Fertilizer Application Can Improve Red Pine Seed Production

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Red pine *(Pinus resinosa* Ait.) is one of the most important reforestation species in the eastern part of temperate North America. Although planted extensively in both the United States and Canada, this species does *not* have frequent seed crops, and seed is often in short supply.

Nutrition has an important influence on flower and fruit production. The fertilizer experiments in Michigan were initiated about the time that workers reported increased seed production on forest trees in other parts of the United States (1, 5, 6, 7) after fertilization. Nitrogen and phosphorus appeared to be the "major added nutrients which stimulated production. A recent report from England (4) contradicted reports supporting the effectiveness of complete fertilizer additions to several tree species.

In a Canadian stud-, Cayford and Jarvis (2) disclosed that ammonium nitrate fertilizer stimulated seed production in red pine. Even more recently, Cooley (3) reported on the effects of thinning and fertilization. Thinning was most effective in increasing cone production in 20- and 55year old stands in Michigan. Complete fertilizers did not affect cone production in the younger stand. In the older one, fertilization increased cone production where the stand had been thinned to 40 trees per acre, but not where the thinning had been lighter (to 160 trees per acre), or nonexistent.

Materials and Methods

Dunbar Forest.-Fertilizer studies were done in a 35-year-old red pine plantation located on the Dunbar Forest Experiment Station near Sault Ste. Marie in Michigan's Upper Peninsula. The dominant trees averaged 9.5 inches d.b.h. and 48 feet tall. The soils were loamy fine sands, water stratified with bedded fine materials, with imperfect to moderate drainage (Rousseau and Ingalls series). The site is better than average for red pine in the region.

At the start of the experiment, the stand contained 575 trees per acre, each having about 76 square feet of growing space. Live crowns were limited to the upper one-fourth to one-third of the boles, and cone production was relatively light.

In 1960 and in each of the following 3 years, sixteen 33 x 33foot (1/40th acre) plots were established, each centered around one dominant tree on which the cone counts were subsequently made. These plots were thinned lightly by removing the trees adjacent to the plot tree.

Each year from 1960 to 1963, two of these 1/40th acre plots were given one of the eight fertilizer treatments shown in Table 1. The fertilizer was broadcast about June 1. Half the plots (one of each treatment) were retreated in the same way the following year.

Raco, Michigan.-Another set of plots was established on the Hiawatha National Forest, near Raco, Mich. in 1965. These plots were in a 39-year-old, sparsely stocked stand growing on a very well drained sandy soil (Rubicon

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TABLE 1.—*Description of fertilizer treatments applied to the Dunbar plots*

Treatment number	N	P	K	Source of active ingredient
	Pounds per acre			
1 (Control)	0	0	0	——
2	100	0	0	Ammonium nitrate
3	100	100	0	Ammonium nitrate, plus 46 percent superphosphate
4	100	44	83	12-12-12
5	200	0	0	Ammonium nitrate
6	200	200	0	Ammonium nitrate, plus 46 percent superphosphate
7	200	88	166	12-12-12
8	100	220	0	Magnesium ammonium phosphate

sand) of below average quality for red pine. The open-grown trees had full crowns. There were 12 treated and 12 untreated plots, all 29 x 29 feet (1/50th acre) with one red pine in the center. Each treated plot was fertilized in June with 9 pounds of urea and 13 pounds 0-46-0 fertilizer and in July with 4 pounds of pelletted slow-release urea; this amounted to about 300 pounds of nitrogen per acre.

Analysis and Results

Diameter measurements were made annually in late fall with a tape at a marked point. Cone counts were made from the ground in September of each year on the red pine tree in the center of each plot. In 1963, conelets were also counted, and the cones were harvested for determination of cone weight, seed yield, and seed weight.

A separate analysis of variance was made on the untransformed Dunbar data for different years of cone counts and for different times after fertilization. A single analysis was made for one series of cone counts done for the Raco plots. Error variances were high, as is often the case with fruiting data, and treatment effects were in no case statistically significant at the 5 percent level.

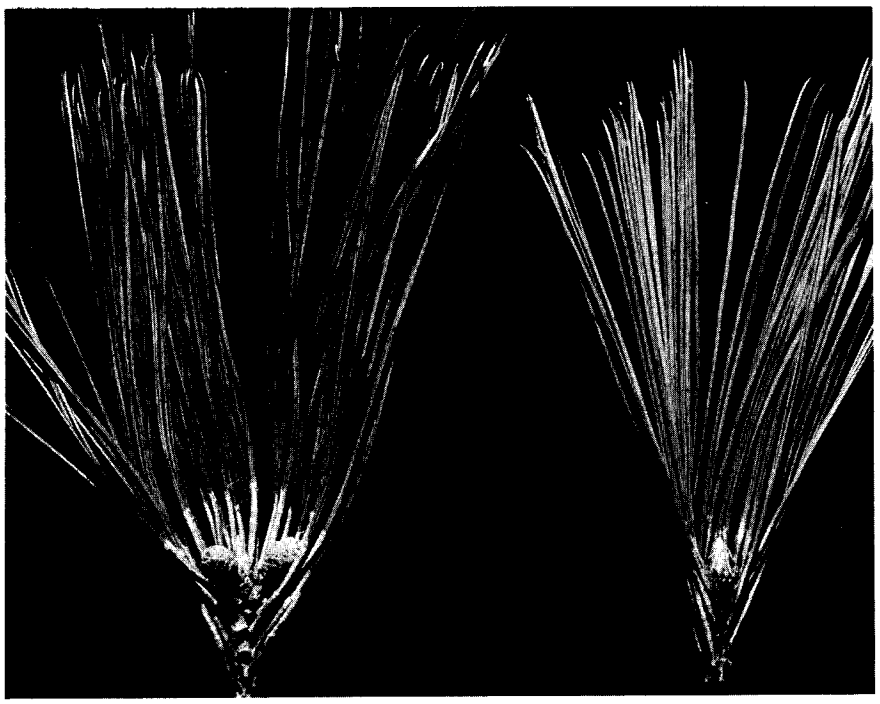
Dunbar.-Contrary to expectations, no diameter increase resulted from the treatments. However, more cones were produced, needles were longer and darker green and had a higher nitrogen concentration 1 and 2 years after treatment (fig. 1'). The light thinning was insufficient to overcome the already crowded condition of the stand.

Rate of diameter growth, which averaged 4.5 mm. per year for the 5-year period prior to thinning and treatment, declined to 3.6 mm. per year for the next 5-year period.

Female flower primordia of red pine are produced in middle or late summer. A fertilizer application in June could conceivably affect formation of flower primordia in July-August of that same year, female flower production the following spring, and cone production three growing seasons after fertilizer application.

Cone and conelet counts made in the autumn (1960-63), followed the pattern expected if the fertilizer was effective. That is, number of conelets was high on

Figure 1.-High nitrogen applications stimulated red pine conelet production, needle color, and needle length of treated trees *(left)* over control trees *(right).* Needle growth response occurred in the season of treatment. Conelet production increased in the growing season after treatment.



trees fertilized in 1962 and number of cones was high on trees fertilized in 1961, as shown in the following tabulation.

Year of fertilizer application	Conelets No. per tree	No. Cones per tree
1960	0	0
1961	58	5
1962	12	52
1963	2	22

In subsequent years, only cones were counted. The results are summarized in Table 2, which shows that the fertilized plots generally produced more cones than the controls three and four growing seasons after treatment. The treatment effects approached significance at the 10 percent level if all treatments were compared with controls for the third growing season after treatment.

In 1963, the cones were harvested and the seeds were extracted from all controls and treated trees. There were no appreciable differences due to treatment in cone weight, seed weight, or number of filled seeds per cone.

Raco.-In the Raco experiment, fertilization with urea and 0-46-0 in 1965 was followed by increased cone production in both 1966 and 1967, as shown in the following tabulation.

Theoretically, there should have been an increase in 1967 but not in 1966, unless the fertilizer enabled trees which had flowered in 1966 to mature a larger percentage of their flower crop. Of course, with only 12 trees per treatment, it is also possible that both increases were due to chance.

Treatment	No. cones per tree 1966	1967
Fertilized	39	12
Unfertilized	18	5

TABLE 2.—*Cones per tree by treatment and number of growing seasons after treatment*[1]

Plot Treatment	No. cones per tree 3 growing seasons	4 growing seasons	5 growing seasons	6 growing seasons
Control ..	5	4	1	0
N	22	11	2	1
NP	23	10	4	0
NPK	23	15	5	7
2N	27	22	5	2
2NP	20	10	2	1
2NPK	28	10	6	8
8-40	10	22	10	2

[1] The counts after 3, 4, 5, and 6 growing seasons are based on 8, 6, 4, and 2 trees per treatment respectively.
(See table 1 for fertilizer amounts.)

Practical Application

During the period of observation, the number of cones per tree varied from 0 to 129. Cone counts on trees given the same treatment varied from 10 to 113. This explains why the error variance was so high, and statistical significance so low. Truly definitive data would probably be forthcoming only if such experiments were done on a much larger scale. That would probably mean working with much younger stands where it would be possible to use large plots and hundreds of trees per treatment.

Because of the lack of statistical significance, our data are valuable mainly when considered in combination with the results of other studies (2, 3). Cayford and Jarvis, Cooley, and this study found that fertilizer application was followed by heavier cone sets after three growing seasons, but Cooley noted that the fertilizer effects were strong only when the stands were heavily thinned to leave every tree with full sunlight clear to the base of the trunk. Unfortunately, even the combined data give no clear picture as to whether nitrogen or a combination of nitrogen with phosphorus and potassium is most effective.

There are four seedling orchards of red pine in Michigan, now in their 10th year from seed. Crown closure has not yet occurred. Cooley's results indicate that timely thinning to keep crowns alive to the ground will be the single most effective method of increasing flowering and fruiting. The fertilizer effects, while not as definite as desirable, appear sufficient to warrant moderate annual applications.

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