Development of Grafting aid Pollination Methods

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The development of satisfactory sexual or vegetative propagation methods for a tree species usually involves a certain amount of trial-and-error experimentation. To minimize these empirical tests, two types of knowledge are essential. The first requirement is information concerning the biology of the species which may include anatomy, morphology, phenology, details of normal reproduction, and inherent limitations of the capacity to reproduce by seed or asexual means. Secondly, a thorough familiarity is needed with basic techniques of grafting and pollinating, the tools needed, and the various materials that facilitate the work. Much information on these topics is recorded in forestry and horticultural literature. Thus, the tree breeder or grafter has a large background of useful experience available which can be used to aid the establishment of an efficient program.

Grafting success depends basically upon achievement of a rapid union and prevention of scion desiccation until the union is formed (Neinstaedt, 1961). Most of the union tissue is formed by the stock plant (Mergen, 1954). All of the various methods and special procedures of grafting are directed toward facilitating the union of the two parts and maintaining the viability of the rootless scion until an effective union has formed.

Similarly, controlled pollination involves collection of pollen and maintaining its viability during pollination and the processes that lead to fertilization of the egg. Additionally, controlled pollination implies prevention of pollination from other sources.

Once the basic procedures have been learned, both pollination and grafting require doing the right thing at the right time in the proper amount to achieve success. Pollination, to some extent, and grafting, in large measure, are arts. The traits which make fora proficient practitioner are difficult to define, but close attention to detail is important in both grafting and pollinating. This paper is a review of the relative success in developing propagation methods for the tree improvement programs of the South.

Grafting of Pines

The many hundreds of acres of pine seed orchards now established in the South furnish ample evidence that successful grafting procedures have been developed. Although the largest portion of these orchards are loblolly and slash pines, smaller areas of Virginia, shortleaf, pond, sand, white, and longleaf pine grafts have been planted. Details of methods and grafting techniques employed in this task are almost as numerous as the individual tree improvement programs, or even the individual grafters involved. However, there are only a few general types of operations.

A convenient method of classifying grafting procedures is by site of the grafting operations. By this division, the major methods employed are pot grafting, field grafting, nursery bed grafting and approach grafting. Each procedure has several minor variations and certain advantages and disadvantages.

For pot grafting, year-old nursery seedlings are potted for grafting stock. A major consideration is stock vigor - the stock must form most of the tissue of the union. Potting of bare root stock must be done several months or even a year in advance of grafting so that stock plants may be fully recovered from transplanting stock. Use of long-potted stock plants has caused trouble with windthrow and root girdling. This difficulty can be avoided by use of a transplant tool which moves a ball of soil with the stock plant, greatly reducing the time necessary to hold the plant in the pot. Stock can be grafted one month or less after transplanting. Grafting of potted stock is often done in a 'greenhouse. At a minimum, a shade house is needed. Its advantages are convenience for the grafter, ease of supervision, some control of adverse climatic conditions and convenience of aftercare of the grafts. However, pot grafting is the most expensive method due to the expense of potting and transportation.

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Approach grafting, which also employs potted stock, has been used on a limited scale. The potted stock is placed adjacent to an established graft (a platform is frequently required) and a branch of the tree is grafted to the seedling stock without severing the connections to the tree until the graft union has developed. The procedure is usually highly successful but is not suited to extensive use because of the expenses involved and physical limitations. Also, the resulting graft is often misshapen as considerable bending is frequently required to match the stock to the scion and the bend is maintained for several weeks while the graft union is developing.

A method especially well adapted to large-scale operations is nursery bed grafting. Stock is grown in beds at low density (a procedure also useful in producing stock for pot grafting). As the name implies, grafting is done directly on plants in the nursery beds. A major advantage is the high vigor of the stock plants. Also, the work is concentrated for an efficient operation during grafting and for the essential after-care. Grafting is usually done in winter or early spring and successful grafts are transplanted to the orchard in mid-summer or fall. At transplanting, the grafts are about two feet tall or larger. Mortality during this phase may be as high as 10% and must be taken into account when planning. In spite of transplanting problems, several agencies with large grafting programs feel that the lowest cost per established graft is obtained by nursery bed grafting.

Field grafting requires no special facilities other than a seed orchard site. Nursery-run seedlings can be planted, two or three to a spot, at the desired spacing in the orchard. Grafting is done a year or two later. With this method, growth is usually superior to that in orchards established in any other manner. The two major disadvantages are relative inefficiency of grafting and after-care and somewhat higher exposure to vagaries of the weather. Individual grafts of a clone are scattered over a large area, requiring moving of materials and equipment a considerable distance between each graft. Late freezes, wind storms and extreme drying conditions can be catastrophic in field grafting.

There are numerous grafting techniques that may be applied. The cleft graft is most commonly used with southern pines whereby the scion stem is formed into a wedge, the top portion of the stock plant is severed, the stock stem is split, and the scion wedge is placed in the split and bound in place.

Side grafting is also frequently employed. This may be a veneer graft in which only one side of the stock and of the scion are cut and the two wound surfaces are bound together, or a wedge scion placed in a split made in the side of the stock plant.

Variations include the whip graft used with or without a tongue to give added strength. A special variation of the veneer graft now seldom used in the South but favored in some locations (Slee, 1967) is the bottle graft in which a tail left on the scion below the cut is placed in water to avoid desiccation prior to formation of a union.

The art of grafting is in the application of grafting techniques. Some grafters develop a special aptitude for making the cuts of proper size and proportion, matching stock and scion tissues, and binding them in place with just the proper firmness and security. The principles of grafting can be taught but real skill is developed only through practice. Some people never develop a real knack for the job.

After the scion is in place, other procedures that affect grafting success or failure are related to protection and care of the plants, pruning of stock limbs, and establishment of the grafts in the orchard. The critical problem for the first several weeks is prevention of desiccation of the scion. This is accomplished by removing a large portion or even all of the scion foliage and by maintaining a humid atmosphere around the scion. Polyethylene bags surrounding the scion and, usually, a portion of the stock plant trap transpiration water and provide an excellent humid atmosphere. In some localities, the bag need not be completely closed and the bag has been omitted with good success in some cases.

Freezing weather can be detrimental. Field grafting in the more northern areas must be delayed until early spring. It is often difficult to schedule operations to avoid late cold snaps.

Considerable heat can develop inside a plastic bag if it is completely closed around the plant. To avoid heat damage, some shading is required. Potted plants can be kept in a shaded location until the polyethylene is removed. In nursery beds and in field grafting, kraft bags are placed over the plastic to provide shade. Where grafting must be done in the spring and there is danger of either hot or cold weather, the graft may be wrapped in aluminum foil before the kraft shade is put on. To protect the grafted plant from insects, dust with malathion or other insecticide before the protective covering is put in place.

For high degree of success, tender loving care of each graft is essential for several weeks. Soil moisture should be maintained at near optimum levels. As the scion shows signs of development, both the kraft and plastic coverings must be removed in two or three stages to avoid sudden changes in conditions. Overly vigorous growth of the stock plant must be cropped back to allow the scion to assume dominance, and any insects that appear on the scene must be promptly controlled.

Potted and nursery bed grafts must be transplanted. If transplanting is done during season of ample rainfall and the plant has not been held overly long in the pot, there is usually little mortality of potted stock during this operation. Moving nursery bed grafts requires more drastic disturbance of the root system and some loss can be expected. Transplanting mortality is minimized if a large transplanting tool is employed which moves a ball of nursery soil with the graft. Such devices have been developed for manual and for machine operation. As with potted grafts, transplanting should be done in the rainy season to aid rapid reestablishment of the damaged root system. Midsummer transplanting operations have been very successful in the lower coastal plains, but fall planting is preferred in areas of low summer rainfall.

A remaining problem which has thus far defied solution is incompatibility of stock and scion. Incompatibility implies the failure to achieve a successful union. Such failure sometimes occurs immediately. In addition, there are forms where the scion portion of a graft gradually fails two or three years after establishment. After poor grafting technique, mistakes in after-care, and unfortunate weather conditions are taken into account, some clones have an inordinantly high failure rate. Little information is available concerning physiological and biochemical phenomena related to grafting woody plants but investigations with herbaceous species indicated increased cytochrome oxidase, polyphenol oxidase and peroxidase activity (Poda-Chikalenko, 1960), increased content of amino acids and proteins prior to formation of a union (Mikhailova, 1957),and a decrease in activity and level shortly after the union was complete. In grapes, scion and stock having complimentary levels of amino acids and sugars were most compatible (Kolesnik, 1963). Metabolic processes, protein synthesis, and growth are accelerated at the graft union. A stable, presumably useful, protein of one plant genotype may be a destructive agent in another. Research is currently underway at the University of Florida to characterize amino acids, enzymes, phenolic substances, and proteins of known compatible and incompatible graft combinations.

Hardwood Grafting

In general, grafting procedures for hardwoods are similar to those used for pine. In addition, some hardwood species may be budded and others root quite readily. Thus, a wide range of procedures and techniques are available for vegetative propagation of hardwood species. The ease of vegatative propagation varies widely, both between and within genera, but McAlpine (1965) stated that most important species have been propagated by one or more methods of grafting or budding. The list includes maples, oaks, ash, cherry, walnut, yellow-poplar, sweetgum, poplar and a number of other species.

As with pines, procedures must be adapted for individual species and for particular situations. With some species, there is a background of experience available. For example, Funk (1966) listed 34 references on walnut grafting, 7 references on budding, 14 references on rootstocks and 9 references on rooting and layering. For other species, forestry agencies are conducting research to determine more successful and efficient procedures. Dorman (1966) indicated that there are current research projects concerned with vegetative propagation of ash, sweetgum, yellow-poplar, sycamore, and oaks.

The dilettante grafter may be satisfied with expensive, inefficient procedures and relatively mild success. One faced with the establishment of a sizable orchard in a year or two must design a program based on reasonable costs and reliable estimates of the number of plants that can be produced. This stage has been realized for most pine species and some hardwoods. Erratic results are still obtained with longleaf and sand pines and with some hardwood species. Further refinement of techniques is needed. However, as improvement programs for other species are developed, in most cases it will be possible to establish clonal orchards if desired.

Controlled Pollination

Pollination procedures for pines are well developed and reasonable success can be achieved with adequate attention to details and timing. There are numerous minor variations in methods and equipment designed for specific program objectives.

Pollen collection, extraction and storage techniques vary; depending upon the objectives of pollination. For detailed genetic studies, great care should be exercised to avoid contamination by other pollen sources. Such measures as collection of catkins before they begin to open and washing them to remove possible contaminating pollen from the catkin surface, extraction and transfer of pollen from one container to another in a pollen free atmosphere may be required. For general progeny testing purposes, such extreme care is not justified' as stray pollen grains will not substantially affect the results.

A procedure which insures pure pollen and supplies an ample quantity for most purposes is bagging of pollen clusters with sausage casing well in advance of pollen shed. Ten or more such clusters supply ample pollen for a number of pollinations. In addition, bagged catkins usually shed pollen several days early. At best, collection and extraction of pollen prior to receptivity of female flowers require a very tight schedule, and any procedure which helps create a time gap is desirable.

All tree breeders prefer to use fresh pollen. However, situations frequently occur in which this is not possible. Pollen storage techniques at refrigerator temperatures (35° to 38°F) and below freezing have been developed. In either case, control of moisture content is essential to maintain pollen viability, but very low moisture is more critical with freezer storage. The technique of freeze-drying may provide optimum storage conditions.

If pollen is in short supply, Callaham (1965) has demonstrated that satisfactory results can be obtained with diluted pollen. Dead pollen of the same or different species provided a satisfactory diluent. Dilution to 30 percent live pollen did not reduce the proportion of sound seed.

Pollination procedures for pines require little discussion. The use of synthetic sausage casing for isolation of female flowers has been almost universally adopted. There are many tools for the application of pollen but most consist of a veterinary hypodermic needle, some sort of reservoir for the pollen and a rubber bulb to force pollen through the needle. Many variations of simple and satisfactory devices can be assembled. With a systematic approach and sound planning, a sizable pollination program can be conducted in a pine orchard without an excessive labor force.

Pollination procedures for hardwoods present a much more confusing picture. The diversity of sexual mechanisms among the several species requires that individual techniques and special tools be developed for each species. Other than the broad statement that pollen collection, isolation of female organs and application of pollen are required, few generalities can be drawn concerning hardwood pollination procedures.

To illustrate the variable requirements for controlled pollination, consider black cherry, yellow-poplar and black walnut. Cherry has perfect flowers, individually quite small, borne in a raceme consisting of 15 or more flowers. Flower development is indeterminant with those near the tip more immature than those at the base of the raceme. Each individual flower can produce one seed. Yellow-poplar has a large flower with numerous spirally arranged stamens and pistils. The conelike fruit produced is an aggregate of samaras. In walnut, staminate and pistillate flowers are borne separately. The pistillate flower is quite small and inconspicuous with usually only two or three flowers in a cluster, each capable of producing only one nut. Walnut is normally wind pollinated whereas both cherry and yellow-poplar are insect pollinated. Obviously, quite different techniques are required for controlled pollination of each.

Familiarity with reproductive structures and stages of floral development are essential for a hardwood breeder. Many of the pollination procedures have already been worked out for the hardwood species in which there is most interest. Breeding techniques have been developed for sweetgum (Webb, 1965), yellow-poplar (Taft, 1962), cottonwood (Schreiner, 1959), walnut (Crane et al., 1937) and for other species. Limitation on controlled pollinations of some hardwoods is not related to lack of techniques but is more closely associated with the small return for the labor involved with species that bear seeds singly or in very small clusters.

Pollination is much simpler in seed orchards than on scattered trees in natural stands. Yet, even in orchards, flowers are most frequently located considerably above the height of the average man. Thus, equipment for getting into trees or for supporting the breeder while he works is unavoidable. Several variations of ladders and platforms have been developed, mostly truck or trailer mounted ladders, platforms or combinations of the two. As stated by McConnel (1965), tree climbing has enough risks without helping it along. Safe rigs should be constructed and safety rules should be developed and enforced by each organization involved.

Summary

Procedures for grafting pines are well developed. Efficient programs involving grafting on potted stock, field grafting, or nursery bed grafting can be organized to fit individual species requirements, climatic conditions and other considerations.

Practical pollination procedures for pines are well established and the required supplies are easily available.

Hardwoods present a much more diverse picture than do pines. Vegetative propagation by grafting, budding, layering or rooting cuttings is possible to some extent for all of the more important species.

Pollination procedures are being developed for the important hardwoods. Special procedures are required for each species.

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