FERTILIZER TIMING TO INCREASE FLOWERING IN EASTERN WHITE PINE *(Pinus Strobus* L.)

R. C. Schmidtlingl/

Abstract.--Fertilizers were applied on four different dates to orchard ramets of eastern white pine to determine optimum time to increase flowering. Male flowering benefited most by fertilizing in late May, and female flowering by fertilizing in late June or early July.

Treatments such as fertilization, irrigation, and subsoiling are routinely used in managing seed orchards for increased seed production. These treatments seem to be effective, but very little is known about their interactions, long-term effects, or relative efficiency. The efficiency of fertilization is particularly important with rising costs of labor and fertilizers. Dosage, formulation, and timing of fertilization, as well as interaction among treatments and site factors, are areas in which more precise knowledge is required to obtain the maximum seed yield per dollar invested.

Previous work has shown that loblolly pine *(Pinus taeda* L.) orchards should be fertilized in mid-to late summer for maximum production of female strobili (Schmidtling 1975). Similar results were obtained in fertilizer timing experiments for other southern pines. Pollen production was also increased by fertilizers applied at earlier times than was optimum for female flowering, but the timing was much more critical (Schmidtling 1983a).

Several researchers have increased fruitfulness of white pine by fertilization. Fertilization in May improved cone production (Hocker 1962) and fertilizing in July increased female flower production (Stephens 1961) in eastern white pines. In a closely related species, western white pine *(P. monticola* Dougl.), fertilizing in August increased female flowering (Barnes 1969). Optimum timing of fertilizer application has not been established for eastern white pine *(Pinus strobus* L.). Perhaps fertilizers should be applied later to eastern white pine than to southern pines since flower primordia differentiate later in the year (Owston 1969).

This paper reports a 3-year study of an eastern white pine seed orchard which has produced moderate numbers of female strobili, but where seed yield has apparently been limited because pollen was inadequate. The aim was to determine the optimum time of fertilizer application, primarily to improve pollen production, but also to increase female strobilus production.

MATERIALS AND METHODS

The study site was a seed orchard in western North Carolina maintained by the U.S. Department of Agriculture, Forest Service. Of 50 clones, 10 were

---

[1]/Principal Plant Geneticist, USDA, Forest Service, Southern Forest Experiment Station, Gulfport, MS 39503. I am indebted to James McConnell and Ed Manchester of the USDA, Forest Service, Southern Region for assistance provided.

chosen to represent a wide range of flowering capabilities (based on female flowering only). The trees averaged 6.4 inches in dbh and were 14-year-old grafts in 1980.

The design was completely random with single tree plots and five treatments, an unfertilized control and one fertilized late May, late June, late July, and late August. Four replications within each clone/treatment combination used a total of 200 trees.

In 1980, 1981, and 1982, 6 lb of fertilizer (23-7-7 N, P205, K20 as a mix of equal parts 13-13-13 and NH4NO3) was divided among six holes under the "drip" line of each ramet. Female strobili and male strobili clusters were counted in spring 1981, 1982, and 1983.

In data analysis, differences among means were tested at the 0.05 level of probability.

RESULTS AND DISCUSSION

The results obtained in the treatments applied in the study were analyzed with respect to yearly variation evident in the controls, and variation due to differences among clones.

Yearly variation. In the control trees, flowering varied considerably over the 3 years studied (fig. 1). Male flowering increased from near zero in 1981 to 700 strobili clusters per ramet in 1982 dropping to 200 in 1983. Female strobili production did not vary as much, and showed a steady increase over the course of experiment, from under 200 female strobili per ramet in 1981 to over 400 in 1983.

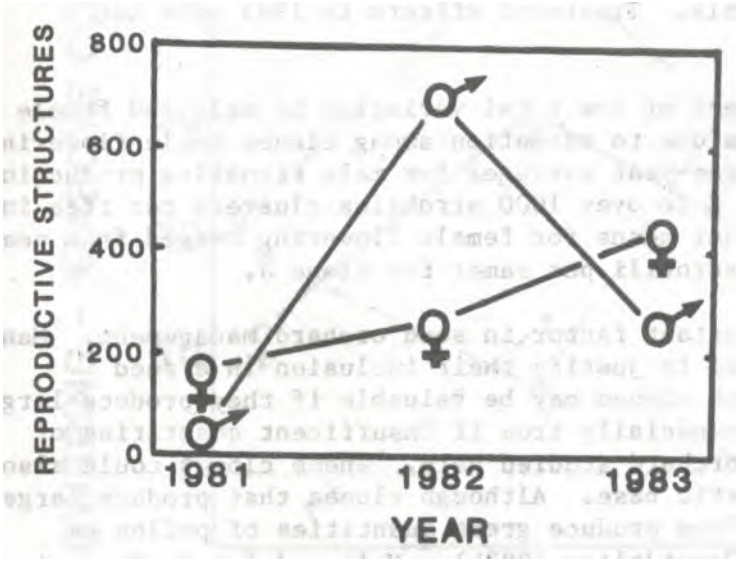

Figure 1. Yearly variation in male and female strobilus production (number per tree) by unfertilized trees. Study site was an eastern white pine seed orchard in western North Carolina.

Male flowering. Fertilization had no effect on male flowering in 1981 (fig. 2). Only a few scattered male strobilus clusters were observed in the entire orchard. In 1982, however, fertilization strongly affected male flowering. Trees fertilized in late May responded best at 200 percent over the controls. Trees fertilized during late June also differed significantly from the controls at about 140 percent above the controls. The late July and late August fertilization treatments did not differ from the controls.

The male flowering response in 1983 was similar to that in 1982. Trees receiving the earliest treatment produced 230 percent more male strobilus clusters than the controls. In 1983, though not in 1982, the last treatment also significantly affected flowering. Trees fertilized in late August produced about 160 percent more male strobili than the controls. An upward turn in the latter part of the fertilizer response curve was indicated in 1982, but was not significant statistically. This response suggests a carryover effect; that is, as fertilizer accumulates, there is a stronger tendency for late fertilization to increase flowering. If so, the true optimum time for fertilizer application may be earlier than the end of May, though it is certain that the first treatment applied in this study was effective.

Female flowering. Fertilization had no more effect on female flowering than on male strobili production in 1981 (fig. 2). In 1980, when fertilizers were applied, a record-breaking drought occurred over much of the southeastern United States, including the orchard location. This lack of rainfall may have owed fertilizer uptake.

Fertilization in 1982 significantly increased female strobili production, but the effect was less dramatic than on male flowering (fig. 2). The second treatment, applied around the 1st of July, was best, but increased flowering only 45 percent above the controls. Treatment effects in 1983 were not significant.

Clonal variation. Over 50 percent of the total variation in male and female flowering in this experiment was due to variation among clones (male flowering. in 1981 excepted) (fig. 3). Three-year averages for male strobilus production varied from neat zero for clone E to over 1000 strobilus clusters per tree in clone B. Similarly, 3-year clonal means for female flowering ranged from near zero for clone A to 700 female strobili per ramet for clone J.

Clonal variation is an important factor in seed orchard management. Many clones do not produce enough seed to justify their inclusion in a seed orchard. On the other hand, such clones may be valuable if they produce large quantities of pollen. This is especially true if insufficent quantities of pollen are produced, as in the orchard studied here. These clones could also contribute toward a broader genetic base. Although clones that produce large quantities of female strobili often produce great quantities of pollen as well, the correlation is weak (Schmidtling 1983b). Male and female flowering were not strongly correlated in this study (fig. 3). Clone J was the best producer of female strobili and was also second best producer of male strobili. Clone B, however, was well below average in female production but was best in male production. Similarly, clone A was well above average in pollen production but had few female strobili. If clone A were removed from the seed orchard because of poor female strobili production, a valuable source of pollen could be lost.

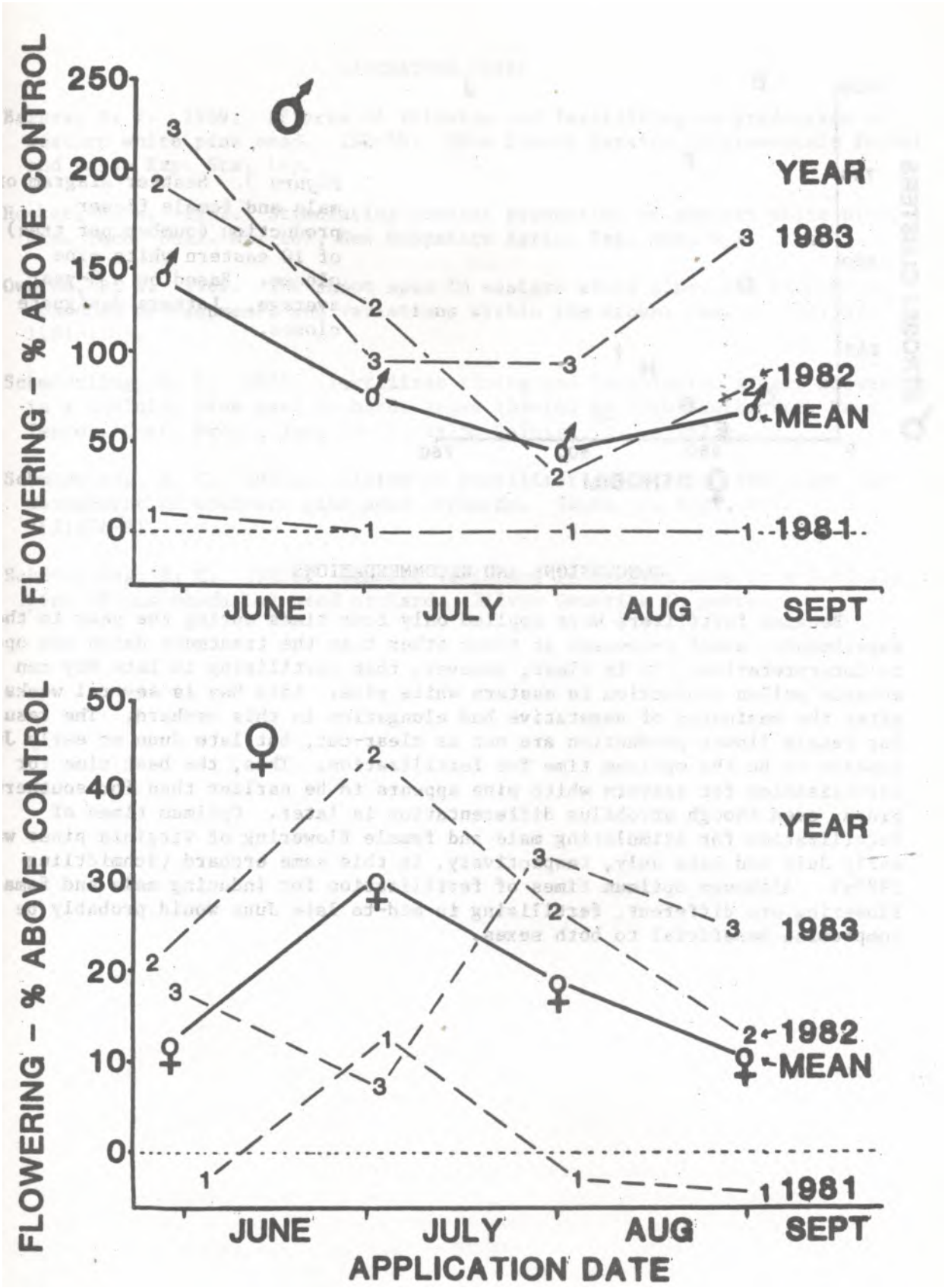

Figure 2. Male and female flowering of eastern white pine clones fertilized at four different times during the year for 3 successive years.

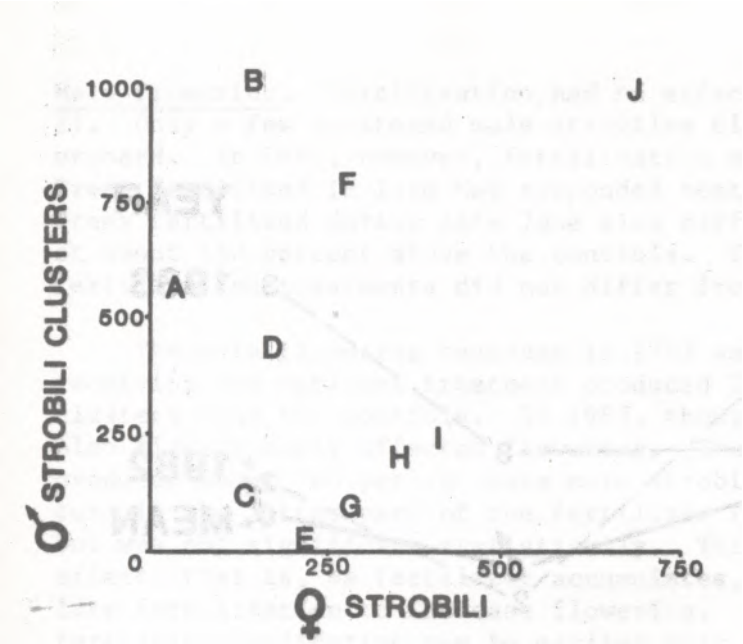

Figure 3. Scatter diagram of male and female flower production (number per tree) of 10 eastern white pine clones. Based on a 3-year average. Letters designate clones.

CONCLUSIONS AND RECOMMENDATIONS

Because fertilizers were applied only four times during the year in these experiments, exact responses at times other than the treatment dates are open to interpretation. It is clear, however, that fertilizing in late May can enhance pollen production in eastern white pine. Late May is several weeks after the beginning of vegetative bud elongation in this orchard. The results for female flower production are not as clear-cut, but late June or early July appears to be the optimum time for fertilization. Thus, the best time for fertilization for eastern white pine appears to be earlier than for southern pines, even though strobilus differentation is later. Optimum times of fertilization for stimulating male and female flowering of Virginia pines were early July and late July, respectively, in this same orchard (Schmidtling 1983a). Although optimum times of fertilization for inducing male and female flowering are different, fertilizing in mid-to late June would probably be a compromise beneficial to both sexes.

LITERATURE CITED

Barnes, B. V. 1969. Effects of thinning and fertilizing on production of western white pine seed. INT-58. USDA Forest Service Intermountain Forest and Range Exp. Sta. 14p.

Hocker, H. W. 1962. Stimulating conelet production of eastern white pine. Sta. Tech. Bull. No. 107, New Hampshire Agric. Exp. Sta. 4 p.

Owston, P. W. 1969. The shoot apex in eastern white pine: its structure, seasonal development, and variations within the crown. Can. J. Bot. 47: 1181-1188.

Schmidtling, R. C. 1975. Fertilizer timing and formulation affect flowering in a loblolly pine seed orchard. Pages 153-160 in 13th South. For. Tree Improv. Conf. Proc., June 10-11, 1975, Raleigh, N.C., 262 p.

Schmidtling, R. C. 1983a. Timing of fertilizer application important for management of southern pine seed orchards. South. J. Appl. For. 7(2):76-81.

Schmidtling, R. C. 1983b. Genetic variation in fruitfulness in a loblolly pine *(Pinus taeda* L.) seed orchard. Silvae Genetica *in press.*