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STIMULATING CONE LET PRODUCTION OF EASTERN WHITE PINE

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INTRODUCTION

Basic to all forest practice is the obtaining of adequate reproduction of the most desirable species following harvesting of a stand of trees. In the case of white pine, regeneration can be accomplished in either or a combination of two ways: natural reproduction from seed produced by trees on or near the cut-over area or by planting seedlings or seed on the area. In either instance, successful reproduction depends upon a reliable source of good-quality seed. Because of the periodicity of seed production by white pine, however, there is no such reliable seed source for the species either for natural reproduction or for nursery-grown seedlings. Any delay in restocking of stands is costly, and should there be some feasible means of stimulating seed production, and thus increasing the certainty of an adequate seed supply, it would help not only in reducing the cost of present management but also in insuring continued production of the species.

In all likelihood, a good portion of the forest tree seed used for artificial regeneration in the future will come from established seed production areas, superior natural stands and from seed orchards of planted superior stock, Normal variations in seed production will, nevertheless, still result in somewhat uncertain seed supply. Furthermore, from the standpoint of economics, it undoubtedly will be necessary to restrict the size of seed orchards and thus the number of seed-producing trees within them. Obviously, then, any practical method by which it would be possible to maximize production from seed orchards would be more than helpful. Where such seed orchards are the result of genetic selection and breeding specifically for commercial seed production, it would be highly desirable also to have tested methods for stimulating seed production in stands which have not yet attained maximum seed-producing age. Seed from seed orchard origin is in demand, and the sooner the orchards are brought into production, the more quickly expenses incurred in breeding and grafting can be offset.

This report is the result of a study begun in 1956 designed to test the effectiveness of several treatments to increase the cone production of white pine trees, and to determine the level of fruitfulness of white pine trees of different ages, of different physical dimensions and of different levels of fruitfulness. It was hoped that fruitfulness could have been measured by the quantity and quality of seed produced, but repeated attacks by white pine cone beetles (<u>Conophthorus coniperda</u>) have prevented collection of any mature cones It will be necessary, therefore, to confine the reporting of results to the number of conelets produced.

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A number of studies reporting the results of various methods of stimulating flower bud formation and seed production have been made. Some of those reporting results with conifer are Holmes and Matthews (1951), Mann and Russell (1956), Allan (1953), Wenger (1953), Shubert (1956), Bilan (1960), Steinbrenner, Duffield and Campbell ;1960), and Stephens (1961). The present study was made to test the effectiveness of crown release, application of inorganic fertilizer, girdling and banding, and combinations of these treatments upon the cone production of eastern white pine trees.

PROCEDURE

The study was initiated in the fall of 1956 in two white pine stands located on the woodlot of the University of New Hampshire. One stand was of the 20-30 year age-class and the other of the 40-50 year age-class. The stands from which 192 trees (96 trees in each stand) were selected were divided into quarters. Within each quarter, eight groups of three trees each were selected to serve as treatment trees. Trees were selected in such a manner as to provide a range of diameters and crown classes within each of the two age groups. Within each quarter eight trees were banded, eight were girdled, and eight were check trees. The treatment trees within one-half of each stand were given full crown release in the form of a thinning. Fertilizer was applied to the trees within one-half of each stand in such a manner that 24 trees which had been released and 24 which had not been released received applications of a complete fertilizer.

Treatment trees were selected in the autumn of 1956, and the following measurements were recorded for each tree: (1) crown class, (2) crown length, (3) average crown width at the base of the living crown, (4) total height, and (5) diameter at breast height. Thinnings were made to effect crown release in the designated portions of each stand in the autumn and winter of 1956-57, Banding and complete stem girdling at breast height were done in May, 1957.

Crown release was accomplished by removing all trees whose crowns touched the treatment trees. This had the effect of achieving a heavy crown thinning in the younger stand and a preparatory cut for shelterwood in the older stand. Forty-eight trees were released in each stand.

Fertilizer was applied to each tree at a rate of 0.1 pound per square foot of projected crown area. The area fertilized was a six-foot annulus at the perimeter of the tree crown. The fertilizer was a 10-10-10 commercial mix. Rate of application ranged from 13-39 pounds per tree in the 30-year-old stand and from 6-34 pounds per tree in the 50-year-old stand. Average rate of application was 21 pounds per tree for both stands. One-half (24) of the released and one-half (24) of the unreleased trees were fertilized in each stand, In the unreleased portion of each stand, though a known amount of fertilizer was applied to each tree, the treatment was in effect an area treatment, whereas the treatment in the released portions was more nearly an individual tree treatment.

Banding was accomplished at breast height by wrapping a 1¼ inch galvanized metal strip around each tree and nailing the two ends together. Girdling was done with a bark scribe. The girdle extended entirely around the stem but the ends were not joined, The two extentions overlapped and were separated by a two-inch vertical strip of intact bark.

Each fall and spring following treatment an estimate of the number of conelets was recorded for treatment trees. Each tree was climbed and a count of the conelets was made. At the same time a count was made of the number of conelets on adjacent treatment trees. Two men were used for the counting. Each man made an independent count from each tree and the counts were compared. When a difference of more than two cones (or 10 percent in the case of very productive trees) was encountered for a tree, additional counts of that tree were made by each man to ensure the best possible estimate of the total number of conelets. Not all conelets were counted, particularly on those trees having a large number, but consistency was maintained and the results, although they may not have absolute accuracy, are accurate in a relative sense.

RESULTS

In order to isolate the many causes of variation which were encountered, multiple regression analysis was utilized to test for treatment effects. Variables tested in the final analysis were:

X_1 = Diameter breast height (OB) 1956 = D

$X_2 = (X_1)^2 = (D)^2$

X_3 = Crown volume - expressed as the volume of a cone whose dimensions conformed to those of the area of the base of the living crown and the length of the living crown = C. V.

X_4 = Released vs. not released

X_5 = Fertilized vs. not fertilized

X_6 = Girdled vs. banded and control

X_7 = Banded vs. control

X_8 = Released and fertilized vs. all other treatments

X_9 = Released and girdled vs. all other treatments

X_{10} = Released and banded vs. all other treatments

X_{11} = Fertilized and girdled vs. all other treatments

X_{12} = Fertilized and banded vs. all other treatments

X_{13} = Released and fertilized and girdled vs. all other treatments

X_{14} = Released and fertilized and banded vs. all other treatments

$X_{15} = (X_1)(X_4)$

$X_{16} = (X_1)(X_5)$

$X_{17} = (X_3)(X_4)$

X_{17} = log (y+2) number conelets autumn 1958

Y = log (y+2) number conelets

The logarithmic transformation of the y's was done to reduce the heterogeneity of variance and to provide a proper form equation of the relationship of number of conelets and tree diameter.

Two analyses were computed for each set of data. The difference between analyses was in the X_{17} variable. Preliminary analysis indicated that previous fruitfulness, represented by the logarithm of the number of conelets produced in the autumn 1958, might mask the several treatment effects; another variable, the interaction between crown volume and release was substituted for previous fruitfulness in one analysis so that a test of treatment effects would be free of the masking effect. The two analyses then are actual tests for treatment effects with and without previous fruitfulness.

when applied prior to emergence in early April and using several follow-up drenches in May and June. It appears that we are dealing with a prolonged emergence period and with secondary infestations. There appears to be only one generation of beetles produced each year.

CONCLUSION

Generally it appears quite possible to increase white pine cone numbers by girdling, by banding, or by applying fertilizer. The most lasting effect is from fertilizer treatment. In the three cone-years since fertilizer application, cone production has been sustained at the same proportionate rate. There were annual differences in the total conelet numbers observed, but the regression coefficients appropriate to the diameter x fertilizer treatment interaction are not significantly different:

b_{16} coefficients - D x fertilized vs. D x not fertilized

		50-year-old stand	30-year-old stand
Without previous fruitfulness			
	Autumn 1958	$b_{16} = 0.010 \pm 0.003$	Not significant
	1959	$b_{16} = 0.010 \pm 0.004$	$b_{16} = 0.014 \pm 0.004$
	1960	$b_{16} = 0.013 \pm 0.003$	$b_{16} = 0.019 \pm 0.006$
With previous fruitfulness			
	Autumn 1959	Not significant	$b_{16} = 0.013 \pm 0.003$
	1960	$b_{16} = 0.007 \pm 0.002$	$b_{16} = 0.016 \pm 0.005$

This would indicate that the proportionate response to fertilization is the same for both age groups; that the difference in cone production levels between the two age groups resides in the basic structure of the trees. It would appear that older trees having greater crown volume and more branch tips are capable of producing a greater number of flower buds. This is indicated by the strong relationship between tree size, represented in this study by diameter or by crown volume and cone production. To produce a large number of cones a tree must have many branch tips upon which to form a large number of flower buds.

Girdling and banding treatments appear to have had only a transient and a less predictable effect upon cone production than did fertilizer treatment. Girdling and banding treatments lack the continuous effectiveness of fertilizer. There is a possibility that the banding treatment as applied in this study did not produce as severe a restriction of growth as would be needed to interrupt downward movement of food.

It is interesting to note the delay in response to treatment in the younger stand. It was anticipated that the treatments would have had some effect on the 1959 cone crop (reported by the autumn 1958 inventory); however, the 30-year-old stand did not show any significant response to treatment until autumn 1959 (the 1960 cone crop) or four years following treatment, whereas the 50-year-old stand showed the effect of treatment a year earlier.

As anticipated, trees of the same physical dimension did not always produce the same number of cones. The ability to produce flowers is a heritable trait. It would appear that in white pine seed orchard management some thought should be given to selection for a high level of flower production.

The results of this study differ in a major respect from studies of similar character conducted with other species. Crown release treatment did not have a stimulating effect upon conelet production in this study, whereas reports of other studies indicate that crown release resulted in a significant increase in cone production as well as seed size and number of seed per cone. In the present study, part of the explanation for the lack of a relationship between crown release and increased cone numbers may be in the definition of physical characteristics of the individual trees and the size of the treatment trees. Two independent variables, diameter and crown volume, were in all cases, in this study, the strongest variables tested and could have masked the effect of crown release. Further, there was a wide range in the diameter of trees used in this study. Previous studies dealt with trees of nearly equal size.

Initial analysis of the data for this study showed the need to include in the regression a second power of tree diameter to prevent the prediction equations from resulting in a set of asymptotic curves. The analysis of the data for the 50-year-old stand showed that for untreated trees there was a tendency for the curve to reflex at about 18 inches diameter, indicating that trees larger than 18 inches did not produce proportionately greater numbers of cones than trees less than 18 inches diameter. Fertilized trees, however, appear to sustain the same proportionate rate of production beyong the 18-inch limit. There were not a sufficient number of larger trees used in the study to indicate at what diameter cone production of fertilized trees might "level off".

SUMMARY

Conelet production of eastern white pine trees can be increased by fertilizing, girdling, and banding. Girdling and banding treatments are transient in their effect and do not appear to hold promise for sustaining cone production over that of the untreated trees for any appreciable period. Fertilized trees produce significantly more corselets than unfertilized trees and appear capable of sustaining the level of production for several years. Maximum cone production is obtained only from older trees, but the young trees respond to treatment at about the same proportion as the older trees and the potential for relatively high levels of cone production in young trees does appear possible when the trees are fertilized.

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