Improvement of Sweetgum

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The economic necessity of efficient land utilization, the rapidly expanding use of hardwoods in a variety of products, and the near famine for hardwoods in certain areas require that forest management plans place more emphasis on growing these species. This situation has come about because hardwood, properties differ from those of pine, and technologists are constantly developing new ways to use these properties. If hardwoods are to be included, in management plans, the species used should have not only high value and extensive utility, but also wide site adaptability. Sweetgum is such a species.

For some time industry has been aware of the high value of sweetgum. However, accompanying increased awareness of value has come awareness of problems in regenerating and growing the species. Tree improvement, through selection, breeding, and use of the proper seed sources, can alleviate some of the difficulties. Today, I want to mention some of the most pressing problems in growing quality sweetgum, and, to suggest ways that the tree breeder can effectively use sweetgum's particular combination of characteristics. Then I will briefly review tree improvement activity currently being carried. out on the species.

TRAITS NEEDING IMPROVEMENT

Workers who are improving sweetgum should concentrate on those problem traits that impair its economical inclusion in forest management programs or restrict its use in certain wood products. These problem traits can be grouped according to their effects on growth efficiency and, on wood quality. Improvement must include numerous traits simultaneously; if only one trait at a time is improved, other important characteristics may regress and actually provide less net economic gain.

The often inadequate supply of sweetgum, especially during wet weather, poses a serious

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problem in many localities. Merely favoring the existing sweetgum will partially alleviate this, but planting and seeding will have to augment natural regeneration. When we are producing improved seed for artificial regeneration we should, strongly emphasize growth efficiency. Selection should favor fast-growing trees that will produce high volumes per acre.

Some of the pulp and paper industry programs want to move sweetgum from its typical wetland habitat to areas that are operable year-round under most weather conditions. These operable sites are probably the best pine sites, site index 90 or better. If this becomes necessary, improved. growth efficiency will assume even greater importance for two reasons: (1) sweetgum is difficult to establish artificially on these sites; and (2) it does not produce as much volume, or revenue per acre, as loblolly pine (Ralston 1955; Beaufait 1957). Although it may be permissible to accept fewer dollars per acre in order to provide sweetgum for the mill, it might be possible to improve growth efficiency to a high enough level to provide a program that is economically efficient at all stages of production.

When we are considering wood quality, it is helpful to equate uniform wood with high quality wood because, regardless of the technology of the future, uniform wood will always be valuable. Wood uniformity is controlled by a number of external characteristics of the tree as well as internal anatomical properties. Clear, knot-free wood is obviously more nearly uniform than knotty wood; therefore, early self-pruning must be emphasized. A high value should be placed on trees that are straight, round, and vertical (i.e. not leaning) because they have a minimum of tension wood. Pin knots, caused by dormant trace buds and epicormic branches, and interlocked grain are irregularities often causing costly defects. Selection should favor straight grain and discriminate against trace buds and epicormic branches. All of these, with the possible exception of interlocked grain, affect the paper-maker as well as the plywood and lumber manufacturer.

Just how important specific gravity, fiber length, and other fiber properties of sweetgum will be to the paper-maker remains a moot question. There may be some merit in breeding for long fibers and high specific gravity (i.e. more pounds of cellulose per acre). But, the inclusion of these traits as major objectives will dilute the effort spent on improving the sure problem traits: volume per acre, self-pruning, and straightness. In fact, it is possible that parents with extremely high or low specific gravities should be rejected to further improve woo uniformity. Regardless of the direction individual tree improvement programs may take, these two traits should be measured. and. recorded on each selected parent tree.

Sweetgum is relatively free of major disease and insect enemies, but intensive management will probably uncover new problems. At present, susceptibility to pests is not important enough to warrant its inclusion as a major consideration in selection. If unhealthy trees are never selected as parents, this rejection will provide some measure of selection for disease and insect resistance.

CHARACTERISTICS AFFECTING TREE BREEDING

It is fortunate that sweetgum has characteristics that the geneticist can work with easily. It is a wind-pollinated, strongly self-sterile species; seed set following self-pollination is rare (Schmitt 1964). These two traits maintain genetically diverse and phenotypically variable populations, both of which are necessary for effective tree breeding. Even a cursory examination reveals wide variation within the species in growth rate, branching habit, self-pruning, straightness, epicormic branching, and adaptability to a variety of sites. There is also much diversity in the wood properties: specific gravity, fiber length, and interlocked grain (Webb 1964).

However, other aspects of the variability in sweetgum, while being assets in most instances, present some complications during the selection process. The selection systems currently used in the pines compare a candidate tree with its neighbors. This is a good procedure, especially when estimating the growth potential of a tree, but its application in sweetgum is complicated by the species' variable growth habit. Sweetgum grows under a variety of stand conditions ranging from pure, even-aged stands or patches to mixed, even- or uneven-aged stands. Also, its tendency to regenerate itself from root suckers, and thence its clonal habit in certain areas, further complicates the use of this procedure. Yet, the practice of comparing a candidate tree with its neighbors is such a valuable procedure that it may be desirable to restrict selection to pure, even-aged stands where there are enough comparison trees. Whether or not this is practical will depend on the organization and the locality where it is working.

Once selections have been made, controlled. pollination for progeny testing should. proceed with no more difficulty than has been encountered. in the pines. The floral buds are larger than the vegetative buds and. can be recognized. as much as 2 or 3 months prior to bud.-break. Sweetgum is a monoecious species, with male and. female flowers originating from the same bud_ The staminate heads stand. erect in a raceme 2 to 3 inches long; the pistillate flowers, in a round. head, hang at the base of the raceme. Unlike pine, the flowers must be emasculated. before being bagged. for control-pollination, but this is easily done.

Pollen can be collected. with little difficulty for the current season's control-pollinations, but means for storing pollen from one year to the next have not yet been developed. There is wide tree-to-tree variation in the time of pollen flight and. female flower receptivity; individual female flowers are receptive for relatively long periods--2 to 3 weeks, contrasted. with 3 to 5 days in the pines. The long receptive period. simplifies timing of pollination but necessitates leaving the bags on 3 to 4 weeks after pollinations have been made, to avoid subsequent contamination.

Collection and extraction of seed. is a simple process permitting the use of methods similar to those used. in pines. As Wilcox (1965) points out, it is possible to collect seed during a 6-week period. prior to seed. fall. This allows flexibility in timing seed. collection.

Seed.-set following controlled. pollination is generally good, and it may be as high as 45 to 85 seed. per head. with 1, 2, or 3 heads per pollination bag (Schmitt 1964). Germination, with or without stratification, is often 80 percent or better.

Several methods have been developed. for vegetatively propagating sweetgum. Root cuttings and. greenwood. cuttings originating from root suckers ha been rooted. successfully (Brown and McAlpine 1964; Farmer 1965). According to McElwee, [1] Orion Peevy, with Weyerhaeuser Company, used cleft and. side grafts to vegetatively propagate selected sweetgum for use in a clonal seed. orchard. in North Carolina. These results mean that we can use vegetative propagation to fulfill various research needs as well as to develop clonal seed. orchards. It is still questionable whether sweetgum can ever be vegetatively propagated. economically on a large scale like cottonwood.

In another application of vegetative propagation, Wilcox and Farmer/are working to develop a method. for combining bottle-grafting and control-pollination for use on sweetgum. Branches bearing flower buds are bottle-grafted. the fall before control-pollinations are to be made. When the flowers develop on the graft, they are emasculated, bagged, and. control-pollinated. in the greenhouse. The next fall seed. are collected. from the graft. So far, Wilcox and. Farmer have had. only limited. success, but if this method. is perfected, it will facilitate pollination of certain problem trees, especially those that are very tall or are in localities flooded. during the spring. It is more important, however, that with this method, workers can start making controlled. crosses for progeny testing early in a tree improvement program instead. of waiting several years to make pollinations in the seed. orchards. Eventual success of the method. will probably depend. on the technique of the person making and caring for the grafts.

POTENTIAL BREEDING METHODS

In the absence of detailed. genetic information, it is only possible to speculate about the breeding methods and their variation that should be used Selection and crossing within the species are assumed to have the greatest potential in sweetgum for several reasons. Mutation breeding using ionizing radiation has produced only limited success in certain agronomic crops, and then only when directed at very specific problems. Its application to sweetgum is not recommended at this time. Hybridizing with the two other species of Liquidambar, found only in the Orient, has rather remote chances of improving our native species (this procedure should and will be explored by organizations responsible for basic research on the species). The most important justification for first selecting within sweetgum is the existence of wide variation within the species, and of a "breeding system" that is easy to manipulate.

2/Personal correspondence,1965.

3/Personal correspondence,1965.

Its wind-pollinated, self-sterile habit, and the availability of methods for vegetative propagation suggest using the clonal seed orchard approach. The first clonal seed orchards in the species will probably resemble closely those in pines and include 30 to 50 clones. Yet, the self-sterility trait may allow the development of special orchards with small numbers of clones in combinations that have proven superior in progeny tests. A conceivable approach is the development of two-clone orchards composed of pairs of clones that have exceptionally high specific combining ability. This method is currently not applicable in the pines because self-fertility in the pines is much more frequent than in sweetgum. Adoption of any of these methods to sweetgum hinges on future studies of pollen-flight patterns and on the time of pollen flight and flower receptivity of the specific clones in question.

Seedling seed orchards appear to have greater potential for use in sweetgum than in most species of pines, primarily because budgetary and time considerations in some programs will allow only limited investments in hardwood tree improvement. In such programs, once selections have been made, seedling orchards can be established using open-pollinated seed. If, however, the organization is willing to expend the extra effort and money to make controlled crosses to produce the necessary seedlings, it should seriously consider clonal orchards as an alternative. In either case, consideration should be given to the relative length of time required for seedling and clonal orchards to produce abundant seed crops. Theoretically, seedling orchards composed of control-pollinated seedlings will produce more gain, but it will come at a later time. Seedling seed orchards in sweetgum will have many of the same complications of roguing and subsequent spacing as the proposed seedling orchards for pines.

Provenance research will necessarily be emphasized at an early stage in the sweetgum improvement process. We have no idea about the magnitude of gains to be achieved in this species from use of the proper geographic seed source, or about the losses to be suffered from use of the wrong seed source. The growth potential of trees growing on poor sites may be quite different from that of trees found on good sites close by. In attempting to develop sweetgum that will grow favorably on sites that are operable year-round, it is logical to consider trying trees from the drier, westernmost part of the range of sweetgum in northeast Texas and Oklahoma.

CURRENT ACTIVITY

In response to the growing awareness of the value of sweetgum, industrial concerns, forestry schools, and governmental agencies have started sweetgum tree improvement programs. Activity is almost south-wide, ranging from Mississippi to North Carolina.

Although the Cooperative Industry--N.C. State Hardwood Research Program is initially emphasizing silviculture, its activities also include an increasing number of genetic studies. One of its cooperators, the North Carolina Division of Weyerhaeuser, has already made 37 field selections of sweetgum, and 20 or 25 of these have been accepted for use in the seed orchard. They are developing a clonal seed orchard and have about 800 successful grafts so far. The North Carolina State program is starting a provenance study including 28 seed sources from North Carolina to Texas. These will soon be planted in 14 different localities from North Carolina to Louisiana.

Sweetgum tree improvement activity by the U. S. Forest Service in the Delta region is centered in Mississippi; the applied breeding phase is conducted at Stoneville in close coordination with the basic genetic studies by the Institute of Forest Genetics at Gulfport. Of the several Delta hardwoods being studied, sweetgum has the second highest priority. Wind-pollinated progeny tests of some 50 selections have been initiated as well as quantitative genetic studies and seed source tests. Forest Service workers will soon plant, in cooperation with the State of Mississippi, a seed source study representing an intensive sampling of that State. Their activities also include development of methods for pollen collection, storage and germination, for controlled pollination, and for vegetative propagation.

At Auburn University work has started on the variation in the wood of sweetgum throughout Alabama. This will eventually be expanded to include a selection and breeding program.

In the territory of the Southeastern Forest Experiment Station, U.S. Forest Service, work has been underway for some time at Athens, Georgia. In addition to developing methods for rooting cuttings of sweetgum, investigations are being carried out on epicormic branching, and on methods for detecting epicormic tendencies of outstanding candidate trees. These investigations have laid a good foundation for the more intensive tree improvement work that will begin there at the end of this summer.

SUMMARY

Recent technological developments, increased demand, and the resultant short supply of desirable hardwoods have focused increased attention on hardwood management in the South. Fortunately, tree improvement is being included from the start. Because of its high economic value, wide adaptability, and broad utility, sweetgum is receiving a high priority. However, improvement of such problem traits as growth efficiency and wood uniformity will expand the utility and hence further increase the value of the species.

Sweetgum has characteristics that facilitate tree improvement; it is wind-pollinated, monoecious, and self-sterile. Seedlings can be grown easily, and vegetative propagation methods are being developed. It is a variable species and can be assumed to respond well to selection and breeding. Clonal seed orchards composed of many, few, or even only two clones seem promising. Seedling seed orchards seem more feasible in sweetgum than in pine.

Sweetgum tree improvement has been initiated by several industrial and governmental organizations. Now it appears that, unlike pine, when seeding and planting sweetgum does start on a large scale, only the highest quality seed available will be used.

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