HORTICULTURAL TECHNIQUES IN HARDWOOD SEED ORCHARD MANAGEMENT

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Possibilities of improving hardwoods through genetics are documented in some of the first Southern Forest Tree Improvement Committee reports, but Committee sponsored activities and action programs of the "fifties" centered on pine rather than hardwoods. The chief reason was a practical one. Pines represented the major planting effort, and it is within the broad area of reforestation that general principles of improvement can best be applied.

Pine tree improvers became busy testing geographic seed sources, selecting superior trees, and establishing seed orchards. We developed a new vocabulary--words strange to most foresters and forest managers of that day, but well known in the field of horticulture. We were thankful for Snyder's (1959) "Glossary for Tree Improvement Workers," which made it possible for us to converse on equal terms.

Little was known about pine seed orchard management but in a very short time successful techniques were developed and much of the establishment work became routine. For the most part, newly planted ramets survived, grew well, flowered, and were soon producing cones and seed. This is not to say everything was easy. There were stock-scion incompatabilities, failure of individual clones to flower, insect and disease problems, and now harvesting difficulties as enumerated by Kellison (1971). But, progress has been rapid and generally rewarding.

This synopsis of early activities is to remind you that hardwoods were given little attention in the "fifties" and to suggest that we turned to horticultural techniques more than realized for help with pine. Trials with some of the techniques did prove ineffectual, but one must remember horticultural practices were developed primarily for use on deciduous hardwoods and not conifers. It is in the field of hardwood seed orchard management--whether clonal or seedling--that horticultural techniques will become important.

"Techniques of seed orchard management with forest trees are more closely allied to fruit orchard problems than they are to conventional forestry problems." Foster (1967) concluded this after attending a symposium of the American Society for Horticultural Science held in conjunction with meetings of the American Institute of Biological Science at College Station, Texas, in 1967. Ten years before, Sax (1957), in

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studies on growth and fruiting of apples, suggested that methods used by horticulturists may have application to timber trees as well as fruit and ornamentals, and even earlier, various tree improvement workers proposed turning to the field of horticulture for solutions to pressing seed orchard problems. Foster was referring to TVA seed orchard goals which are to obtain quantity production of improved seed of black walnut, black cherry, chestnut oak, northern red oak, white oak, and yellow-poplar, and to get orchard trees in best form for rapid, efficient harvest of seed crops.

The question that first comes to mind is how can production practices of the fruit tree orchardist have application in hardwood seed orchard management. The horticulturist works with different tree species and is interested in a different end-product. His chief concern is with the outer perishable, fleshy part of the fruit that encircles the seed. He seeks to produce fruits of optimum color, firmness, texture, flavor, size, and keeping quality.

Even harvesting and storage techniques are designed to protect the fleshy or pulpy tissues. With the above objectives it is apparent that the fruit tree orchardist has more complex production problems. But one may also assume that the cultural practices that result in a quality fruit are probably those that produce a sound seed with viable embryos.

The forest tree seed orchardist, like the horticulturist, is interested in cultural practices that promote annual bearing, maximize yields and facilitate harvest. In addition, he wants the seed to be large, uniform in size, and to maintain good germination potential through an extended storage life.

HORTICULTURAL CONTROLS

Among controls used by orchardists to increase production of fruit and nut crops are tree spacing, cultivation, irrigation, mineral nutrition, mulching, pesticides, herbicides, growth regulators, rootstocks, pruning, and tree training. When applicable, controls are regulated to facilitate mechanical harvest.

Spacing. Tree spacing is tailored to provide for efficient operation of machinery in cultural and harvesting operations and also give maximum yields of quality fruit per acre. Depending on whether fruit trees are on dwarf or regular rootstock, spacing may vary from as close as 10 x 14 feet to a maximum of 30 x 30 feet. The trend is toward more trees and closer planting. Wright (1968) reports one Pennsylvania orchardist has 50 acres of semi-dwarf apples on trellises at close spacings of 10 x 14 and 12 x 12 feet. Another 350 acres on standard rootstock at wide spacing is being converted by interplanting with semi-dwarf varieties. Hedgerow or fruiting wall planting used extensively in Europe presents a straight, unbroken fruiting surface, and lends itself to economic machine harvest (Anon. 1968). More trees can be planted per acre, and cross alleys, usually a maintenance problem, are eliminated. The trend to high-density planting and maximum production per acre is also of interest to peach growers who are conducting trials of training systems, including tree walls, for growing trees at high density--up to 220 trees per acre (Owen 1968).

Georgia pecan growers who seek high yields per acre plant trees at 40 x 40 feet and thin on diagonals when crowding occurs (Livingston and Fletcher, 1967). Twenty years ago walnut growers on the West Coast planted orchards at 50 x 50 feet, but now are planting at 30 x 30 feet. Martin et al (1969) found yields per tree similar at these and intermediate spacings early in the life of an orchard but unit area yields later increased proportionately to the number of trees per acre. Today, West Coast researchers are suggesting trials at 27 x 27 and 20 x 20 feet.

Cultural Practices. Horticulturists make wise use of cultivation, irrigation, and other cultural practices to improve growth of newly planted orchards, and to increase fruit and nut yields. For guidelines, orchardists rely on the work of researchers at state and federal experiment stations. Only a few of the many available references need be cited to illustrate the different kinds of research. An example is the work of Simmons (1965) on the relationship of soil cover practices and their variable effects on conservation and availability of soil moisture. Another is the study by Merrill (1952) on the beneficial effects of irrigation, hoeing, mulching, and herbicides on the growth of newly planted tung trees. With respect to fruit size and yield of peaches, Feldstein and Childers (1957) reported supplemental irrigation can be a benefit during periods of soil moisture shortage. For young pecan trees, Livingston and Fletcher (1967) recommend the soil area around the trees be kept clean of weeds and grass; for trees in production they recommend clean culture management in combination with planting winter cover crops.

Stephens and Jaynes (1969) report that cultivation, mulching, or incorporating organic matter into the soil when transplanting trees helps maintain conditions favorable for growth of nut tree species. These cultural practices improve soil aeration, thus increasing ability of tree roots to function efficiently.

Fertilization. Growers of horticultural crops are well versed in the nutritional requirements of major fruit and nut species and can recognize mineral soil deficiencies by amount of growth, abnormal leaf color, and other leaf characteristics. Horticulturists were among the first to chemically analyze plant tissues for determining concentration of elements and mode of nutrition in plants (Thomas, 1937; Frear and Anthony, 1943). The kind and amount of fertilizer needed depends on soil type and nutrient requirements of individual trees. In all, 14 elements--5 major and 9 minor--must be supplied by the soil for normal plant growth (Stephens and Jaynes, 1969).

Much reliance is placed on the value of nitrogen in promoting growth and yields. It has proven to be important with apple (Overholser et al, 1942), peach (Schneider and McClung, 1957), almond (Proebsting, 1937), pecan (Livingston and Fletcher, 1967) and black and Persian walnut (Stephens and Jaynes, 1969). The rate of application of nitrogen and other key elements depends on the amounts available in the soil and the amounts removed by the tree through growth and fruiting processes.

Tree Manipulation. Fruit tree orchardists control growth and fruiting mechanically, by planting cultivars grown on dwarfing understocks and with chemicals. Mechanical practices include top and root pruning, girdling and/or inverting the bark on the trunk of the tree, ringing, stem-knotting and training branches to grow on wires or trellis in a horizontal position. Sax (1957) reports knotting of the rootstock stem or interstock promotes earlier flowering and that inverting a ring of bark before or during the normal time of flower bud initiation induces fruiting the following year. This manipulation temporarily slows vegetative growth but needs to be repeated. Dwarfing rootstock exerts a permanent influence and keeps tree size small for more efficient cultural and harvesting operations.

Chemicals are used to shape trees and regulate flowering and fruiting. One of the more promising, Alar (N, N dimethylamino succinamic acid), has been called the wonder chemical in horticulture. On apples it reduces shoot growth, promotes flower bud formation for the next season, prevents preharvest drop of fruit, and may delay flowering in the spring for frost protection (Wittwer, 1969).

Advances made with chemicals in controlling fruit drop are part of the reason for the swing to mechanical harvesters. As a result of this and a shortage of labor, manufacturers across the country are offering machines for harvesting deciduous tree fruits, grapes, berries, and nuts. They range from one-man lifts for hand-picking to self-propelled harvesters which can gather up to two tons of blueberries per hour. In between there are tree shakers and catching frames for soft fruit harvesting. Some tree shaking machines come equipped with pick-up reels or are used with a vacuum unit for gathering nuts. So the orchardist gears his management operations to fit advances made in harvesting machinery.

APPLICATION IN SEED ORCHARD MANAGEMENT

Total acreage **in** the U. S. now in hardwood seed orchards probably does not exceed 100 acres but may involve 10 or more species. Most of this acreage is in clone banks in trees not yet of production age. Before horticultural practices as described above can be adapted for seed orchard use, more information will be needed on growth habit and on flowering and seeding characteristics of each species. By utilizing current knowledge and by applying cultural techniques in seed orchard trials, we can begin evaluating treatment effect on seed production and on tree growth and vigor. We need to work closely with tree physiologists who also turn to horticultural literature for help with their problems. In the TVA tree improvement program three scientists devote full time to the physiology of hardwoods. Our field trials usually start where they leave off. My remarks on technique application will refer primarily to black cherry, black walnut, yellow-poplar, and three oaks--chestnut, white, and northern red.

With regard to spacing controls, we can be satisfied with one standard planting distance or follow the lead of horticulturists and determine the most effective orchard spacing for each species. Since good orchard sites within convenient travel distance are at a premium, we should aim for maximum production per unit area. Spacing trials should emphasize high density plantings, at least when the trees are small. Proponents of hedgerow plantings claim tall, narrow walls of hedgerows produce as much bearing surface as a series of hemispheres. We should also consider group or clump plantings of different clones. Both group and hedgerow plantings could aid cross-pollination of species like yellow-poplar and black cherry. Until dwarfing understocks become available, tree planting densities in hardwood orchards will not approach that found in fruit orchards.

Taft (1966) determined that a tree spacing of 20 x 20 feet would be adequate to age 12 and 40 x 40 feet to age 32 for new TVA black walnut seed orchards. His calculations were based on crown measurements available on 32-year-old walnuts growing at a 50-foot spacing in a TVA nut orchard. Planting at the 20-foot spacing increased tree density from 17 to 109 trees per acre.

No one questions that soil cultural practices will pay off in the early life of the orchard, and later, as trees come into bearing. However, we will find one method of management is needed for young trees and another for trees of production age. We know newly planted trees will respond to treatments that keep down weed growth and conserve soil moisture. One factor in determining what method to use will be operational cost. Another is the total benefit which is manifest in tree growth and development. Annual mulching will cost more than herbicidal applications but yield more direct benefits by preventing soil movement and surface washing, reducing extremes of soil temperature, reducing soil moisture losses by direct evaporation, and improving the soil gradually during the course of decomposition of organic matter. Mechanical cultivation to control annual and perennial weeds and grasses may cause root damage to young trees and is costly because repeated treatments are needed to be effective. One disadvantage of mulching is possible damage to trees from rodents which burrow and hide under the mulch.

In orchards of production age a sod cover should be maintained until more is known about long-time effects from clean cultivation and repeated herbicide treatments. The orchardist should guard against development of too thick a sod which prevents proper soil aeration for optimum tree growth.

Fertilization goes along with soil cover management but very little is known about orchard requirements for the species under consideration here. Like pecan (Livingston and Fletcher, 1967) trees should be fertilized enough to maintain some minimum annual terminal twig growth to keep trees in production. This could require single applications of a complete fertilizer with additions of nitrogen as needed. Time and rate of applying fertilizer should be determined for the particular species and orchard site and related to amount of nutrients removed by growth and yield functions. In considering fertilization, foresters tend to overlook lime which could be significant with hardwoods. Leaf analysis for determining nutritional needs is a tool that will become more useful than soil testing once requirements of individual species are known. Eventually, leaf analysis services will be available through laboratories maintained by your state universities.

The major breakthrough with horticultural techniques will be in the area of tree manipulation. A first step is to learn how to train and prune young trees. By selecting shoots to form the future framework of the tree and deshooting undesirable ones, we later avoid large pruning cuts that are slow to heal and invite decay. All the growth goes directly to selected branches. Follow-up pruning will be light--for shaping and to encourage early bearing. Studies (Krajicek and Bey, 1969) by the U. S. Forest Service at Carbondale, Illinois, are already providing information on how to train black walnut seedlings. Findings will have application in black walnut seed orchard management.

Secondly, we must test various mechanical treatments to find out if they contribute to early flowering. There is evidence that yellow-poplar will respond. This spring Taft 2/ observed heavy flowering on young, six to eight-foot ramets in the orchard at Norris, Tennessee--on trees that developed bark splits from low temperatures during the winter of 1969-70. Taft also noted the flowers occurred on secondary branches rather than on terminal leaders, which suggests that pruning or other mechanical treatments will favor development of this type growth.

We should determine the value of dwarfing understocks for growth inhibiting effects and their ability to influence early flowering. Their use may prove unimportant with heavy seeded species such as the oaks and walnut whose seed falls to the ground.

We need to investigate the role of chemicals, especially retardants like Alar, in regulating growth and flowering of seed orchard species. Based on horticultural experience they could help us by (1) keeping trees small by limiting shoot growth, shortening internodes and thickening stems; (2) promoting flower formation in non-flowering clones; (3) delaying flowering in the spring to avoid late frosts; (4) facilitating time of flowering in dichogomous species like walnut; and (5) controlling abscission of fruits for more efficient harvest, as needed in black cherry. The retardants may also prolong storage life of oak and black walnut seed. While chemical retardants are highly specific and have proved ineffective with some plants, our species may be sensitive and respond. If so, they will have great seed orchard management potential.

To fully evaluate horticultural practices that may be effective in hardwood seed orchard management, it is desirable that orchards be established especially for test use. This eliminates factors that contribute to experimental error such as ramet age differences, unequal clone numbers and previous soil management and tree tendance practices. Trials should be initiated when the orchards are established and continue through the development stage to at least early maturity. Insofar as possible planting schemes should be designed to facilitate mechanical harvest. Obviously, all techniques in need of testing cannot be studied at one time or in a single orchard.

SUMMARY

As improvement efforts focus on hardwoods, seed orchard managers will find that orchard trees do not respond like pine but will require more intensive treatments if full development potential is to be realized. He will be interested in techniques that promote annual bearing, maximize yields, and facilitate mechanical harvest. The techniques will be those commonly used in horticulture today but which need to be evaluated for their application in hardwood seed orchard management. Among the

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21 Personal communication with Kingsley A. Taft, Jr. , TVA.

techniques and practices most likely to affect seed production and harvest are those related to tree spacing, soil culture and fertilization , and tree manipulation, which can be effected either mechanically or with chemicals.

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