18. STIMULATING SEED PRODUCTION BY FERTILIZATION AND GIRDLING

T. E. Maki, Professor of Forest Management
School of Forestry, North Carolina State College
Raleigh, N. C.

Within the past two decades, the advent of tree improvement activities on practically a world-wide scale has aroused increasingly greater interest and effort in stimulating fecundity of forest trees. Various methods have been employed in attempts to achieve greater seed production. Two of these methods, loosely termed "fertilization" and "girdling", will be discussed here.

Fertilization, or simply the application of fertilizers, has long been a standard horticultural practice for improving the fruitfulness of orchards. In forestry, experience with fertilizers is very limited but there have been sufficient trials to indicate real potentialities. Paul and Marts (1931) in a study of summer wood production in longleaf pine in a deep sand region of Florida applied up to 19,058 pounds per acre (270 pounds per tree) of nitrate of soda and sulphate of ammonia, plus 245 pounds of superphosphate and 189 pounds of potassium sulphate per tree, alone and in combination with mulching, watering, or both, over a 3-year period. Four years after initial application, incidental counts of cone production showed that the average number of cones on check trees was only two; on mulched trees, 11; on trees supplied with sodium nitrate, 16; on irrigated trees, 25; on trees receiving sodium nitrate and irrigation, 54; and on trees irrigated and given an application of a complete fertilizer, 62. The improvement brought about by the joint treatments is worth noting.

Chandler (1938) found that heavy additions of sodium nitrate and ammonium sulphate increased the yield of seed for both beech and sugar maple, and also increased the viability of maple seed. Detwiler (1943) accidentally applied a heroic dosage of 14,000 pounds per acre of a 10-5-4 mix to a 23-inch white oak tree in Alexandria, Virginia, and observed that the acorn production jumped from the "normal" of two bushels to eight bushels after about 18 months following application. Wenger (1953) reported the results of a formal experiment undertaken by Pomeroy near Franklin, Virginia, and involving, among other treatments, the use of fertilizers to stimulate seed production in. loblolly pine. The dosage per tree was either twenty-five or fifty pounds of a 7-7-7 mix. Cone production of 25-year-old trees, averaging 12.6 inches in d.b.h., increased about three times over that of check trees in the third season after application, but in 40-year-old trees, averaging 14.7 inches in d.b.h., cone production failed to increase significantly. Wenger postulated that the amount of fertilizer was not sufficient to produce a response in the older trees; he also found that in the younger trees there was no significant difference between light and heavy fertilizing, the number of cones per tree averaging 36 for checks, 98 for the 25 pound rate, and 123 for the 50 pound rate.

Allen (1953) reported on preliminary results of fertilizing and releasing longleaf pine in South Mississippi and South Alabama, where eight-inch trees were given a dosage of 19 pounds of a 5-15-5 mix, 10-inch trees 30 pounds, and 12-inch trees 44 pounds of the same mix. Three years after treatment, the treated trees produced 12 times more cones than the untreated ones (check trees bearing 1.8 cones per tree), and in the fourth year four times more cones than the check trees which averaged only 0.9 cones per tree. The two-year average cone production actually was 1.3 cones per check treatment, 6.9 per release, 13.5 per fertilized, and 1.6.7 per fertilized and released. Allen pointed out that size of tree appeared to be important, eight-inch trees yielding only 4.6 cones, but 10-inch trees bearing 10.3 cones, and 12-inch trees bearing 13.9 cones. Of perhaps greater significance was the finding that three years after treatment trees bearing cones in a good seed year were more than three times as fruitful as those trees that bore no cones at time of treatment, the actual valued being 14.7 cones per tree versus 4.5 cones, respectively. Grano (1951) emphasized this point also with his data on pines in South Arkansas where 90 percent of trees having cones in 1949 bore cones also in 1951, averaging 129 per tree, while 70 percent of the trees with no cones in 1949 had cones in 1951, but averaged only 37 cones per tree. Similarly, Wenger (1953) showed that the fecundity of loblolly in southeast Virginia, after release, was directly related to fruitfulness before release, the ratios for three levels being 10:37, 30:80, and 50.124, respectively.

These instances will perhaps suffice as evidence that fertilizing of forest trees will stimulate seed production, but the results of these, as well as other studies, are too variable to permit formulating any clear-cut prescriptions. To some extent, fertilizing will continue to be somewhat of a local matter, depending on soils, climate, species, age of tree, and other specific factors. However, many general principles can doubtless be worked out after more experience has been gained and critical evaluation of -dosages, salt combinations, seasons of application, placement tests, and other treatments have been made.

Let us now consider, briefly, the practice of "girdling" or, perhaps more appropriately, ringing, as well as of banding, or strangulation, as methods of improving the fecundity of forest trees. Again, horticulturists began employing these practices years ago, often with good results. Recent interest in these practices among foresters has, doubtless, been intensified by the appearance in 1948 of English translation of Bertil Lindquist's book entitled "Genetics in Swedish Forestry Practice".

The immediate objective of girdling is to retard or interrupt sap movement, thus retarding water and salt flow from the roots upward, and the flow of elaborated foods or photosynthates from the leaves to the roots. If girdling is complete and thorough the tree should die within five years, depending on the species, size, or age. The purpose of "girdling" in seed stimulation work is not to kill the tree but to bring about certain changes in carbohydrate metabolism and salt mobilization which are believed to aid either flower formation, fruit setting, or both.

The effects of "girdling" or ringing have been observed in a number of investigations on, forest trees. For example, Baldwin (1934) found abnormally large quantities of sugars trapped above the girdle during the first season following the operation, but at the end of the second season sugar reserves had fallen lower than in the trees not girdled. Stefansson (1948) applied strangulation to young Scots pines and Norway spruce in an attempt to induce increased seed production. He found marked stimulation of flowers, mainly male ones, two to three seasons after the operation was begun. Strangled older trees (40 to 70 years) took longer to respond, and the response was not strong. Ring-barking, leaving at least two inches of bark intact, and root pruning at least one meter from the tree, produced effects that were clearly detectable after three seasons. Stefansson concluded that in older conifers strangulation is perhaps not worthwhile, but that ringing and the addition of phosphate fertilizer might be a desirable practice. Holmes and Matthews (1951) compared girdling and banding in a 20-year old plantation of Corsican pine. Stem girdling in the form of a continuous knife incision at breast height gave the best results which showed up in the second season after treatment. Girdling was more effective on larger trees. Two semicircular cuts caused the heaviest swelling, and metal bands the least. In general, metal bands produced lower cone yields than did other treatments. Girdling was found to be most effective in May, least effective in January.

Wenger's (1953) report on fertilizing of loblolly pine also includes results of some comparisons on the effectiveness of girdling. In the main experiment the girdle consisted of a knife cut halfway around the stem and three feet above the ground. The knife cut wound made in late April had completely closed by June of the first season., and the lack of response from this treatment was attributed to the rapid healing of the "girdle". A small side experiment was installed in 1947, taking a 1/4-inch strip of bark halfway around the stem. This strip was wide enough to remain open through the following season, sufficient to significantly increase cone production the following year, with 53 cones per "girdled" tree against 15 cones per check tree.

Vincent (1940) in Czechoslovakia carried out partial girdling and complete girdling, either at the breast height point or just below the crown, on both pine and spruce. In no instance did he find any increased seed production in treated trees, compared to equally vigorous trees not girdled. He concluded that satisfactory seed production in timber stands can best be assured by repeated heavy thinnings beginning at least 20 years in advance of the needs for abundant seed supply.

These and other records of girdling, or ringing, and strangulation, or banding, indicate something of the nature and magnitude of response that may be expected. Generally speaking, these practices tend to reduce the vigor of the tree, seeming, therefore, less desirable than fertilizing, irrigation, release, and other practices which usually improve tree vigor and growth. Be that as it may, it seems important at this stage to avoid condemning any of these practices until additional experience and study provide a broader basis for more sound conclusions.

Since forestry investigations on both fertilizing and ringing have been generally of more or less empiric nature, we may find it worthwhile to review some of the principles that horticulturists have developed over the years. The work of Kraus and Kraybill (1918) nearly four decades ago focused attention of horticulturist on the practicability of employing some of the basic knowledge of carbohydrate and nitrogen mobilization in fertilizing and other practices for improving fruit production. Kraus and Kraybill were the first to supply chemical data demonstrating the relationships between fruiting response and carbohydrate and nitrogen levels in the plant. In their early work, primarily concerned with the fruit setting in tomatoes, they were careful to point out that the processes involved in fruit setting were not necessarily the same as those involved in flower formation.

These differences can be more clearly brought out by considering the main environmental factors that affect flower-bud differentiation in contrast to those affecting fruit setting. Following are the main factors affecting flower-bud differentiation:

1. Light intensity: In the interior of the crown, light intensity may be as low as 500 foot-candles, a value too low for flower-bud differentiation.

2. Duration of light: Extremely important with many fruit species. Photo-period may also be important with forest trees.

3. Ringing
    a. Trees with stone fruits are frequently injured by ringing.
    b. Poor vigor trees are likewise injured.
    c. Very young trees and small limbs are usually not responsive to ringing.
    a. For "alternate" bearing species, ringing in "off" years is of no avail.

    e. Timing is important. Ringing should be done three to five weeks before floral differentiation which occurs usually in early summer.

4. Root pruning: Has often been effective. Must be done a few weeks before floral primordia differentiate.

5. Defloration: Complete defloration usually results in abundant differentiation of floral primordia for the succeeding year's crop.

6. Bending: Pulling upright branches to a horizontal or downward position usually causes flower buds to form.

7. Defoliation: Usually bad; prevents differentiation of flower buds.

8. Growth regulators, acetylene, and ethylene: Very effective on some plants.

9. Water supply: Continuous reduction of soil water during the period in which flowers are differentiated produces intensely stimulating effect on flower formation.

10. Effect of nitrogen application: Fertilizing with organic manures (like chicken and pig manure) definitely delays flower formation in young bearing trees. Trees low in vigor may be benefited. Late summer applications may be most helpful by delaying leaf-fall and permitting carbohydrate accumulation.

11. Pruning: Delays flower formation on young non-bearing trees.

12. Sprays: Usually reduce flower formation; possibly interfere with photosynthesis.

Among the factors that affect fruit setting are:

1. Nutrients: Nitrogen is frequently most limiting; should be so timed as to become available after flowers are formed and fruit are ready to set.

2. Water: Lack of water may cause abscission of immature fruit.

3. Pruning: Light to moderate pruning is beneficial, reducing excessive competition between flowers.

4. Ringing: Has variable effect; should not be done later than blooming.

5. Carbohydrate-nitrogen relationships: Excessively rapid rate of amino acid synthesis induced by large amounts of inorganic nitrogen results in rapid vegetative growth, with little carbohydrate material left for development of sex organs to functional condition, hence may prevent fertilization. In such situations, supplementary light will cause fruit to set.

6. Competition between flower and fruit: May occur even in vigorous bearing trees.

7. Ecological factors: Temperature, wind, humidity, rain, etc., may, obviously, interfere with pollination, fertilization, and subsequent development.

8. Fungal and insect attack.

9. Spray materials.

It is evident from this listing, that not even common factors, such as water supply and nutrient salts, necessarily affect flower bud formation in the same manner, degree, or both, as they affect fruit setting. Variable results in experiments involving repeated treatments could well stem from possible carry-over effects or timing effects that influence flower bud differentiation in one instance and fruit setting in another.

In the future, fertilizing, "girdling," or both, for stimulating seed production in forest trees, may become a routine practice particularly in the development of seed orchards. If so, it will be important to fully consider the requirements of both flower bud differentiation and fruit setting. In addition, it is well to remember, that neither fertilizing nor "girdling" has so far shown much promise for stimulating abundant seed production in very young trees.

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