Oak Grafting Techniques

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INTRODUCTION

The vegetative propagation of oak species via grafting is a fairly efficient means by which valuable germplasm can be replicated for both horticultural and forestry purposes. While softwood cutting propagation, and even tissue culture technologies, have been successfully applied to the genus, at least on the research level, these methods have been generally confined to either just a few species and/or limited in their success to only juvenile plant material. Although it can be argued that mature clones of some species can be successfully rooted via softwood cuttings (Zaczek et al., 1993), the resulting plants may fail to overwinter, or grow very slowly, and may even display plagiotropic-type growth habits. For these reasons, it is quite likely that the propagation of oaks via grafting and budding techniques will be the method of choice for those of us interested in this valuable genus. The purpose of this paper is to provide a short review of the grafting techniques that are currently being employed at both the research level and also in commercial nursery operations.

An earlier review of oak grafting techniques was offered to this Society by Flemer (1962). Much of the information presented in that paper is still appropriate today. In addition, new insights can be added in terms of the work conducted by Santamour (1983, 1988) on delayed graft compatibility problems, which can be especially troublesome for species in the red oak subgenus.

SCION/STOCK RELATIONSHIPS

It is intuitive that greater success rates will be achieved by matching the scion to a rootstock of the same species. This can be especially true when propagating species and cultivars in the red oak subgenus. However, in the case of species in the white oak group, there is considerably more latitude available. The common practice is to utilize understocks that are capable of producing a more fibrous root system, such as *Quercus bicolor* or *Q. michauxii*. For planting in areas with high soil pH, *Q. muhlenbergii* might be an appropriate understock species to use.

There seems to be little, if any, compatibility problems associated with species in the white oak subgenus. As an illustration of this fact, a total of 252 valid cultivar names for oaks have been cited by McArdle and Santamour (1985, 1987a, 1987b). Of these, 119 were for English oak (*Q. robur*), and only 28 represent species in the red oak subgenus. It is acknowledged that the red oak subgenus is not native in Europe, and nurserymen in the United States have generally not been focused on selecting many oaks for ornamental purposes. However, one other important factor needs to be considered, namely delayed graft compatibility. It can be a definite problem for species in the red oak subgenus. This may at least partially explain the imbalance in the numbers of named cultivars between the white oak and red oak subgenera.

The potential reasons for delayed compatibility problems in oaks have been reviewed by Santamour (1983, 1988). For a graft union to be successful, callus tissue must form a "bridge" between the scion and stock, followed by cambial strands that

later differentiate into vascular bundles of phloem and xylem. Incompatible graft unions result when no vascular tissue develops, but is instead filled by ray tissue that fails to lignify. This interruption of vascular continuity between the scion and stock is the definition of incompatibility.

Santamour (1988) discussed a number of potential causes of graft incompatibility including the presence of viruses in either the scion or stock, wound compartmentalization ability, and cell wall lignification. Lignification of the cell walls ultimately provides the physical strength for tree growth. For some "difficult" genera such as the oaks, the peroxidase enzyme, which is directly involved in the polymerization of alcohols into lignin, has been shown to be genetically variable (Santamour, 1983). If the scion and stock do not possess genetically identical forms of the peroxidase enzyme, then lignin bonding of adjacent cell walls will be disrupted, resulting in a lack of vascular development (Santamour, 1988).

For the white oak subgenus, there appears to be little, if any, variation for the cambial peroxidase enzyme. This means that different species within the subgenus can be successfully employed as scion and stock material. However, in the red oak (*Lobatae*) subgenus, a total of seven different phenotypes of this enzyme have been detected (Santamour, 1983). It also appears that certain species within the subgenus express different levels of variation for this enzyme, with northern red oak (*Q. rubra*) being the most variable. As an example of how widespread this problem can be, delayed compatibility symptoms for a 180-clone collection of northern red oak in Indiana began to be noticeable 5 years after grafting and reached 17% by age 8 (unpublished data).

SCIONWOOD HANDLING

Collection of scionwood during the dormant season is fairly straightforward. Robust, 1-year-old wood is normally collected in January or early February. Care should be taken to store the scionwood dry in plastic bags in a cooler just above freezing. Experience has shown that no moisture-retaining material (such as sphagnum moss) is needed in the scionwood bag, and in fact may contribute to mold development. I have stored scions of several genera in this fashion for up to 3 months. Scionwood can also be stored successfully for up to 6 weeks by waiting to collect it in late March, or as long as it is dormant. Once collected, it can be dipped in a 10% bleach solution, wrapped in moist paper towels, placed in closed plastic bag, and *stored in a refrigerator (Earl Cully, pers. comm.).*

GRAFTING METHODS

A number of grafting techniques for oaks have been reported in the horticultural and forestry literature and will be reviewed here. Undoubtedly, there may be additional variations that have been attempted on an informal basis by a number of propagators. A case in point has been my experience in pot grafting large numbers of *Q. rubra* and *Q. alba* clones in a greenhouse in the spring.

A short description of the following techniques will be provided: pot grafting, bench grafting, root grafting, field grafting, acorn grafting, and summer budding.

Pot Grafting. This approach to oak propagation is perhaps the most reliable method for those of us who do not enjoy the pleasures of living in a mild climate like the Pacific Northwest, or in Britain. My personal experience has been to expect at

least a 90% success rate by grafting northern red oak and white oak selections onto potted rootstocks in the greenhouse in the spring. The key to this success is to focus on rootstock health and size, and the use of robust scionwood. The process begins in late January-early February, by either potting up large size 1-0 seedlings into 14-in.-deep pots, or moving stored seedlings grown the previous year in 8-in.-deep pots into a cool greenhouse. Depending upon the daylength and temperature regime within the greenhouse, the actual grafting operation can commence in approximately 3 to 4 weeks. The timing is dependent upon bud swell on the rootstock. I do not focus upon root growth, but rather begin to graft as soon as the rootstock buds become noticeably active. Success rates will tend to decrease as the stage of leaf expansion and development on the rootstock increases.

Dormant, 1-year-old scions are removed from storage and grafted using a side veneer graft onto the rootstock approximately 2 in. above the soil line. The actual scion possesses only a single lateral bud and the tapered wedge cut is approximately 1.5-in. in length. The scion is inserted into a previously made corresponding cut on the rootstock and wrapped with a budding band. This budding band is firmly (not tightly) wrapped with spaces between each wrap. The entire graft is covered with Parafilm, a plastic tape product which allows for gas exchange while preventing desiccation of the cut surfaces. The actual top of the rootstock is removed just above the scion approximately 10 days after grafting. Depending upon the temperature within the greenhouse, bud break of the scion should be expected in approximately 14 days. The Parafilm covering will not impede the shoot development of the scion in any way, even if the bud is covered with 3 or 4 layers. Temperature regimes within the greenhouse range from 65 to 95F. No supplemental lighting is used.

Grafts are moved out of the greenhouse after any danger of spring frosts, and placed in a shade structure for about 10 days. The shadecloth is then removed and the potted grafts are exposed to full sun all summer and watered as needed. Since the graft union is quite weak, it is recommended that the scion be staked with a bamboo cane. Two flushes of growth can be expected during the first summer if the pots are top dressed with a time-release fertilizer such as Osmocote 17N-6P_2O_5-12K_2O (3-4 months). Grafts can be outplanted in the field the following spring.

Flemer (1962) suggested that oaks could also be successfully pot grafted in a humid greenhouse in August. Scions from the current year's growth are collected and the leaf area is reduced by one-half.

A large number of oak cultivars are propagated via grafting in the Low Countries of Europe by specialty nurseries. The common understock species are English oak (*Q. robur*) for all white oak species, pin oak (*Q. palustris*) for the red oak group, and Turkey oak (*Q. cerris*) for the Mediterranean species and their hybrids. The propagation of evergreen oaks can be troublesome due to a lack of hardiness of the roostocks. A potential solution is to plant the graft deep, after wounding the scion so as to promote the rooting of the scion (Michel Decalut, pers. comm.).

Bench Grafting. Bare-root seedlings can be used as understocks in oak grafting when combined with the use of a hot callus pipe device (Lagerstedt, 1981). This device allows for the rapid callusing of the graft union while the distal end of the scion and also the rootstock is completely dormant. The graft is prepared as in pot grafting including the use of Parafilm, and placed within the slot in the pipe. A constant temperature of 75 to 80F for a 2-week period will result in healthy callus development.

The root systems are heavily mulched with damp sawdust or sphagnum moss to prevent cold winter injury. The graft can then be removed from the pipe and placed in cold storage for either subsequent outplanting or potting up in the spring. This particular approach to oak propagation has a number of advantages. No heated greenhouse or potted rootstocks are needed, and the work can be conducted throughout the winter season, which is a traditionally slower time of year.

Root Grafting. The use of root sections as a source of understock material was described by Leiss (1984). Root pieces of English oak (*Q. robur*) were potted up in clay rose pots in mid December. The root piece was covered with peat except for the very top and covered with opaque plastic. Temperatures within the greenhouse ranged from 43 to 68F. Root growth began in approximately 3 weeks and grafting operations began in mid February. Side veneer grafts were made using 3 to 4 bud scions of *Q. robur* f. *fastigiata* of similar diameters as the root pieces. Completed grafts were placed in a grafting case covered with glass sash. Temperatures within the case ranged between 68 and 82F. The grafting case was gradually vented over a 4-week period. The grafts sprouted uniformly and there were no suckering problems, which is common when using seedling rootstocks.

Leiss (1995) provided a further description of root piece grafting to this Society and addressed the challenge of propagating red oak group species and cultivars. His answer was to employ the same technique as described above and simply use root pieces harvested from either the original plant, or an obviously successful graft.

I conducted a small grafting experiment using root pieces in conjunction with a hot callus pipe device for four northern red oak (*Q. rubra*) clones. Despite the fact that only 2 of 48 grafts developed any callus tissue, it appears that this strategy may warrant additional testing. In this initial attempt, the temperature within the pipe fluctuated during the callusing period due to equipment malfunctions. In addition, I failed to completely cover the graft union with Parafilm over the entire length of the scion and root piece that was within the callus pipe. If any uncovered tissue is exposed within the callusing pipe, it will desiccate resulting in graft failure (Robert Tomayer, pers. comm.).

If it can be shown that root piece grafting in conjunction with a hot callus pipe device is possible, it could result in a method for producing grafts of red oak species and cultivars. Root sections could be harvested from older grafts that are obviously compatible and used as understock material in a hot callus pipe device. For certain species, the optimal temperature within the pipe and/or the duration of the callusing period will need to be determined. Dunn (1995) provided some insight into how grafts are bench grafted using a hot callus device in Britain. His recommendation was to place the grafts into the pipe for 17 days at 75F. He reported a success rate of 95% to 99%.

Field Grafting. Propagators in the Low Countries of Europe employ the use of cleft grafting onto established rootstocks in the field. This approach is also successful in Britain, where the cool, moist spring weather conditions are ideal for this method. Scions are collected in March and grafted when the rootstock buds begin to swell, usually in April (Dirr and Heuser, 1987).

High rates of success can be expected in the Midwestern U.S. by employing the use of either side veneer or cleft grafts on vigorous rootstocks up to 2 in. in diameter. This can be an effective technique when establishing a new stock block. Scions are tied

with budding bands, waxed, and held in place with black electricians tape (Earl Cully, pers. comm.). As with any other grafting technique, high rates of success are dependent upon the use of vigorous rootstocks and scionwood.

Acorn Grafting. This technique utilizes newly germinating seeds as the understock source, and could also be considered as a form of rooting. Newly emerging shoots are decapitated just prior to leaf development, and the hypocotyl is carefully split with a grafting knife. Small diameter scions are cleft grafted onto this hypocotyl and carefully wrapped with cotton string. The scions are collected at the onset of budbreak in the spring. The completed grafts are potted up in containers and placed in a polytent under shade in a greenhouse. The polytent is gradually vented as shoot development begins on the scions. This grafting technique was described by Goggans and Moore (1967), and reportedly resulted in a 50% success rate for both chestnut oak (*Q. prinus,* syn. *Q. montana*) and pin oak (*Q. palustris*). It has also been reported to be a successful grafting technique for *Castanea* and *Camellia* species in which root formation actually developed on the scions.

Summer Budding. This is the method of choice for the production of shade tree whips on the West Coast. Depending upon experience, various nurseries begin their budding operations in late July or early August. Some propagators bud oaks into early September. Both 1-0 and 2-0 seedling understocks are used. The length of the chip bud ranges from 1 1/4 to 1 1/2 in. long. Clear budding tape is used to tie in the chip buds. Success rates generally exceed 80%, with some cultivars approaching 100% (Michael Reish, pers. comm.). It is common to expect an 80% bud take and 5-ft tall, lightly branched whips when using 1-0 understocks. A 2-0 understock will result in 7- to 8-ft tall whip, but the success rate is usually lower, only about 60% (Earl Cully, pers. comm.). Since compatibility is not a great concern for species in the white oak subgenus, English oak (*Q. robur*) and swamp white oak (*Q. bicolor*) are the understock species employed, depending on the cultivar. Selections of Hungarian oak (*Q. frainetto*) are budded onto *Q. robur* (Keith Warren, pers. comm.).

In the Midwest, oak selections can be chip budded onto 1-0 seedlings of either swamp white oak (*Q. bicolor*) or bur oak (*Q. macrocarpa*) that have been fertilized heavily in the field for an additional growing season. Timing is in late July to early August. Buds are wrapped with 1.5-mil white budding tape and the top of the rootstock is removed the following spring. Despite the fact that the buds will knit well together, they may fail to grow the following spring or else die and fall off during the winter. Success rates can be somewhat erratic due to the subsequent winter temperatures (Earl Cully, pers. comm.). These same problems were also reported by Flemer (1962) in New Jersey. High rates of success are dependent upon the use of vigorous understocks. Also, collection of the budsticks from well maintained and irrigated stock blocks is critical to achieving high rates of success.

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