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Grafting: A Review of Basics as Well as Special Problems Associated With Conifer Grafting©

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INTRODUCTION

The role of grafting in contemporary plant propagation has declined with advancements in conventional cutting propagation and subsequent micropropagation. However, grafting is sometimes still the method of choice when dealing with certain rare and unusual woody plants and is therefore currently employed by a handful of specialty nurseries and a few larger firms that still market specialty crops.

The purposes of this brief paper are twofold: (1) To enumerate the advantages and liabilities of grafting with the implicit question: Is grafting a viable method for a given nursery to adopt and use in its production? (2) To describe the basic steps in grafting while examining a few unique requirements of grafting evergreen conifers relative to deciduous plants.

REVIEW — DIFFERENCES BETWEEN GRAFTING CONIFERS AND DECIDUOUS PLANTS

- Timing is critical when grafting conifers versus deciduous plants. Temperatures should be cool to avoid premature shoot flushes on the scions, and late December through February is best.
- Humidity is essential, and conifers require closed frames and high humidity.
- Understock must be in active growth before grafting, and rootstock must be warmed up 2–3 weeks before grafting ensues.
- Conifers require a side-veneer or modified-side-veneer graft.
- Fungal contamination is always a major concern and must be closely monitored. Sanitation is therefore critical, and removal of yellowing or blackened needles is essential. Routine applications of broad spectrum-fungicides or sterilants will be necessary.
- Acclimation to outside conditions is far more problematical than with deciduous grafts.

ADVANTAGES OF GRAFTING

1) Grafting may be the only method to efficiently propagate a given species or variety. This is very much the case with the majority of dwarf conifers, which cannot be successfully cloned by means of cutting propagation. Selections of Japanese maple (*Acer palmatum*), arboreal dogwoods (*Cornus*), European beech (*Fagus sylvatica*), hybrid witch-hazels (*Hamamelis*), and oak cultivars (*Quercus*) are additional examples of woody plants that are still largely grafted.

2) Grafting is often the most reliable way to rescue plants that are in advanced stages of decline or those that exhibit anomalous growths such as witches' brooms. Witches' brooms usually possess thickened and compressed stem tissue. By the same token, trees or shrubs in advanced maturity offer the propagator little in the way of good cutting material. Once grafted and placed under an improved cultural regime, it's possible to effect their rejuvenation so they can be more easily multiplied through cuttings.
3) Grafting may produce a larger plant in a given period of time. Grafters often describe the "jump start" effect that the rootstock's vigor and energy supply to the scion. Cultivars of Nootka falsecypress [*Callitropsis* (syns. *Chamaecyparis* and *Xanthocyparis*) *nootkatensis*] represent one such example because they can be propagated through cuttings or by grafts. Grafted plants, however, are known to reach saleable size 2–3 times faster than those on their own roots.
4) Grafting may employ a selected rootstock which, when compared to growing a given taxon on its own root system, represents improved tolerance of heat and drought, resistance to disease, and a more fibrous root system allowing for improved anchorage, transplanting, and reestablishment.
5) Grafting employs rootstocks that are historically valued for their dwarfing effects on plants. It is likely that this dwarfing may be related to incompatibility between stock and scion.

LIABILITIES OF GRAFTING

1) Grafting is by far the most labor-intensive form of clonal propagation. Aside from the actual process of joining plants together, the grafting process requires considerable time in rootstock preparation as they must be carefully potted, trimmed of unwanted needles and stems, and weeded. Then, too, scions must be cleaned prior to grafting, taking great care to avoid wounding cambial tissue. When grafting conifers, the labor involved in the aftercare is significant; constant monitoring for disease, gradual trimming back of the understock, and the loosening of grafting rubbers all are time-consuming activities.
2) Grafting is a costly process requiring the purchase of rootstock, coolers, or refrigerators for the storage of scions, heated greenhouses, and the essential tools of grafting such as grafting knives, rubber ties, and wax.
3) Success in grafting is inherently unpredictable, and the percentage of "takes" can vary widely from year to year and is often weather dependent. Scions from parent plants that are weakened or stressed due to drought or cold temperature injury will limit success as will the exposure of rootstock to an adverse environment.
4) The relationship between stock and scion may yield undesirable growth responses and unsightly graft unions; this relates to the concept of latent incompatibility.

GRAFTING: A REVIEW OF THE BASICS AND THE SPECIAL REQUIREMENTS OF CONIFERS

All successful grafting can be broken down into three major factors: (1) The condition of the rootstock, (2) proper grafting technique, and (3) the aftercare process. Of these three factors, the condition of the rootstock is, by far, the greatest determinant in the success or failure of grafts. The aftercare of grafts is also exceedingly important especially as it concerns traditional winter-grafting (bench grafting) procedures, and this includes needle-bearing evergreens. Nontraditional strategies, such as the current use of hot-callus-tube systems whereby heat is applied directly to the graft union to promote faster callusing and healing, simplify aftercare considerably. Under this protocol, grafts can be performed anytime on dormant stock, and once healing has commenced (20–25 days), grafts are removed from the greenhouse and placed in minimally heated cold frames, thus avoiding the trickiness of acclimating them to outside conditions. However, many grafters complain that hot-callus-tube systems promote too much warmth and too little humidity to efficiently graft evergreen conifers, and most conifers are still grafted traditionally onto actively growing rootstocks (as indicated by the presence of white root tips). Consequently, conifer grafts are best left in the greenhouse until the danger of hard freezing is over.

Rootstocks. Rootstocks must be potted and well rooted, of vigorous growth, and appropriately sized. Most grafters buy or grow their rootstock several months ahead of the grafting season to ensure they are properly "seasoned." Grafters generally acquire more rootstocks than they intend to use so they may best select a rootstock whose diameter most closely matches the diameter of the scion, which varies considerably between cultivars.

The choice of the rootstock is likewise critical, and in general, the rootstock and scions must share a strong botanical affinity. Exceptions are noted in the rose fam *Rosacea*e) and the olive family (*Oleaceae*) where grafting between genera is possible. But trial and error as well as cost and availability often determine the selection of rootstock when more than one species is possible. In a few cases, the rootstock selection may relate to climate and soil types of the area. A good example is the use of Momi fir (*Abies firma*), a species noted for tolerance to heat and heavy soils, as the rootstock of choice for southern areas.

Grafting Technique. The following materials should be acquired before grafting.

- A good-quality, grafting knife of German or Swiss make, composed of soft steel that can be sharpened to a fine edge. Razor blades or box cutters work well for tiny, thin scions. Never use a grafting knife for any other purpose than grafting!
- A honing stone for sharpening — an Arkansas oilstone or ceramic stones work well.
- Grafting rubbers — lighter grades for small scions and heavier grades for larger wood.
- Sealants such as sheet parafilm to wrap graft unions or paraffin (candle wax) heated to a liquid state and brushed on the unions. Note: melted wax should be cooled to 140 ºF before applying.

While a range of grafting techniques can be employed on deciduous plants, evergreen conifers are exclusively grafted using a side-veneer or modified-side-veneer

graft. This is necessary because conifer grafts are generally much slower to heal and flush growth than deciduous grafts, and retaining the shoot portion of the rootstock functions to provide nutrients and photosynthates to young growing scions. Therefore the rootstock nurses the scions through the healing process and during its acclimation to outside conditions.

The reader may consult the literature for illustrations depicting this technique but, for new grafters, the best way is to gather copious amounts of practice wood and sit down with an experienced grafter until one acquires a "feel" for the knife and cuts can be made with a one-stroke motion. First-time grafters tend to whittle or turn the knife while cutting, causing uneven cuts or bevels that prevent a close knit between the scion and stock.

Scions should be collected no sooner than 10–14 days before grafting. Scions should match as closely as possible the diameter of the rootstock and, with few exceptions, the goal is to graft as close to the crown (root-shoot interface) of the rootstock as possible while matching the cambial layers on both sides. If the rootstock is thin or light, scions composed of 1-year wood may work best; larger scions of 2-year-old wood can be used on thicker stock. Ideally, the temperature should be above freezing when collecting scions since the wood may be brittle and crack at lower temperatures. Scions collected at below-freezing temperatures should be warmed up gradually in cold water before grafting.

There are excellent propagation manuals that summarize the most efficacious rootstock and scion combinations. For conifers, grafters have historically used the following combinations:

- Eastern white pine (*Pinus strobus*) for all five-needled and some three-needled pines.
- Scotch pine (*P. sylvestris*) for all two-needled and some three-needled pines.
- Norway spruce (*Picea abies*) for all spruces.
- White fir (*Abies concolor*), Fraser fir (*A. fraseri*), or Cannan fir (*A. balsamea* var. *phanerolepis*), Veitch fir (*A. veitchii*) popular in Europe, and Momi fir for southern regions for all firs.
- For other genera, grafting scions onto species rootstock generally works out well.

Aftercare. The acclimation of grafts from a greenhouse environment to outdoor conditions, where temperatures fluctuate widely and humidity levels are lower, is most often the greatest single source of failure in grafting. This is especially true of conifer grafts where the soft flushes of new growth are prone to desiccation and dieback. Consider the following steps as a useful guideline in the aftercare of conifer grafts:

January Through February.

- Fresh grafts require a high degree of humidity, and conifer grafts are traditionally held in a plastic-covered grafting case or frame and plunged into a moistened medium consisting of perlite or a combination of perlite and peat moss deep enough to cover the graft union.

- Grafts should be periodically misted lightly to maintain high humidity and to cool scions during sunny days. Misting grafts every 7–10 days is usually sufficient in early winter but misting more frequently will be necessary as greenhouse temperatures rise in late winter and early spring.
- Monitoring fungal disease is critical, and broad spectrum fungicides or sterilants should be applied every 10–14 days.

***March Through May*.**

- Check periodically to ensure that rootstocks are well watered.
- On easy-to-graft species, such as five-needled pines, callusing and healing will occur within 2–3 weeks. By the end of the winter, it is advisable to check grafting rubbers and loosen them to allow for cambial expansion. Grafting rubbers should remain on, however, until the following fall.
- Rootstock should be lightly headed back to remove succulent shoots, which are most prone to fungal infection; otherwise, rootstock should remain intact to nurse young scions.
- Closely monitor for fungal infection [gray mold (*Botrytis*)], paying special attention to young candle growth on scions.
- Remove plastic coverings in the morning hours to gradually acclimate grafts to lower humidity and higher temperatures.
- Discard dead or dying grafts. Separate strongly growing, well-flushed grafts from weaker, nonflushed grafts.
- When removing grafts from cases, shade them under benches, shade cloth, or moistened burlap before setting them outside.
- Place grafts outside under shade cloth or lath.

ADDITIONAL READING

Dirr, M.J., and **C.W. Heuser, Jr.** 1987. The reference manual of woody plant propagation: From seed to tissue culture. Varsity Press, Inc., Athens, Georgia.

Garner, R.J. 1988. The grafter's handbook 5th ed. Oxford University Press, New York.

Hartmann, H.T., D.E. Kester, F.T. Davies, Jr., and **R.L. Geneve.** 2002. Hartmann and Kester's plant propagation: Principles and practices. Prentice Hall, Upper Saddle River, New Jersey.

McDonald, B. 1986. Practical woody plant propagation for nursery growers. Vol. 1, Timber Press, Portland, Oregon.

Nelson, S.H. 1968. Incompatibility survey among horticultural plants. Comb. Proc. Intel. Plant Prop. Soc. 18: 343–407.