PROGRESS REPORT
EFFECTS OF FERTILIZATION ON VEGETATIVE GROWTH AND EARLY FLOWERING AND FRUITING OF SEED ORCHARD BLACK CHERRY

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Black cherry (*Prunus serotina* Ehrh.) seedling seed orchards are now being established on the Allegheny and Monongahela National Forests (Fig. 1). It has been estimated that ten to twenty years may be required from the time that a seed orchard is established until it begins to produce large quantities of seed. Therefore, anything that could be done to reduce this time and enhance the growth of the orchard trees would have substantial economic benefits, and would hasten the availability of genetically-improved seed.

Fertilization has been used successfully in other species to stimulate flowering and improve the seed yield of older trees (1, 2, 3, 4, 5, 6, 7, and others), but there is a considerable difference between stimulating mature trees to produce higher seed yields and inducing young trees to flower earlier. Woody plants apparently must reach a certain stage of development before flowering and fruit production begins. It is not known if this stage of development is a certain age or a certain size, or how this stage may be modified by cultural techniques that accelerate growth. If size is the important factor, it seems probable that early flowering might be achieved in seed orchards by fertilization if the fertilizers induced seedlings to grow faster and reach critical size earlier.

This study is being conducted with 17 half-sib families of black cherry established at the Blue Jay Seed Orchard on the Allegheny National Forest. The objective is to determine the effect of annual applications of nitrogen *(N)* and phosphorus (P) on their vegetative growth, flowering, and seed production. The original intention was to limit this study to flowering and seed production, but upon the suggestion of the research people at the NEFES at Warren, vegetative growth was included, in view of the fact that genetic variation in vegetative growth response might be ascertained. This paper reports the results of four growing seasons after planting, and after two annual applications of fertilizers.

Fertilizer applications for subsequent plantings, based upon results of this study, will be incorporated into the Blue Jay Seed Orchard management plan with the view of stimulating early initiation of seed production and maximizing continuing production.

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Figure 1.--The Allegheny National Forest Seed Orchard four growing seasons after planting.

The Bishop Knob Seed Orchard is located on a different soil series and type. However, the original soil analysis showed a somewhat lesser amount of both phosphorus and potassium than the Blue Jay site and so it seems reasonable to expect this orchard would also benefit from the same fertilizer applications.

METHODS

The study area is located on the Allegheny Plateau near Marienville in northwestern Pennsylvania. Soils are a Hazelton/Cookport sandy loam complex that is well to moderately-well drained and generally deeper than three feet to bed rock or fragipan. Laboratory analyses of the surface six-inches of soil indicated 25 lbs/A extractable P, 147 lbs/A extractable K, and a pH of 4.6 - typical values for forest soils in this area. Topographic position is on a broad flat ridgetop.

Prior to clearing and site preparation the area supported a well-stocked, middle-aged stand of black cherry and sugar maple (*Acer saccharum* Marsh). In 1968 after removal of the vegetation, brush was piled and burned, stumps removed, and the land leveled with a dozer. Lime was applied at 2.5 tons/A and 0-20-20 fertilizer at 500 lbs/A (equivalent to 44 lbs/A P and 83 lbs/A K). Additionally, the entire area was fenced to eliminate browsing from deer.

In the spring of 1969, 17 black cherry families were outplanted as 1-0 stock. These seedlings were grown in the State Nursery at Clearfield, Pennsylvania, from open-pollinated seed collected from superior phenotypes which were selected for their outstanding growth rate and form in Pennsylvania and West Virginia.

The orchard consists of four blocks, each containing four seedlings from 17 families, planted at a spacing of 8 X 8 feet. After planting, each seedling was tagged to identify its parent, and hardwood bark mulch was applied to a 4-foot circular area around their base to control competing vegetation.

Two years after planting, two blocks were randomly selected for fertilization treatment. The two unfertilized blocks were used as controls. In 1971 (spring of third growing season) fertilizers were applied to all seedlings of each family in blocks two and four at the rate of 100 lbs/A N and 200 lbs/A P_2O_5. In succeeding years the annual N rate was increased to 300 lbs/A. In terms of amounts of elements per tree this was 40 grams of nitrogen and 11 grams of phosphorus. Fertilizers were confined to circular 4-foot diameter plots and were applied in two equal doses during early May and late June of each year to insure nutrient availability throughout the entire growing season. Urea and triple superphosphate were used as nutrient sources. Fertilizers were applied to the mineral soil after raking the mulch away from the seedlings and the mulch was then replaced. Because there was no physical separation between fertilized and unfertilized blocks, 3-foot deep trenches were dug, lined with polyethylene, and refilled with soil to insure that nitrates from fertilized blocks would not affect seedlings in adjacent unfertilized blocks.

To resolve the problem of comparing height and diameter growth between single and multiple stemmed trees, corrective pruning was done in the fall of 1972 to produce only single stem individuals. This was necessary because many trees had multiple stems originating near ground level which were competing more or less equally. Additionally, a paint band was applied to the stem 30 cm above ground level to insure comparability among future diameter measurements.

Annual measurement of total seedling height, current height growth, and diameter at 30 cm above ground level have been recorded each fall since 1970. Additionally, all seedlings were inspected each spring for flower production.

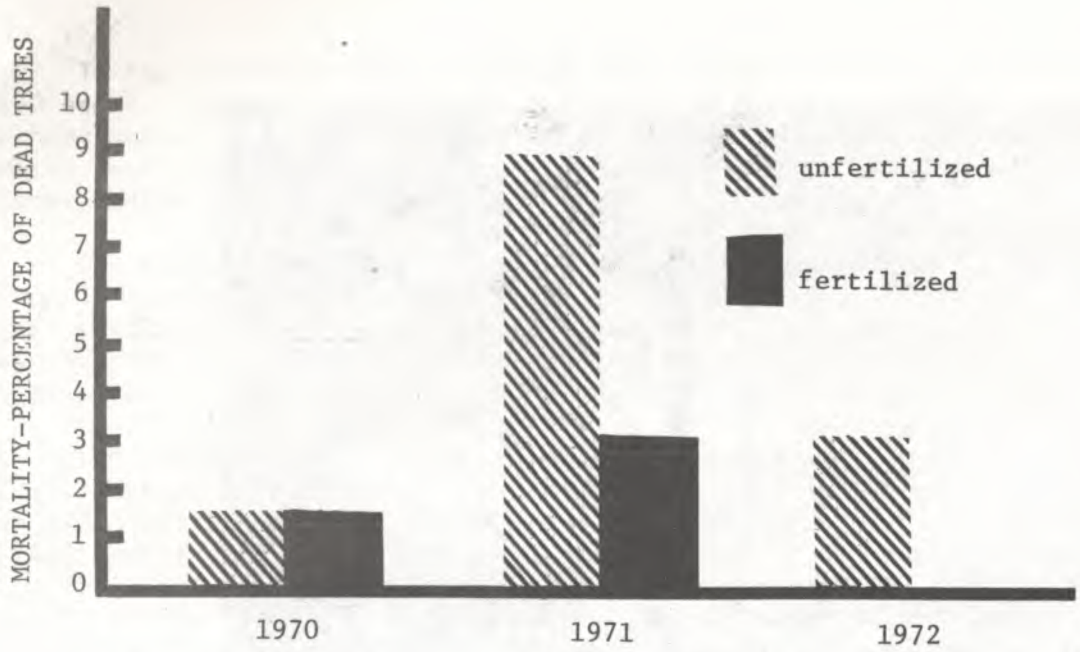
RESULTS

Survival - Initial seedling survival was good in comparison to many other hardwood plantings, All but three of the 272 planted trees survived through the second growing season. However, in the third year mortality increased, apparently from severe ice and snow damage occurring in the second winter (1970-1971), producing effects still prominent three years later (Fig. 2). There was no apparent relationship between mortality and family, but generally the smallest individuals still suffering from planting shock had the highest death rates.

Figure 2.--Early snow and ice damage was acute on some seedlings.

Fertilization (first application two seasons after planting) has had an important role in reducing mortality from this cause (fig. 3). In 1971, mortality in the fertilized blocks was only about one-third of that which occurred in the unfertilized blocks, reflecting the apparent ability of fertilized seedlings to respond from ice and snow breakage of the previous winter. Moreover, this effect persisted through the 1972 season where mortality continued in the unfertilized blocks from the loss of weakened individuals which had not died the previous year.

In the spring of 1973 attack by the peach tree borer (Sanninoidea exitiosa) caused three large fertilized trees to die. There were no attacks on unfertilized trees. Because this insect generally attacks trees only after they have attained a basal diameter of about 2 inches, the largest and fastest growers are most susceptible since they reach the critical size first. Since the trees in our orchard are still not very large they are unable to withstand borer injury and one attack is usually fatal (fig. 4). Therefore, beginning in 1973 a control program was initiated; Thiodan, 50% wetable powder at the rate of 1 1/2 pounds/100 gallons of water, will be used to soak all stems to a height of 30 cm twice annually (July 15-20, August 10-15).



igure 3.--Mortality as affected by fertilization (adjusted for mortality in one section of block 4 due to poor soil drainage; trees planted in spring 1969 and fertilized in spring 1971).

Figure 4.--A large black cherry orchard tree dying from peach borer attack in the fifth season after planting.

Additional mortality and poor growth was caused by a drainage problem which occurred primarily in blocks three and four. Trees that died in 1973 were eliminated from consideration. This required revision of the 1971 and 1972 data to eliminate data from trees that were alive at the time of measurement but subsequently died.

It is hoped that this problem has now been corrected, as drain tile was installed in the wet portions of the seed orchard in July 1973.

<u>Height Growth</u> - Response to fertilization varied considerably among families (Fig. 5). In 1971 all families but one showed a positive height response, although the increase varied from 1 to 33 cm (2 to 151 percent) but differences were statistically significant ($P < .05$) for only five families. In 1972 all but two families responded positively, with response ranging from 4 to 46 cm (10 to 165 percent) and differences being significant ($P < .05$) for four families. Average 2-year height increment for all families without fertilization was 28 cm, whereas growth with fertilization was 43 cm, representing an overall response of 15 cm or a 56 percent increase. Families that showed the best growth response in 1971 were not usually those that were most responsive in 1972. Family MO-20 was an exception; it ranked second in fertilized growth in 1971 and first in 1972.

Generally, the fastest growing families with fertilization were not the fastest without fertilization, and the best unfertilized families were usually less responsive to fertilization than the slower growers. Nevertheless, 1972 height growth for the five fastest growers with fertilization amounted to 58 cm, whereas the five fastest growing unfertilized families grew only 38 cm, representing a 53 percent increase in height growth obtainable through fertilization over and above that from genetic selection alone. Since only the fastest growing families are used as a basis of comparison, the growth rates obtained are due to a combination of family selection and fertilization. The increased growth rate (over unfertilized) is therefore due to fertilization alone. Similar calculations for 1971 (first year of fertilization) showed a gain of 22 cm representing a 69 percent increase obtained by fertilization of selected families (i.e., the five fastest growing unfertilized and fertilized families).

Height growth within families varies considerably. How much of this variation is due to the fact that half-sibs were used and how much is due to microsite variation is unknown. This undoubtedly accounts for the lack of more significant differences from fertilization where average gains were appreciable. For the 2-year period following fertilization, annual within-family coefficient of variation ranged from 14 to 76 percent for fertilized families and from 26 to 98 percent for unfertilized families. Moreover, the average within-family variability was generally less in fertilized than in the unfertilized blocks.

<u>Total Height</u> - It was evident that considerable block-to-block variation in height existed before the study was initiated. Unfortunately, annual height growth data for the years prior to the fertilizer applications were unavailable. However, mean total height in 1970, one year before the study began, for the trees in blocks one and three (excluding those that later died) was 74 cm. The corresponding figure for blocks two and four (later to be fertilized) was 70 cm, a difference of minus 5.4 percent.

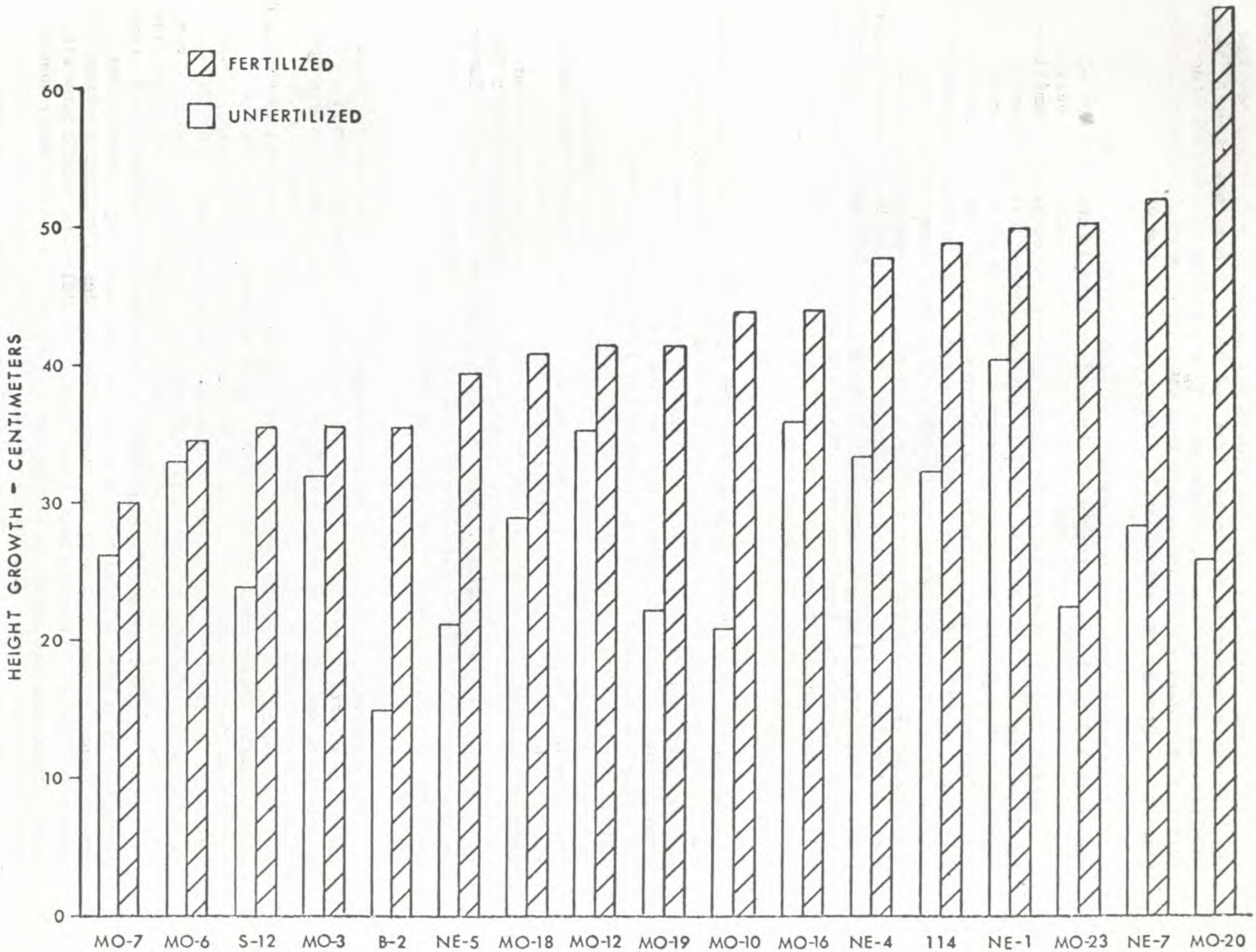


Figure 5.--Two-year height growth response of 17 black cherry families to nitrogen and phosphorus fertilization.

This difference was reversed in 1971 and 1972 measurements. Unfertilized and fertilized blocks were 96 and102 cm respectively for 1971, a difference of plus 5.9 percent; the 1972 figures for unfertilized and fertilized blocks were 122 and 139 cm, a difference of plus 12.2 percent.

Basal Area Growth - Twelve families responded to fertilization with increased basal area growth in 1971 and fourteen responded positively in 1972 (Fig. 6). A strong differential response occurred between families for both years similar in fashion to that observed for height growth. Differences in growth due to fertilization, however, were significant ($P < .05$) for only five families in 1971 and for only four families in 1972 due to considerable within-family variability. Overall response between fertilized and unfertilized families ranged from 0.009 to 0.194 square inches in 1971 representing a maximum within-family increase of 257 percent. In 1972 the increase ranged from 0.035 to 0.553 square inches and represented a maximum within-family increase of 632 percent. Generally, ranking of families according to their responsiveness to fertilization was about the same for both years, although response in 1972 was much more dramatic than in 1971.

Basal area growth of the five fastest producing families with fertilization averaged 0.248 square inches in 1971 and 0.443 square inches in 1972. Corresponding growth figures for the fastest growers without fertilization were 0.138 and 0.180 square inches in 1971 and 1972, respectively. Thus, the increase in growth due to fertilization was 0.110 and 0.263 square inches, an increase of 80 and 146 percent for 1971 and 1972, respectively.

Within-family basal area growth varied appreciably and detection of significant differences was doubtlessly limited by this factor. Coefficients of variation for the 2-year span following fertilization ranged from 35 to 151 percent for fertilized families and from 34 to 140 percent for unfertilized families. Excluding the extremes, within-family variability was usually less in unfertilized than in fertilized blocks, and was generally greater than that for height growth.

Foliar Characteristics - Foliar samples were obtained from representative individuals in early September 1972. Three unfertilized and three fertilized families were sampled. Tissue dry weight was determined and analyses were made for total N by the Kjeldahl procedure.

Striking differences were apparent between fertilized and unfertilized individuals (Table 1). Fertilization increased leaf weight and the concentration (percent) and content (mg/leaf) of N in the foliage. Based upon these limited data it appears that N concentrations of about 2.00 percent and contents of 5.35 mg N/leaf represent deficiency levels. Thus, a response to applied N would be forthcoming for black cherry with similar or lower foliar N composition providing that other growth limiting factors were not in control. Determining this critical level will provide the forest manager with a diagnostic tool, if he wishes to maximize growth rate by means of fertilization. Possibly, critical levels will vary with families and this will be reviewed more closely in the forthcoming season.

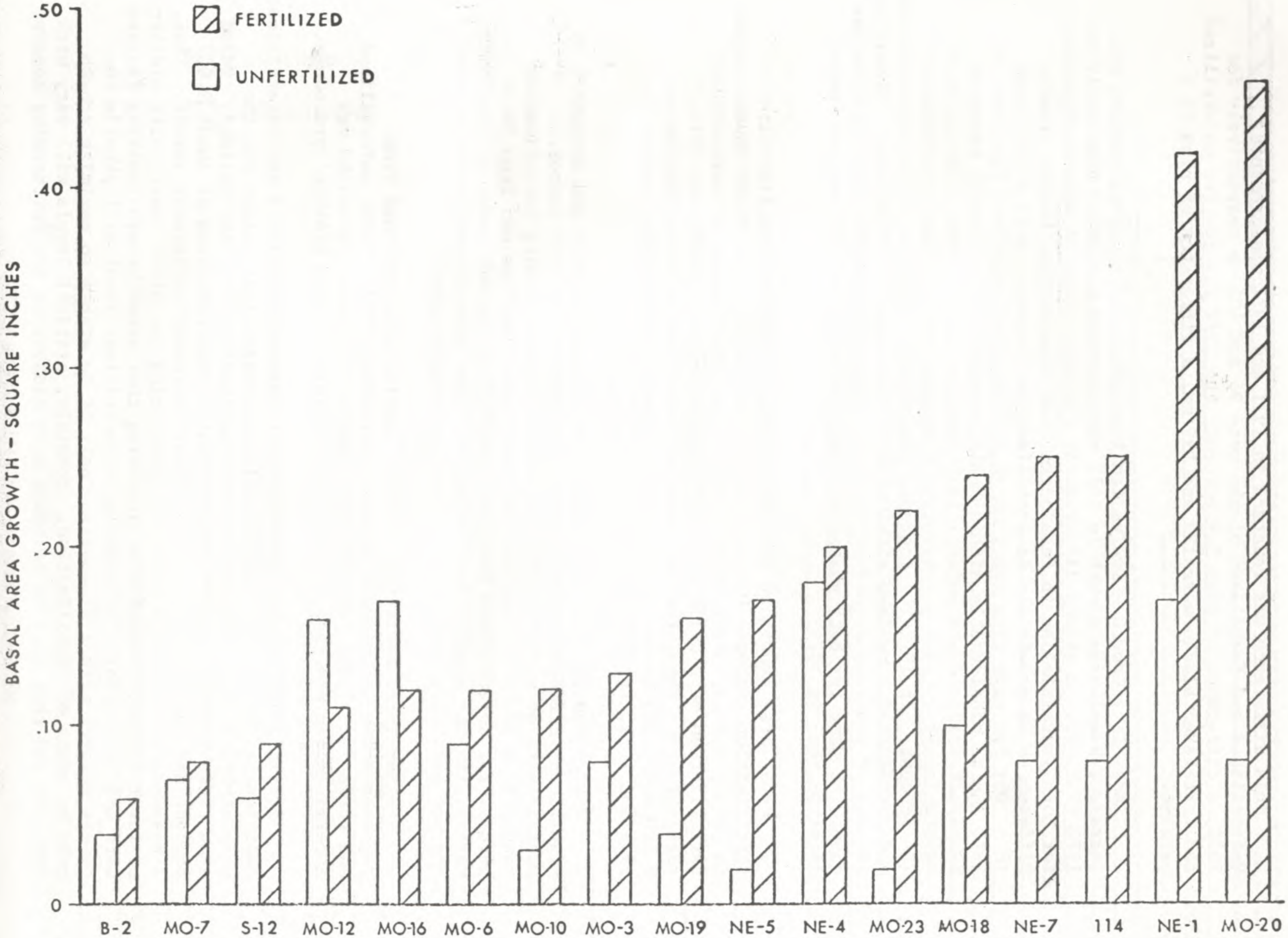


Figure 6.--Two-year basal-area response of 17 black cherry families to nitrogen and phosphorus fertilization.

Table 1.--Certain foliar characteristics of fertilized and unfertilized black cherry.

Treatment	Leaf Weight	Nitrogen	
	mg	Percent	mg/leaf
Fertilized	351	3.40	11.85
Unfertilized	270	1.98	5.35
Difference	81	1.42	6.50

Whether the response to fertilization in this study is related to N only or to a combination of P with N, N values correspond with deficiency levels determined in other field experiments. [1]

It is not implied that these levels represent the critical concentration or content for black cherry levels above which a response to applied N would not be obtainable. Quite likely, critical levels would be substantially higher than levels indicated by the control trees since this foliage was a light yellowish-green color, indicating apparent visual symptoms of N stress. The data are mainly to extend the scant published information on foliar levels of black cherry.

Flowering - Limited flowering first occurred in the spring of 1973, four full growing seasons after planting. All eight flower bearing trees were in fertilized blocks; there were no flowers produced in unfertilized individuals. The eight trees represented four of the 17 families in the test. Families MO-10 and MO-7 flowered in both replicates; families MO-23 and NE-7 each produced flowers on one tree in replicate two. The average number of racemes per tree was six and the largest number of racemes on any one individual was 16.

Interestingly, flower bearing trees were not the largest in the orchard. They were average size trees, but were represented by individuals showing good response in both height and basal area increment from fertilization.

Conclusions - Although it is not possible within a 2-year span to draw firm conclusions about the growth behavior of our seed orchard black cherry under intensive fertilization regimes, the data tentatively indicate that:

Fertilizers applied two seasons after planting (with control of competing cover) effectively reduced mortality due to planting shock and ice breakage.

Response to fertilization within our 17 black cherry families varied substantially. Certain families responded dramatically while others did not, indicating that there is considerable genetic variability with respect to nutrient requirements for maximum production.

[1] Unpublished foliar data on file at NEFES, Warren, Pennsylva

Growth rates within our pool of families can be increased substantially by fertilization. Our test suggests that juvenile height and basal area growth rates can be easily increased by more than 50 and 145 percent, respectively - and perhaps more by propagating only the one or two most responsive families to fertilization. It is important to emphasize, however, that this orchard site is nutrient deficient, and other sites with increasingly better nutrient regimes might react differently - presumably with decreasing response.

The fact that the five fastest growing families without fertilizer were generally not the same families as the fastest growers in the fertilized blocks holds implications for future progeny testing, if we anticipate fertilization will be a common timber management practice in the future. This finding should not be surprising in view of the corn breeders' experience in which the best producers without fertilizer did not always show up the best in fertilizer tests.

Foliar N levels of about 2.00 percent and 5.35 mg/leaf represent deficiency, and a response to applied N is likely at or below this state of nutrition. Critical foliar N levels probably exceed these values since visual symptoms of N stress were apparent.

Fertilization promoted early flowering in four families. The first flower clusters were observed four years after planting (spring of fifth groWing season). It is impossible to draw firm conclusions about flowering when such a small number of trees have flowered. However, the fact that all flower bearing trees were in fertilized blocks and that only four of the 17 families flowered is suggestive that early flowering can be induced by fertilization and that it is under strong genetic control. It is also encouraging that even a small number of trees have flowered at such an early age. In the event that many more trees flower in the orchard next year the conclusion that some black cherry seedling families will produce seed at an early age under intensive nutrient regimes can be confirmed or rejected.

LITERATURE CITED

Allen, R. M. 1963. Release and fertilization stimulate longleaf pine cone crop. J. Forestry 61:827.

Brinkman, K. A. 1962. Fertilizers increase seed production of shortleaf pine in Missouri. Tree Planters Notes 53:18-19.

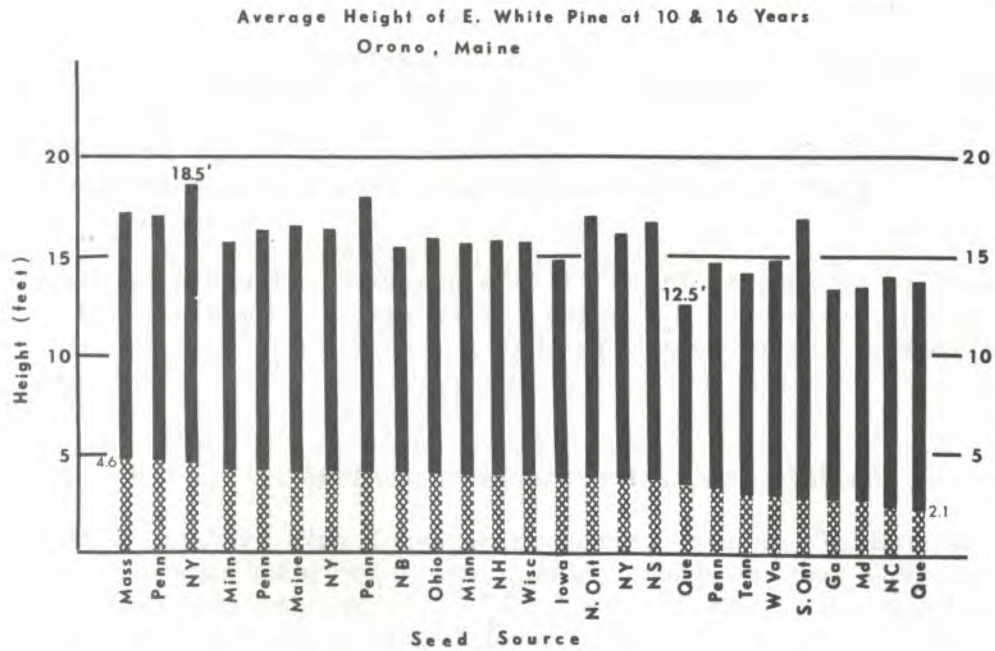
Chandler, R. F. Jr. 1938. The influence of nitrogenous fertilizer applications upon seed production of certain deciduous forest trees. J. Forestry 36:761-766.

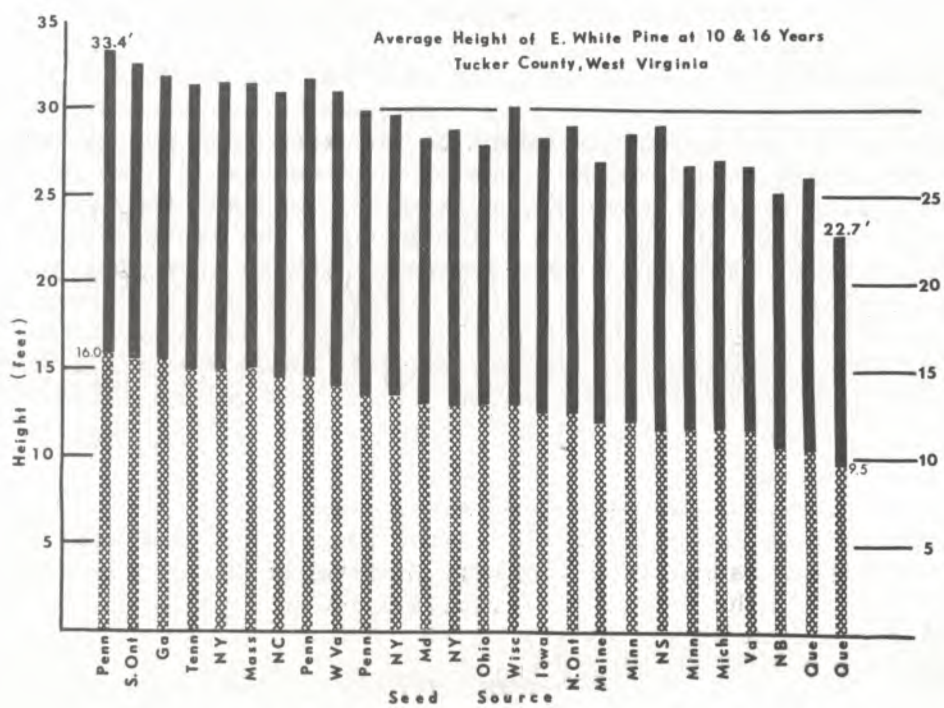
Hocker, H. W. 1962. Stimulating conelet production of eastern white pine. N.E. Forest Tree Impr. Conf. Proc. 9:35-40.

Steinbrenner, E. C., J. W. Duffield, and R. K. Campbell. 1960. Increased cone production of young Douglas-fir following nitrogen and phosphorus fertilization. J. Forestry 58:105-110.

Wenger, K. F. 1953. The effect of fertilization and injury on the cone and seed production of loblolly pine seed trees. J. Forestry 51: 570-573.

Height growth of eastern white pine seed sources representing the most northern and southern plantings by the Northeastern Forest Experiment Station. For information on the performance of provenance tests of eastern white pine in the Lake States see article beginning on page 36.





DISCUSSION

Critchfield - I want to ask about the spacing in the seed orchard.

Dorn - 8 X 8.

Long - Is there any indication from your foliar analysis that the individuals that flowered will be peculiar in any way?

Dorn - No, I can't say one way or the other because for foliar analysis we only took four families from each lot, rather than a sample from each tree.

Schmitt - I want to go back to Critchfield's question. I was a little surprised by the 8 X 8 spacing. This seedling seed orchard you have is also the progeny test. Is that correct?

Dorn - No.

Schmitt - Why are you doing multiple selective pruning?

Dorn - Well, we wouldn't except for the purposes of this study. It is not a progeny test. We have other progeny tests to base our roguing on, and that is why we felt we could do corrective pruning and apply fertilizer. It really wouldn't hurt the seed orchard because the roguing would be based on other progeny tests. That is why we were willing to do all of these various things on these trees.

Lee - How much gain in height did you get due to fertilization as compared with the growth differentiation between the two extreme families?

Dorn - Average gain of the fertilized trees was 56%, but it varied a great deal between families. They only grew on the average of a little over a foot a year, and you might be thinking this pretty poor growth for black cherry, which it is. One of the reasons is some of these trees in these poorly drained areas grew virtually none and they were averaged in with the rest of the trees which brought the average way down. Now some of these trees grew three feet a year, which is more what you should be able to expect.