FLOWER STIMULATION IN PINUS STROBUS L.[1]

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Introduction

The increasing awareness of the necessity for using seed of known provenance in reforestation has prompted considerable research on the management of seed orchards and seed production areas. However, some means are necessary to ensure abundant seed crops each year. A good flower crop is a necessary prerequisite., In breeding programs stimulation of early sexual maturity of the trees is also desirable. Most of the work undertaken in flower stimulation in this country has been with the southern pines and Douglas-fir. Success with these species has been encouraging. This paper is a progress report on flower induction in eastern white pine, *Pinus strobus L.*

Materials and Methods

Two white pine plantations located on a sandy loam soil of glacial till origin in Simsbury, Connecticut, were selected for treatment, The trees were 14 and 22 years from seed in 1959 and had been planted at approximately 6 x 6 foot spacing.

Treatments consisted of fertilization with ammonium sulfate (20 per. cent available N), root-pruning, and girdling and strangling of branches in the upper crown. Fertilizer was applied at the rate of 0, 18, 53, and 158 pounds of nitrogen per acre. Fertilizer for the root-pruned trees was ap plied within the root-pruned circle, while unpruned trees were fertilized over an area four times as great. Root pruning was done to a depth of 14 to 18 inches on a radius of four feet with a tiling spade. Competing lesser vegetation was cut from the area to be fertilized.

Two branches were selected as an untreated control, two were strangled with wire, and two were partially girdled on each tree. Three-year-old branch whorls were treated whenever possible, but occasionally it was necessary to drop down to a lower whorl in order to secure six branches of similar size. Strangulation was accomplished by twisting a piece of 16 or 18 gauge copper wire around the branch until it started to cut into the bark. Girdling consisted of making two overlapping partial girdles on opposite sides of the branch. Each girdle covered approximately three-fourths of the circumference and was separated from the other by an intact band of bark and phloem one-half inch wide. A strip of bark and phloem approximately three-eights inch wide was removed in making the girdle. By applying the mechanical treatments to the limbs rather than the main stem, it was hoped to overcome any tree-to-tree variation.

A 3 x 4 factorial design was used with five replications. Since the site appeared to be relatively uniform, the trees to be treated were ranked according to D.b.h. and divided into five blocks. A split plot was employed within each block for root-pruning. Each sub-plot contained a single tree. Treatments were applied in late July, 1959; April, 1960; and late June and early July, 1960.

[1] This material is a portion of a dissertation to be submitted to the Graduate School, Yale University, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Results and Discussion

The 14-year old stand did not produce any flowers on treated trees in 1960. The flowering response of the 22-year-old trees is shown in table 1. Since the June, 1960, treatment was not initiated until after flowering had occurred it can be considered an untreated control. The April, 1960, treatment was designed to test the effect of an early spring treatment. There is no indication that it had any effect on the flowering response. The results of this treatment have been pooled with the controls for testing. When this is done the difference between the means of the number of female strobili per tree for fertilized versus unfertilized trees becomes significant at the 0,5 percent level (t=3.28, n = 118). A comparison of the effect of root pruning also shows the difference of the means to be significant at the 2.5 percent level (t = 2.58, n = 118). The number of trees flowering at each fertilizer level is not significantly different.

Table 1.--Female conelet production in 1960

Treatment dates	N per acre	Conelets per tree Check	Conelets per tree Pruned
	Lbs.	Number	Number
None	0	0.7	1.0
July, 1959	18	0.6	3.6
	53	8.0	8.2
	158	---	7.4
April, 1960	18	0.4	---
	53	0.2	0.2
	158	1.6	3.6

Table 2 shows the flowering response to strangling and girdling. The difference between the means of the control and girdled branches is not significant. However, the single control branch involved was considerably larger than the treated branches and had been partly strangled by the wire of the tag used to designate it as a control. The difference between the means of the girdled and strangled branches was significant at the 1.0 per cent level (t = 2.75, n = 158). It is evident that fertilization, root-pruning, and girdling all favor increased production of female strobili under these conditions. This is similar to the results obtained by Hoekstra and Mergen (1957) for slash pine in Florida.

Table 2.--Female conelet production in 1960 - July, 1959 treatment

N per acre	Control		Branch strangled		Branch girdled	
	Check	Pruned	Check	Pruned	Check	Pruned
Lbs.	Number	Number	Number	Number	Number	Number
0	---	---	---	---	---	---
18	---	---	---	1	---	9
53	---	5	---	2	4	12
158	---	---	---	---	---	7
Totals	0	5	0	3	4	28

None of the trees in the firc two replicates produced cones in 1930 These trees comprised the smaller diameter classes. Of the remaining six trees in each fertilizer treatment the third level (3 lbs. N/acre) produced the greatest number of cones per tree in four cases If one adopts the hypothesis of equal probability that any one of the four levels will produce the greatest number of cones per tree, then the probability that the third fertilizer level would do so four out of six times by chance alone is only 3.3 percent. This extremely small probability suggests that the optimum nitrogen application in this case lies between 53 and 18 pounds per acre, possibly about 100 pounds per acre. Further work is necessary to define more precisely the amount of nitrogen necessary under varying conditions of climate and soil.

The effect of root-pruning and girdling is not entirely clear. It is not possible to determine in this case whether root-pruning provides only release from competition of adjacent trees, or if there is some direct effect on the tree itself such as an alteration of auxin level and distribution. Presumably the effect of girdling is to limit downward translocation from the foliage. Strangulation should also produce the same effect, particularly in this instance, since the wire was tightened until it cut into the bark. Many of the strangled branches produced large swellings above the wire, which indicates that translocation has been impeded. In contrast, most of the girdled limbs showed little or no swelling. However, girdling was far more effective in inducing flowering.

The treated trees ranged from 2.7 to 7.4 inches D.b.h. The smallest flowering control tree was 5.0 inches, while the smallest fertilized tree to respond was 4.9 inches. Ability to flower appears related to size. There is a significant positive regression of increasing cone production with increased diameter. The larger trees were all dominant trees with well- lighted crowns. The smaller trees comprised the codominant and intermediate crown classes. The smaller cone-bearing trees had exposed crowns. No thinning has been performed in this stand and the only openings are a result of natural mortality. The barren condition of the smaller trees may be due to shading of the crowns.

Climate as reflected by annual variation, also plays an important role in flower production. Evidence of this is shown by the size of the 1955 flower crop. The same trees which produced 141 cones in 1960 after treatment, produced 175 cones in 1958 without any treatment. In addition, thirteen trees which remained barren in 1960 produced 104 cones in 1958 Wenger (1951) has suggested that internal competition for nutritional elements might occur between rapidly developing second-year cones and new buds. This could conceivably inhibit differentiation of new flower primordia. There is no indication of such competition in this case. The regression of the 1958 flower crop on diameter is positive and significant. The regres -sion of the 1960 conelet count on the 1958 conelet number shows a positive, significant trend. These observations are in line with those made in lobolly and longleaf pine by Grano (1951) Allen (1953) and Wenger (1954) that cone production is related to diameter and past fruitfulness. Holmes and Matthews (1951) also found that cone production in Corsican pine was related to past fruitfulness and diameter regardless of stimulatory treatment.

Conclusions

The results so far indicate that eastern white pine will respond to flower stimulation treatments with increased female strobili production. Optimum fertilizer application in this case lies between 53 and 158 pounds of nitrogen per acre. The minimum size of tree expected to respond is about five inches d.b.h. In seed orchards and seed production areas it is assumed that each tree will have a completely exposed crown. Under these conditions one might expect somewhat smaller and younger trees to respond.

Root pruning is also beneficial and is applied without too much difficulty. In a rocky till soil only 5 to 20 minutes were required to completely encircle a tree on a radius of four feet.

Girdling and strangling, although easily applied, are not recommended for trees designated for continuous seed production. Whether applied to the branches or main stem both treatments mechanically weaken the tree and increase the possibility of snow or wind breakage. Girdling also provides an entrance for insect and disease attack.

One serious drawback has appeared in this study,, Examination of the trees in 1960 revealed an almost complete absence of male strobili. Only two small clusters were noted on a single tree. It has been noted by others that the presence of female conelets may precede the appearance of male strobili on young trees by several years. This condition could have serious consequences for seed production unless an adequate supply of desirable pollen was available nearby. Techniques might have to be devised for mass pollination of the trees.

The results so far have been encouraging. While the response to treatment was not overwhelming, increased conelet production was evident. This justifies continuation of work with this species.

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