breeding success and seed orchard management techniques can also be evaluated through cone-seed relationships. This paper presents some cone-seed relationships for two seed years from the University of New Hampshire's White Pine Breeding Arboretum.

## BACKGROUND

The University of New Hampshire's White Pine Breeding Arboretum was initiated between 1962 and 1966 and contains most of the clones that have been included in the White Pine Seed Orchard at the New Hampshire State Forest Nursery. The Breeding Arboretum has been used in developing seed

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orchard management techniques and in the production of control pollinated material for progeny testing, It is 0.9 acres in size and contains approximately 255 grafts representing 44 clones.

In the course of a year, management of the Breeding Arboretum consists of spraying for cone beetle and the white pine weevil every two to three weeks with a one-percent Lindane solution from the time snow leaves until mid-August. Grass in the Arboretum Ls mowed throughout the growing season. In late June, or early July, 150 pounds of active NPK fertilizer is broadcast on the area, From the time after control pollination is completed (late June) until cone ripening (late August), the Arboretum is irrigated in any week in which less than 1 inch of rain occurs, with sufficient water to equal 1 inch of precipitation.

Control pollination starts with the isolation of the female by bagging developing female flower buds in late May and into early June prior to their opening, while pollen heads are picked just prior to ripening and the pollen is extracted in the laboratory. This pollen, along with stored pollen, is used in making controlled crosses. Control pollination is carried out by cutting off the end of each isolation bag, applying pollen with a brush, resealing the bag, and tagging the branch denoting the pollen source. The isolation bags are removed in late June after pollen dispersal and usually after a rain so that the pollen is purged from the air.

Cones are harvested individually as they ripen in late August and early September. They are kept separate by clone and pollen parent. After harvesting, seed is removed from cones, dewinged, winnowed to remove "pops"[3] and trash, electronically counted and weighed. Seed sources[4] containing enough sound seed (40 sound seed for the 1971 and 50 sound seed for 1973 seed years), were planted in plastic tubes in early winter, stratified for 65 days at 43°F, germinated in a greenhouse and transplanted in July into transplant beds at the State Forest Nursery. The germination capacity for each seed source was determined in the greenhouse as the seed germinated.

## MEASUREMENTS AND ANALYSIS

The following cone measurements were made after seed extraction of the 1971 and 1973 seed:

1. Cone length to nearest 0.1 inch.
2. Cone weight to 0.1 grams.
3. Number of bracts per center inch; i.e., the number of bracts that would touch a line 1-inch long at the center of the cone parallel to the cone's axix.

[3] "Pops"-seed coats containing no endosperm.

[4] Seed source - for open pollinated seed lots - seed lots having the same female parent and of the same seed year. For control pollinated seed - seed lots having the same female and male parents and of the same seed year.

4. Number of seed pockets per cone obtained by destructive subsampling in which the cones were stratified by cone length.

5. Number of bracts per cone obtained by destructive subsampling again stratified by cone length.

Only seed sources having complete cone and seed data were used in the analysis (for 1971, 37 open-pollinated and 67 control-pollinated seed sources, and in 1973, 24 open-pollinated and 41 control-pollinated sources). For the 1973 seed year, the number of "pops" for each seed source was also determined.

A screening regression program was employed to determine various relationships between several variables, and to select the best one, two, and three variable regression based on the highest $R^2$ and the significance of all the coefficients for a regression achieving a 0.95 percent level of probability (Table 1).

The dependent variables tested for each seed source were:

$Y_1$ = Number of sound seed.

$Y_2$ = Number of sound seed per cone.

$Y_3$ = Number of seed pockets per cone.

$Y_4$ = Percent germination.

The independent variables for each seed source included:

$X_1$ = Number of cones.

$X_2$ = Cone weight.

$X_3$ = Cone length.

$X_4$ = Number of bracts per center inch.

$X_5$ = Number of seed pockets per cone. (Not used in regressions 7-12, and 20-23).

$X_6$ = Number of bracts per cone.

$X_7$ = Number of sound seed. (Not used in regressions 1-2, and 13-16).

$X_8$ = Weight per 100 sound seed.

$X_{10}$ = Number of sound seed per cone. (Not used in regressions 3 6 and 17-19).

$X_{11}$ = Total seed/cone. (1973 seed year only).

Example - Regression number 7 (Table 1).

$$Y_3 = 29.01 + 6.46X_2 - 22.41X_8 + 0.50X_{11}$$

Where:

$Y_3$ = Number of seed pockets per cone.

+29.01 = Intercept.

+6.46 = Coefficient for the cone weight ($X_x$).

-22.41 = Coefficient for the weight per 100 sound seed ($X_8$).

+0.50 = Coefficient for the total number of seed/cone ($X_{11}$).

0.68 = Coefficient of determination ($R^2$).

Table 2 presents some averages and ranges (maximum and minimum) of some of the variables measured, the number of cones per pound of seed, the number of sound seed per pound, as well as an estimate of the number of trees which might be expected to survive outplanting.

RESULTS AND DISCUSSION

It was not possible to estimate germination percent through the regression techniques used for either open- or control-pollinated seed sources for the 1971 and 1973 seed years. The inability to estimate germination percent was probably due in part to the ideal germination conditions and the good quality of the seed produced.

Number of sound seed was related to cone production for both seed years for the open pollinated sources (Table 1, Regressions 1 and 2). The best single variable for estimating the number of sound seed was cone production for the controlled pollinated sources; however, this independent variable in combination with the number of seed pockets per cone 1973, and in combination with the number of sound seed per cone 1971, produced a better fitting two factor regressions(Table 1, Regressions 13-16). These results appear to indicate that the stress point of the number of cones per tree in terms of sound seed production has not been reached in either 1971 or 1973.

Number of sound seed per cone was best estimated in 1973 for both open- and control-pollinated seed by the total number of seed per cone (Table 1, Regressions 3 and 17). This variable was not attainable for the 1971 seed crop, as the number of "pops" per seed source was not determined, The best regression for the number of sound seed per cone for the 1971 seed year included a negative relationship for number of cones and a positive relationship for number of sound seed, This regression might be questioned, as the number of sound seed and the number of cones were used to generate the dependent variable. The best single variable then for estimating number of sound seed per cone for 1971 was the number of seed pockets per cone. Number of seed pockets per cone and the total seed per cone are closely related as each seed, sound or "pop" produces a seed pocket.

The number of seed pockets per cone for open-pollinated seed sources in both 1971 and 1973 included the best estimate available for total seed production (total seed per cone 1973, and total sound seed per cone 1971), as well as an interesting negative relationship to seed weight (Table 1, Regressions 7, 8, and 10). This negative relationship appears to indicate that the cones with a large number of seed pockets were stressed and resulted in the production of lighter seed. The number of seed pockets per cone was not as strongly estimated for the control pollinated sources, in which only variables that were directly related to seed production per cone were used (Table 1, Regressions 21-24).

Table 1.--Relationships between some cone and seed measurements and the number of seed and seed pockets per cone.

| Regression No. | Dependent Variable | Year | Intercept U | $X_1$ No. Cones | $X_2$ Cone No. | $X_5$ Seed Pockets /Cone | $X_6$ Bracts /Cone | $X_7$ Number Sound Seed | $X_8$ Wt./100 Sound Seed | $X_{10}$ No. Sound Seed /Cone | $X_{11}$ Total Seed /Cone | $R^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Regression Coefficients[a] | | | | | | | | | |
| OPEN POLLINATED SEED SOURCES | | | | | | | | | | | | |
| 1 | No. Sound Seed | 1973 | -281.5 | +45.6 | | | | | | | | .93 |
| 2 | No. Sound Seed | 1971 | -786.0 | +49.8 | | | | | | | XXXX[b] | .94 |
| 3 | No. Sound Seed/Cone | 1973 | +5.07 | | | | | | | | -0.61 | .54 |
| 4 | No. Sound Seed/Cone | 1971 | +20.36 | -1.27 | | +0.47 | | +0.02 | | | XXXX | .65 |
| 5 | Same as #4 | | -39.90 | | | +0.65 | | | +22.69 | | XXXX | .54 |
| 6 | Same as #4 | | +7.84 | | | +0.61 | | | | | XXXX | .34 |
| 7 | No. Seed Pockets/Cone | 1973 | +29.01 | | +6.46 | | | | -22.41 | | +0.50 | .68 |
| 8 | Same as #7 | | +60.68 | | | | | | -11.86 | | +0.54 | .50 |
| 9 | Same as #7 | | +32.95 | | | | | | | | -0.55 | .42 |
| 10 | No. Seed Pockets/Cone | 1971 | +45.20 | | | | +0.58 | | -19.94 | +0.68 | XXXX | .62 |
| 11 | Same as #10 | | +13.93 | | | | +0.57 | | | +0.55 | XXXX | .50 |
| 12 | Same as #10 | | +44.63 | | | | | | | +0.60 | XXXX | .37 |
| CONTROL POLLINATED SEED SOURCES | | | | | | | | | | | | |
| 13 | No. Sound Seed | 1973 | +134.60 | +33.63 | | +2.66 | | | | | | .79 |
| 14 | Same as #13 | | +23.49 | +25.16 | | | | | | | | .39 |
| 15 | No. Sound Seed | 1971 | -143.85 | +54.36 | | | | | | +2.17 | XXXX | .96 |
| 16 | Same as #15 | | +4.29 | +52.65 | | | | | | | XXXX | .71 |
| 17 | No. Sound Seed/Cone | 1973 | +3.02 | | | | | | | | +0.69 | .89 |
| 18 | No. Sound Seed/Cone | 1971 | +54.64 | -17.98 | | | | +0.32 | | | XXXX | .86 |
| 19 | Same as #18 | | +7.12 | | | +0.64 | | | | | XXXX | .42 |
| 20 | No. Seed Pockets/Cone | 1973 | +53.64 | -9.38 | | | | +0.25 | | | | .69 |
| 21 | Same as #20 | | +21.55 | | | | | | | | +0.55 | .55 |
| 22 | No. Seed Pockets/Cone | 1971 | +15.56 | | | | +0.40 | | | +0.59 | XXXX | .48 |
| 23 | Same as #22 | | +35.65 | | | | | | | +0.66 | XXXX | .42 |

[a] All coefficients and regressions significant at 0.95 level of probability.

[b] Data not available for 1971 as number of "pops" not determined.

Table 2.--Cone and Seed Relationships

| | 1973 | | 1971 | |
| --- | --- | --- | --- | --- |
| | Open Pollinated | Control Pollinated | Open Pollinated | Control Pollinated |
| AVERAGE NUMBER | | | | |
| Sound seed per cone | 35.0 | 34.4 | 55.6 | 51.6 |
| Range[a] | 4.6-62.0 | 8.8-91.0 | 22.8-88.5 | 15.0-89.7 |
| "Pops" per cone | 13.7 | 11.7 | Not counted | |
| Seed per cone | 48.7 | 47.1 | " " | |
| Average weight per 100 sound seed (grams) | 2.2835 | 2.4677 | 1.9535 | 2.0181 |
| Range | 1.5540-2.9950 | 1.4360-2.9740 | 1.5025-2.8431 | 1.2464-2.7235 |
| Average number sound seed per pound | 19908 | 18422 | 23271 | 22526 |
| Range | 15178-29253 | 15268-31657 | 15989-30256 | 16692-36473 |
| Average number cones per pound sound seed | 569 | 520 | 418 | 437 |
| Range number cones per clone | 1-182 | 1-7 | 1-109 | 1-6 |
| Average germination percent sound seed | 92.8 | 91.6 | 91.1 | 86.0 |
| Estimate number seedlings per pound of sound seed | 18474 | 16874 | 21200 | 19372 |
| Estimate number seedlings surviving through outplanting (25% mortality) | 13855 | 12650 | 15900 | 14529 |
| Estimate number acres which can be planted per pound seed (@ 10 x 10 ft. spacing) | 31.8 | 29.0 | 35.5 | 33.3 |

[a] Range - Maximum - Minimum Values

Means for the open- and control-pollinated seed sources were very similar for each seed year (Table 2), This appears to indicate that the method of control pollination was, at least comparable to open pollination, and may be slightly better, as control pollinated seed sources were slightly heavier.

Cone stress was also indicated in comparing the number of seed per cone and the seed weight for the two seed years. However, in terms of tree production, seed weight was not a factor as the germination capacity was similar for the two years. A pound of sound seed from 1971 would produce more seedlings than the 1973 seed, as there were more viable seed per pound.

## CONCLUSIONS

I. It was not possible to estimate germination percent from any of the traits measured.

2, Total sound seed production was best estimated through cone production, as there was a direct relationship between total amount of sound seed and the number of cones. Therefore, for a seed orchard manager to maximize seed production, it is necessary to maximize cone production.

3. Number of seed pockets per cone was directly proportional to seed production and inversely proportional to seed weight. This appears to indicate that more seed per cone stresses a cone which results in the production of lighter seed.

4. Heavy seed with high germination capacity was the apparent result of the management methods used in this White Pine Breeding Arboretum.

5, Control pollination methods used were comparable to the open pollination in the number of sound seed per cone and in the germination capacity. Control pollination produced slightly higher seed weights than did open pollination.

6. Even though number of seed pockets was inversely proportional to seed weight, seed weight did not appear to affect germination, therefore, the number of seedlings produced from a pound of sound seed was directly proportional to the number of sound seed per pound.