

The Effect of Fertilization and Injury on the Cone and Seed Production of Loblolly Pine Seed Trees¹

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The frequent shortages of loblolly pine seed for natural regeneration prompted investigation of ways to stimulate seed production of seed trees. Partial girdling failed because, as applied, it was too mild an injury. Fertilization was not effective with 40-year-old trees, but significantly increased the cone crop of 25-year-old trees. As explained in summary, the amount of fertilizer may have been inadequate for the 40-year-old trees.

LARGE AMOUNTS of seed are needed to assure success in regenerating loblolly pine stands under even-aged management. Insects, birds, rodents, poor seedbed conditions, and possibly other factors, may inflict large losses. Many stands of pole size are now being harvested, however, because of the heavy demand for pulpwood, and the remaining seed trees are often too young to produce enough seed, especially in poor seed years.

The success enjoyed by agriculturists in increasing the yields of field, forage, and orchard crops has suggested fertilization as one way to increase the seed production of young loblolly pine seed trees. Although fertilization of forest trees has not been studied extensively, the few cases on record indicate that it can substantially increase seed production. Gemmer (5) recorded the cone production of long-leaf pine trees that had been treated with pine-needle mulch, sodium nitrate with and without irrigation, irrigation alone, and a complete fertilizer with irrigation. Soil treatment for 5 years resulted in 7 to 30 times as many cones as on untreated trees. The complete fertilizer plus irrigation produced the greatest response, 62 cones per tree compared with 2 cones per untreated tree. Chandler (2) fertilized sugar maple and beech trees in a second-growth stand with varying amounts of nitrogenous fer-

tilizer. He expressed the response to fertilization by the seeding index, which was the percentage of trees bearing seed multiplied by the average percentage of the crown surface that bore seed. In beech the seeding index of fertilized trees was 133 to 647 percent of that of the check trees. In maple the difference amounted to 3,040 percent of the seeding index of check trees. Detwiler (4) reported an oak shade tree that had produced 1 to 2 bushels of acorns in good seed years before fertilization and 8 to 10 bushels after an accidental, heavy fertilization.

Girdling and banding have also been used on an experimental scale to increase fruiting. Pond (6) girdled black ash trees by removing a 1/2-inch band of bark spiralled three times around the stem, by a 1/2-inch complete girdle, and by a complete knife-cut girdle. The first two treatments killed all trees, but the knife-cut stimulated 50 percent to produce seed compared with 10 percent of the check trees that were fruitful. Arnborg (1) partially girdled pines by making two semi-circular overlapping cuts. Treated trees produced 0.73 liters and check trees 0.35 liters of cones. Similar responses have followed banding.

In view of these results, a study was undertaken in southeastern Virginia in 1948 to determine the effects of fertilization and injury on the cone and seed production of loblolly pine.

Procedure

Two seed-tree cuttings made in the winter of 1947-48 were chosen for the study. One stand was 25

years old at the time of cutting and the other was 40 years old. The soil was the same type and series, Norfolk loamy sand to sandy loam, at both locations and the site index was 80 feet.

Each of the following treatments was applied to 25 well-formed, sound, uninjured trees at each location in April 1948:

1. No treatment.
2. Knife-cut through the bark to the wood halfway around the stem 3 feet from the ground.
3. Twenty-five pounds of complete fertilizer (7-7-7) spread around the tree to 2 feet beyond the edge of the crown.

4. Fifty pounds of complete fertilizer applied as in treatment (3).

The trees selected averaged 12.6 inches d.b.h. in the younger stand and 14.7 inches in the older stand.

The rate of fertilizer application was based on the minimum amount per tree required to produce responses in nut trees (3) and on the amounts applied in Chandler's (2) study. Twenty-five pounds of 7-7-7 fertilizer contains 1.75 pounds each of total nitrogen, phosphate and potash.

Cones were counted with binoculars every fall from 1948 to 1951. In 1948 only sound cones were counted but in the last three years defective cones also were counted and were recorded separately. In 1950 two sound cones were taken from each study tree, the seeds were extracted and cut, and the numbers of sound and defective seeds were recorded.

Effect of Injury and Fertilization

The total numbers of cones per tree produced under each treatment in 1950 and 1951 are shown for both locations in Table 1. Treatment effects are reflected with greater accuracy by the total number of cones per tree than by the number sound, because cone losses are independent of flowering. Since treatments could not affect

¹This study was planned and installed on lands of the Camp Manufacturing Company, Inc., by K. B. Pomeroy and I. H. Sims, silviculturist and research center leader, respectively, of the North Coastal Plain Research Center, Franklin, Va., at the time the study was started.

TABLE 1.—AVERAGE NUMBER OF CONES PER TREE ACCORDING TO AGE, NUMBER OF GROWING SEASONS AFTER TREATMENT, AND TREATMENT

Treatment	Cone yield of 25-year-old trees		Cone yield of 40-year-old trees	
	3 years after treatment	4 years after treatment	3 years after treatment	4 years after treatment
None	36	149	191	213
½ girdle	27	100	191	305
25 lbs. fertilizer.....	98	176	201	265
50 lbs. fertilizer.....	123	157	254	334
Average all trees	71	146	209	279

cone production in less than three growing seasons, the production before 1950 is not shown. Loblolly pine cones require two growing seasons to mature, and flower buds must first be formed.

The knife-cut injury failed to cause an increase in cone crop in both stands, apparently because the injury healed over before bud formation. Treatments were applied late in April and by the end of June all knife cuts had healed. A small-scale test of full knife-cut

girdling and of partial girdling by removing a ¼-inch strip halfway around the stem had been initiated in a partially-cut stand in 1947. The ¼-inch strip did not heal during the following season and that treatment caused a significant increase in the 1948 cone crop—53 cones per tree compared to 15 per check tree.

Both lightly and heavily fertilized 25-year-old trees produced significantly more cones than the check trees in the first effective

year, but the production of the heavily fertilized trees was not significantly greater than that of the lightly fertilized trees. Apparently most of the additional 25 pounds of fertilizer was superfluous.

In the next year all of the 25-year-old trees produced more cones but the effect of fertilization had disappeared. The response to fertilization only in the earliest possible year suggests that its effect was directly nutritional rather than indirectly through the development of more foliage and an increase in reserve carbohydrates, as seems to be true with deciduous species (2). If a greater concentration of reserve carbohydrates following the development of more abundant and efficient foliage had caused the increased cone production, it seems likely that a response would also have been evident in the second effective year since the larger

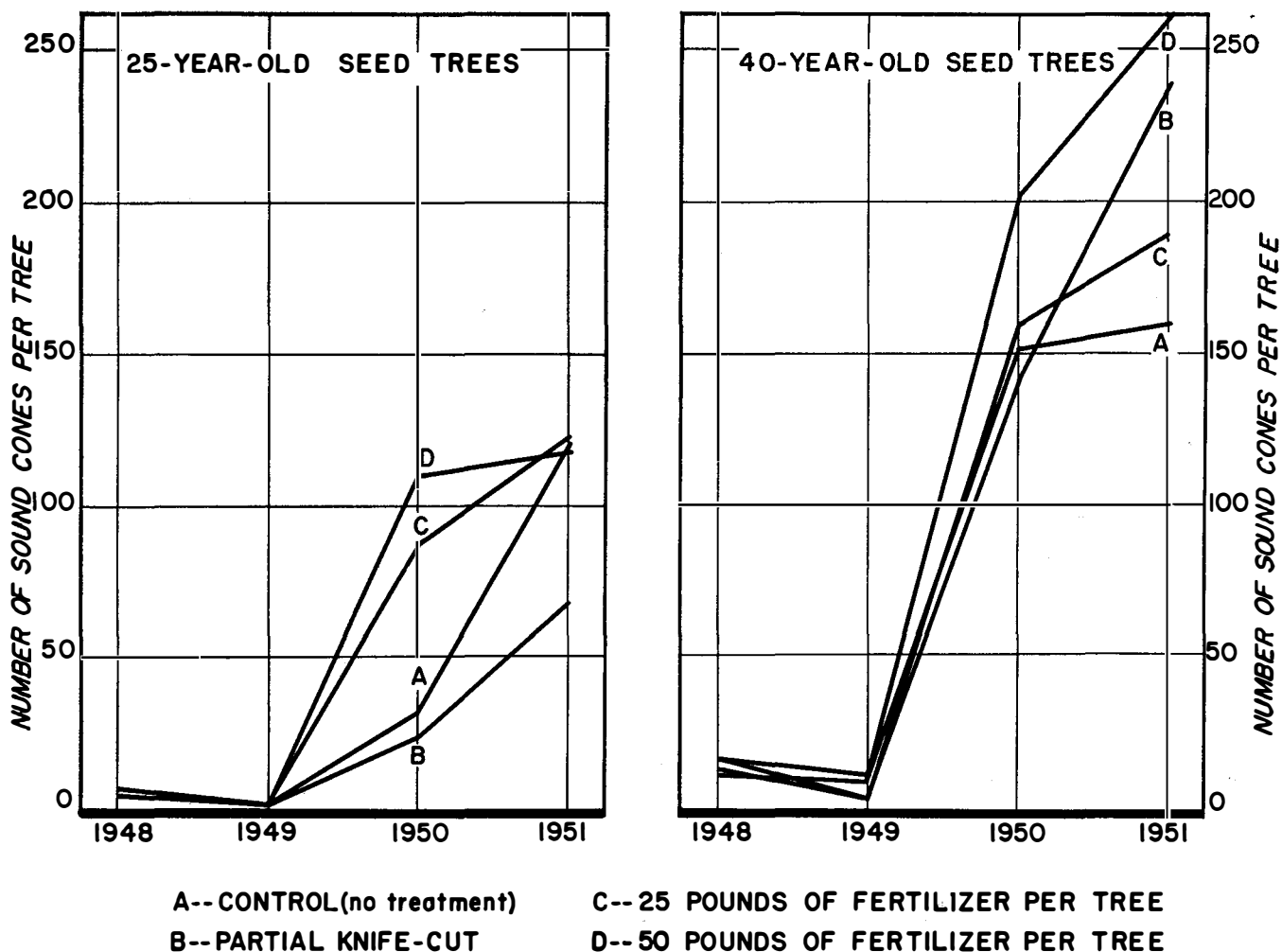


FIG. 1.—Trend of annual cone crops for treated seed trees (sound cones only).

amount of foliage would still have been present during the second growing season after fertilization.

Although the level of cone production in the older stand was much higher than in the younger, the effect of fertilization was not significant. The trends of cone crops over the years since treatment, shown in Figure 1 (sound cones), in comparison with the regional trend suggest the reason for this behavior. During the first three years, 1948 through 1950, the regional level remained low but in the last year, 1951, it rose nearly to the level of the bumper 1947 crop (7). Since the large increase in cone crops of the 40-year-old trees in 1950 occurred in the face of generally unfavorable conditions just three years after release, it can be attributed mainly to the effect of release. In the younger stand only the trees that had been fertilized increased their cone production substantially, and even then not nearly so much as the older trees. The great response of the older trees to release may have obscured the effect of fertilization, or it may be that even the heavier fertilizer application was not enough to increase cone production significantly in the larger trees. The larger average cone crop on the heavily fertilized trees, 53 cones per tree more than on the lightly fertilized trees, although not significant, does suggest an effect of fertilization that might have been enhanced by heavier applications.

The further increase in cone production by both age classes in 1951 was apparently caused partly by the continuing effect of release and partly by the improvement in climatic and cyclic factors. Fertilization contributed little, if anything, to that increase since cone crops on fertilized trees were not significantly greater than those on unfertilized trees.

None of the treatments significantly changed the percentage of defective cones, the total number of seeds per cone, or the percentage of sound seeds per cone.

Practical Aspects of Artificial Seed Tree Stimulation

Since the knife-cut girdling treatment apparently was not severe enough to cause an increase in cone production, little can be said about the practical usefulness of such methods. The possibility exists that injury treatments on a practical scale might result in considerable mortality or might reduce the vigor of the trees enough to make them highly susceptible to insect and disease attack.

The responses to fertilization by trees of both age classes suggest that fertilization can increase cone production significantly only in very young trees. Good forest management does not permit loblolly stands as young as 25 years to be harvested; consequently the occasions when fertilization might be used to increase seed production would be quite limited in practice. And even though fertilization might substantially increase seed production of young trees, initial establishment of reproduction might not be much greater because of the decline in favorability of post-logging seed bed conditions during the three years needed for fertilization to be reflected in seed production. The results of this study thus suggest that fertilization for seed production is not very promising for use in practical loblolly pine management.

The highly desirable coincidence of a plentiful supply of seed and a fresh seedbed can be assured by a more practical way of stimulating seed production—the selection and release of seed trees three years or more before the harvest cut. An investigation of that method will be reported in a forthcoming publication.

One situation in which fertilization of seed trees is likely to be more profitable than in regenerating a single stand is in seed orchard culture. Interest in seed orchards is growing because of the increasing need for planting stock and because of the realization of the benefits to be gained from using seed of good genetic quality. The prices paid for loblolly cones in the

last few years, \$2.00 to \$3.00 a bushel, are in line with those paid for other orchard crops and therefore would justify considerable cultural work in seed orchards. The results of this study suggest that fertilization can increase cone production enough to make its use profitable in seed orchards but nutrient requirements, fertilizer composition, methods of application, need for cultivation, and similar problems, would have to be studied before proper fertilization regimes could be prescribed. Problems of that kind can be studied more efficiently in a seed orchard itself than in seed-tree cuttings aimed at regenerating stands.

Summary

Twenty-five isolated seed trees in each of two locations were treated in one of the following ways: (A) no treatment, (B) knife-cut girdle halfway around the stem, (C) 25 lbs. of 7-7-7 fertilizer per tree, and (D) 50 lbs. of 7-7-7 fertilizer per tree.

The knife-cut girdle produced no increase in cone crop.

In the 25-year-old stand lightly fertilized trees produced 98 cones per tree and heavily fertilized trees produced 123 cones per tree in the first effective year (third growing season after treatment) compared to 36 cones per check tree. The difference between lightly and heavily fertilized trees was not statistically significant.

Forty-year-old trees did not respond significantly to fertilization but produced 209 cones per tree compared to 71 cones per tree produced by the younger stand. This greater production was attributed to a greater effect of release on the older trees. The results suggested that the amount of fertilizer applied was insufficient for the larger trees or that the effect of fertilization was obscured by the great response to release.

The effect of fertilization was no longer significantly evident in either stand in the second effective year, although average cone production was greater. The increase

was attributed mainly to the continuing effect of release combined with more favorable climatic and cyclic factors.

Treatments did not significantly affect the percentage of defective cones, the total number of seeds per cone, or the percentage of defective seeds per cone.

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