# Second-Field-Year Growth of Eastern White Pine Progenies From Seed Orchards[1]

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*In the second year after field planting at New Brunswick, N.J., about 1,100 white pine seedlings from 60 different seed sources showed highly significant differences in current year's growth and in dates of beginning and ending growth. Seedlings from Maryland, Pennsylvania, and Vermont seed orchards performed best; overall, growth was negatively correlated with latitude of origin, but there were marked exceptions. Progeny of selected clones in seed orchards performed an average of 7 percent better than seedlings from wild-collected seed; the best half-sib family was 57 percent better.*

Eastern white pine *(Pinus strobus* L.) is the most planted tree species in New Jersey. More than 600,000 a year are planted for timber, windbreak, Christmas tree, and landscape use. Provenance variation in growth rate has been reported, with performance of trees from the best seed sources exceeding that of those from the poorest by 40 to 80 percent (2, 4). At most test plantations except those farthest north, Southern Appalachian sources have performed best up to age 10 (1, 3).

Seed orchards of locally selected, superior white pine clones have been established in several States. It would be advantageous for New Jersey nursery personnel and growers to identify orchards and clones that produce progeny best suited for use here and to quantify genetic gain over trees grown from wild-collected seed. Correlations between juvenile and mature trees are useful in predicting growth and allow early selection for timber trees. Moreover, isolation of clones having vigorous juvenile growth is highly important for Christmas tree, windbreak, and landscape use.

## Materials and Methods

In March 1981, we obtained about 1,200 2-year-old seedlings representing 60 different sources of white pine (table 1) from the U.S. Department of Agriculture Forest Service. Of the 60 lots, 49 were half-sib families of open-pollinated seedlings from ramets of selected clones grown in seed orchards. Nos. 1 and 20 were mixed seed orchard progeny from New York; no. 43 came from an Ohio plantation of unknown seed source; and the remaining eight were progeny of wild trees in native stands. All the seedlings were grown for their first two seasons at Buckingham State Nursery, Harmans, Md.

Seedlings were planted in four randomized blocks on a uniform Nixon loam site at Cook College horticulture farm no. 1, New Brunswick, N.J. Each source was represented by one five-tree plot in each block. No fertilizer was applied. Simazine was used to control weeds in a 0.3-meter-diameter circle around each seedling in 1981, and a Simazine-Enicle mixture was used in 1982.

During the 1982 growing season, three responses were measured:

1. Date of beginning of growth, defined as the date on which the first new shoot exceeded 2 centimeters in length (because no budburst occurs in white pine).
2. Date of ending of growth, defined as the date after which further shoot elongation was less than 1 centimeter.
3. Length of leading shoot after the date of ending of growth.

Data were subjected to analysis of variance to determine whether the seed source was a significant cause of variation in responses. After significance had been determined, responses were regressed against latitude of genetic

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**Table 1**—*Second-year growth of open-pollinated white pine seedlings from 60 seed sources, at New Brunswick, N.J.*

| | Female parent | | | | Number | 1982 season's growth | | |
|---|---|---|---|---|---|---|---|---|
| No. | Clone | Origin | Latitude | Source[1] | living | Began | Ended | Length |
| 13 | --[2] | Pickett County, Tenn. | 36°35′ | 1 | 15 | 4/29 | 5/20 | 11.97 |
| 41 | PA 104 | Ashton, Md. (plantation) | 39°00′ | 6 | 15 | 4/30 | 5/23 | 13.70 |
| 52 | MD 3 | Harmans, Md. (plantation) | 39°07′ | 4 | 18 | 4/28 | 5/21 | 14.12 |
| 62 | MD 8 | Harmans, Md. (plantation) | 39°07′ | 4 | 16 | 4/23 | 5/23 | 18.19 |
| 66 | PA 53 | Harford County, Md. | 39°30′ | 6 | 16 | 4/28 | 5/24 | 14.24 |
| 32 | MD 7(PA93) | Swallow Falls St. Pk., Md. | 39°30′ | 6 | 17 | 5/1 | 5/21 | 10.91 |
| 54 | MD 7 | Swallow Falls St. Pk., Md. | 39°30′ | 5 | 18 | 4/30 | 5/20 | 10.97 |
| 60 | MD 19 | Potomac St. For., Md. | 39°30′ | 4 | 16 | 4/30 | 5/19 | 9.48 |
| 39 | PA 111 | Mont Alto, Pa. | 39°45′ | 6 | 20 | 4/29 | 5/21 | 12.70 |
| 3 | PA 90 | Hagerty's Crossing, Pa. | 40°45′ | 6 | 18 | 4/28 | 5/25 | 13.65 |
| 17 | PA 18 | Pottersdale, Pa. | 40°45′ | 6 | 17 | 4/27 | 5/20 | 11.27 |
| 45 | PA 26 | Rush Twp., Clearfield Co., Pa. | 41°00′ | 6 | 20 | 4/27 | 5/21 | 12.22 |
| 31 | PA 19 | Stroudsburg, Pa. | 41°00′ | 6 | 18 | 4/26 | 5/20 | 12.92 |
| 36 | PA 78 | Mifflinburg, Pa. | 41°00′ | 6 | 18 | 4/27 | 5/22 | 15.54 |
| 30 | PA 12 | Cook Forest, Clarion, Pa. | 41°20′ | 6 | 20 | 4/27 | 5/22 | 13.72 |
| 33 | PA 8 | Cook Forest, Clarion, Pa. | 41°20′ | 6 | 19 | 4/29 | 5/19 | 12.09 |
| 44 | PA 9 | Cook Forest, Clarion, Pa. | 41°20′ | 6 | 19 | 4/28 | 5/23 | 14.06 |
| 50 | PA 15 | Cook Forest, Clarion, Pa. | 41°20′ | 6 | 18 | 4/28 | 5/22 | 13.43 |
| 43 | -- | Findley St. Pk., Ohio (plantation) | 41°08′ | 3 | 18 | 4/27 | 5/21 | 13.78 |
| 26 | -- | New London, Conn. | 41°30′ | 1 | 18 | 4/29 | 5/25 | 11.44 |
| 46 | -- | New London, Conn. | 41°30′ | 1 | 16 | 4/24 | 5/21 | 13.19 |
| 20 | Mixed | Southern N.Y., northern Pa. aver. | 42°00′ | 7 | 17 | 4/26 | 5/21 | 13.68 |
| 16 | PA 77 | Oxford, N.Y. | 42°30′ | 6 | 18 | 4/28 | 5/21 | 11.57 |
| 1 | Mixed | Warren & Saratoga Co.'s, N.Y. aver. | 43°00′ | 8 | 16 | 4/28 | 5/27 | 11.59 |
| 34 | PA 79 | Oneonta, N.Y. | 42°30′ | 6 | 15 | 4/29 | 5/21 | 11.92 |
| 27 | PA 61 | Saratoga Spring, N.Y. (plantation) | 43°00′ | 6 | 17 | 4/27 | 5/21 | 12.19 |
| 12 | -- | Adirondacks near Jay, N.Y. | 44°30′ | 1 | 17 | 4/28 | 5/18 | 9.96 |
| 42 | VT 9-1 | Brattleboro, Vt. | 42°52′ | 9 | 20 | 4/28 | 5/21 | 13.09 |
| 9 | VT 7-2 | Shaftsbury, Vt. | 43°00′ | 9 | 17 | 4/29 | 5/23 | 13.22 |
| 18 | VT 6-1 | Shaftsbury, Vt. | 43°00′ | 9 | 18 | 4/26 | 5/21 | 12.79 |
| 24 | VT 7-1 | Shaftsbury, Vt. | 43°00′ | 9 | 20 | 4/27 | 5/20 | 13.68 |
| 10 | VT 3-2 | West Rutland, Vt. | 43°35′ | 9 | 18 | 4/27 | 5/21 | 12.87 |
| 51 | VT 15-1 | West Rutland St. For., Vt. | 43°38′ | 9 | 16 | 4/27 | 5/23 | 15.63 |
| 29 | VT 2-1 | Moretown, Vt. | 44°15′ | 9 | 18 | 4/30 | 5/21 | 12.68 |
| 40 | VT 2-1 | Moretown, Vt. | 44°15′ | 9 | 14 | 4/26 | 5/21 | 13.26 |
| 7 | ERL-1 | Rindge, N.H. | 42°44′ | 10 | 18 | 4/29 | 5/25 | 15.82 |
| 28 | ERI | Rindge, N.H. | 42°44′ | 10 | 17 | 4/29 | 5/19 | 9.92 |
| 5 | HLY-1 | Lyndeboro, N.H. | 42°52′ | 10 | 19 | 4/25 | 5/21 | 12.95 |

origin of female parent to determine whether there was a significant association.

### Results

At the end of the first summer, overall survival was 91 percent and 1 year after planting, it was still 90 percent. Only seedlings of no. 63 from Minnesota had a markedly lower survival rate. Seed source differences in growth responses (table 1) were highly significant (table 2). Regressions showed negative correlation of height growth with latitude of origin of female parent and wider dispersion of actual values above and below predicted values at lower latitudes (fig. 1). In spite of the significance of seed source as a source of variation in dates of beginning and ending growth, regressions of these dates against latitude of origin of female parent were not significantly different from 0.

While mean growth of the 51 sets of seed orchard progeny was 7 percent better than mean growth of the 8 sets of progeny of wild trees in native stands, it was 25 percent better than that of no. 12 from an area in New York that has produced commercial white pine seed. Mean growth of seedlings from the best source, no. 62 (Maryland), was 46 percent more

**Table 1**—*Second-year growth of open-pollinated white pine seedlings from 60 seed sources, at New Brunswick, N.J.—continued*

| | Female parent | | | | Number | 1982 season's growth | | |
|---|---|---|---|---|---|---|---|---|
| No. | Clone | Origin | Latitude | Source[1] | living | Began | Ended | Length |
| 19 | HNBO-3 | New Boston, N.H. | 42°58′ | 10 | 20 | 4/26 | 5/22 | 13.66 |
| 49 | HNBO-1 | New Boston, N.H. | 42°58′ | 10 | 18 | 4/25 | 5/21 | 12.69 |
| 8 | MBO-1 | Gerrish, N.H. | 43°23′ | 10 | 20 | 4/28 | 5/22 | 12.44 |
| 25 | SCL-1 | Claremont, N.H. | 43°22′ | 10 | 16 | 4/29 | 5/20 | 10.11 |
| 65 | BSA-1 | Sanborton, N.H. | 43°30′ | 10 | 19 | 4/26 | 5/19 | 11.76 |
| 35 | ONOR-1 | Northumberland, N.H. | 44°30′ | 10 | 18 | 4/29 | 5/21 | 11.49 |
| 22 | ME 33 | Wells, Maine | 43°20′ | 11 | 18 | 4/30 | 5/25 | 12.53 |
| 23 | ME 32 | Wells, Maine | 43°20′ | 11 | 19 | 4/26 | 5/21 | 13.57 |
| 11 | ME 23 | Standish, Maine | 43°45′ | 11 | 18 | 4/25 | 5/19 | 11.08 |
| 64 | ME 10 | Durham, Maine | 43°55′ | 11 | 19 | 4/26 | 5/20 | 13.14 |
| 15 | ME 12 | Fryeburg, Maine | 44°00′ | 11 | 17 | 4/29 | 5/20 | 11.46 |
| 21 | ME 28 | Waldoboro, Maine | 44°05′ | 11 | 18 | 4/27 | 5/18 | 10.00 |
| 2 | -- | Searsmont, Maine | 44°30′ | 1 | 19 | 4/28 | 5/22 | 12.26 |
| 48 | ME 2 | Anson, Maine | 44°50′ | 11 | 16 | 4/29 | 5/22 | 12.59 |
| 47 | -- | Ile du Grand Calumet, P.Q. | 45°47′ | 2 | 18 | 4/28 | 5/23 | 12.97 |
| 4 | -- | Ile aux Allumettes, P.Q. | 45°54′ | 2 | 18 | 4/27 | 5/20 | 11.06 |
| 14 | -- | Deux Rivieres, P.Q. | 45°16′ | 2 | 20 | 4/28 | 5/19 | 9.92 |
| 53 | ONT 538 | Ontario | n.a. | 12 | 15 | 4/29 | 5/20 | 9.61 |
| 61 | WI 133 | Chequamegon N.F., Wis. | 45°55′ | 12 | 15 | 4/28 | 5/19 | 9.97 |
| 55 | U 113 | Ontonagon County, Mich. | 46°35′ | 12 | 18 | 4/30 | 5/20 | 9.40 |
| 58 | Patton 312 | Plantation at Duluth, Minn. | 46°45′ | 12 | 20 | 4/27 | 5/21 | 11.84 |
| 63 | MN 27 | Beltrami Co., Minn. | 47°38′ | 12 | 8 | 5/2 | 5/19 | 8.18 |
| | | Plantation mean | | | | | | 12.42 |

[1]Sources: native stand (bulk collection) = 1; native stand (single tree) = 2; plantation (bulk) = 3; seed orchards at Harmans, Md. #1 = 4; Harmans, Md. #2 = 5; Potters Mill, Pa. = 6; Chenango Co., N.Y. = 7; Chemung Co., N.Y. = 8; Moscow, Vt. = 9; Merrimac St. For., N.H. = 10; Veasie, Maine = 11; Oconto River, Wis. = 12.
Seed orchard means and dispersion from plantation mean:

| | |
|---|---|
| Native stands | 11.60 (+6% to −25%) |
| Ohio plantation | 13.87 (+12%) |
| Harmans, Md. #1 | 13.93 (+46% to −31%) |
| Harmans, Md. #2 | 10.97 (−13%) |
| Potters Mill, Pa. | 12.88 (+25% to −14%) |
| Chenango Co., N.Y. | 13.68 (+10%) |
| Chemung Co., N.Y. | 11.59 (−7%) |
| Moscow, Vt. | 13.40 (+26% to +2%) |
| Merrimac St. For., N.H. | 12.32 (+27% to −25%) |
| Veasie, Maine | 12.06 (+9% to −24%) |
| Oconto River, Wis. | 9.8 (−5% to −52%) |

[2]– = no number assigned.

than the plantation mean, 57 percent more than the mean for the eight native-stand lots, and 122 percent more than mean growth of the poorest lot, no. 63 (Minnesota).

A block effect present in dates of beginning and ending growth, but absent in length of new shoot, appeared to be caused by earlier growth at the less windy end of the plot.

**Discussion**

Great differences in performance between the best and worst seed orchard lots reflect genecological divergence between white pine strains from opposite ends of the tree's natural range. This and the effects of selection under domestication are the chief causes of seed source variation in performance.

As might be reasonably expected, seedlings from the northwestern edge of white pine's range were the poorest growers at New Brunswick, which lies along the southeastern border of its range in New Jersey. Seedlings of trees selected in nearby Maryland and Pennsylvania, where the climate is more like that in New Brunswick, performed best. Among the Maryland families tested, all four from seed parents native east of the

**Table 2**—*Results of analyses of variance for second-year growth of white pine at New Brunswick, N.J.*

| | Date new growth > 2 cm | | | |
|---|---|---|---|---|
| | df | SS | ms | F |
| Block | 3 | 3.16 | 1.05 | 3.00 ($p < 0.05$) |
| Provenance | 59 | 51.48 | .87 | 1.71 ($p < 0.0001$) |
| B × P | 174 | 88.45 | .51 | |
| Tree (B × P) | 800 | 281.75 | .35 | |
| Total | 1036 | 424.66 | | |
| | **Date further growth < 1 cm** | | | |
| | df | SS | ms | F |
| Block | 3 | 3.49 | 1.16 | 4.64 ($p < 0.01$) |
| Provenance | 59 | 57.67 | .98 | 2.88 ($p < 0.0001$) |
| B × P | 174 | 59.47 | .34 | |
| Tree (B × P) | 799 | 199.03 | .25 | |
| Total | 1035 | 318.98 | | |
| | **Season's growth** | | | |
| | df | SS | ms | F |
| Block | 3 | 20.28 | 6.76 | 0.49 n.s. |
| Provenance | 59 | 2970.86 | 50.35 | 2.18 ($p < 0.0001$) |
| B × P | 174 | 4027.89 | 23.15 | |
| Tree (B × P) | 799 | 11020.08 | 13.79 | |
| Total | 1035 | 18042.75 | | |

Appalachians were outstanding, while those from seed parents native in western Maryland (Garrett County) were poor. The strong showing of Vermont seedlings runs counter to the general latitude trend and may indicate either a local region of fast growth or high caliber of Vermont's white pine improvement program.

The inverse correlation of juvenile growth with latitude of origin of genetically improved white pine points to desirability of testing seed orchard progeny from the Southern Appalachians. Although the prediction equation does not indicate that an advantage will be gained by testing trees originating from this area, the increasing dispersion of actual seedlot performance above and below predicted values as one moves southward indicates that some southern lots might be extremely good. Further, the prediction equation is influenced by the presence of three subpar lots from Garrett County, Md., an area of short frost-free growing seasons comparable to those of higher latitude areas. In earlier provenance tests (2, 3), Southern Appalachian white pine performed exceptionally well at midrange-latitude test locations.

Our data represent only 1 year's growth at one test location in New Jersey. Our plantation is one of 10 roughly similar ones in New Jersey, Maryland (2), Michigan, Pennsylvania, New York (2), Connecticut, Vermont, and New Hampshire. After data from other plantations and other years become available, intelligent decisions on retention or roguing of parent clones in seed orchards can be made. We believe that our most significant finding is the large variability among families within seed orchards.

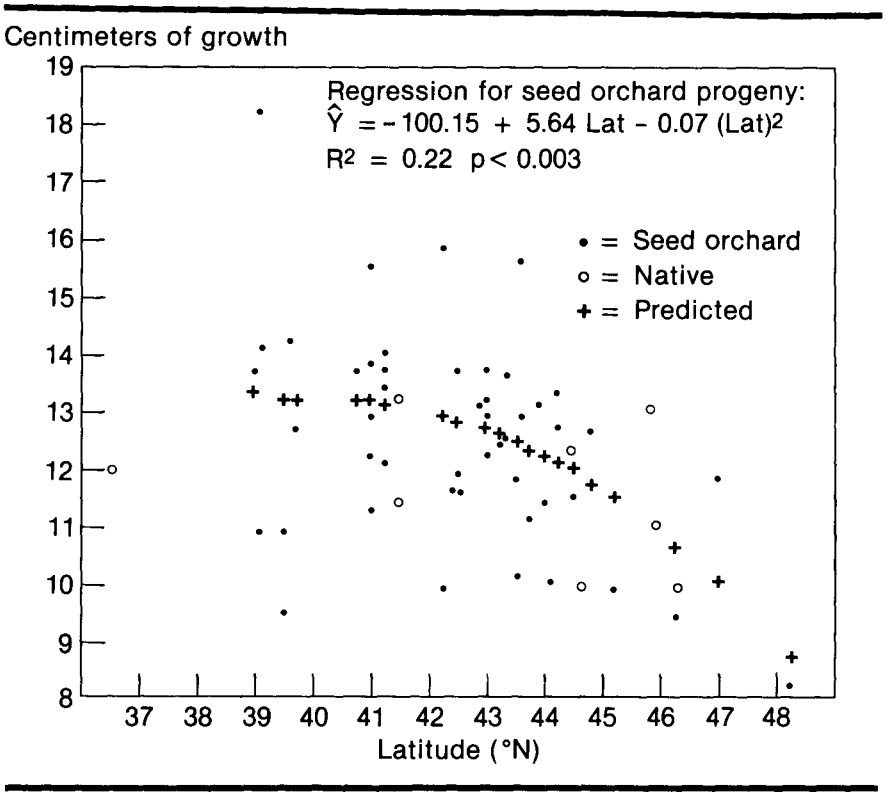


**Figure 1**—*Relation of second-field-year growth of white pine at New Brunswick, N.J., to latitude of origin of female parent.*

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