PLANT PROPAGATION
BUDDING AND GRAFTING

History goes back 2000+ yrs (Chinese). Aristotle (384 - 322 BC). Paul in Bible - grafting of olive. Budding and grafting is the process of joining two plant parts together.

Terminology: grafting, budding, stock (rootstock, understock), interstock (intermediate stock, interstem), vascular cambium, callus.

Reasons: Perpetuating clones difficult to propagate in other ways, benefits of a certain RS (disease resistance, insect resistance, dwarfing, nutrient efficiencies, soil type preferences, special forms), hastening reproductive maturity of seedling selections, repairing damaged plants, changing the cultivar of an established plant (topworking), and studying virus diseases (*Prunus serrulata* - Shirofugen flowering cherry is used as a tool to detect various viruses).

Advantages of clonal rootstocks - well understood in Europe - reduces variability, adds refinement to adaptation of a clone. Concept of "clean" rootstocks.

Double working - avoids certain kinds of compatibility, refines the degree of dwarfing.

Formation of the graft union: 1) Lining up of the vascular cambiums, 2) wound healing response, 3) Callus bridge formation, 4) Cambium formation, 5) Vascular tissue formation.

Limits: easy to graft within a species, less easy between genera, very difficult between families.

Factors influencing the healing: 1) incompatibility, 2) kind of plant, 3) temperature, moisture and oxygen conditions during and following grafting, 4) growth activity of the stock, 5) propagation techniques, 6) virus contamination, insects and diseases, 7) plant growth regulators in the healing of graft unions.

Polarity: 1) in most cases, proximal end of scion into the distal end of stock), 2) In nurse-root grafting, proximal end of scion goes into proximal end of the rootstock. Think!

Symptoms of incompatibility: poor unions, overgrowths or undergrowths, dies over time, deficiency symptoms, dwarf trees, premature defoliation.

Three types of graft incompatibility: 1) localized, translocated and virus-induced. The first (localized) can be corrected by using a mutually compatible rootstock (interstem). Translocated incompatibility cannot be overcome. Virus-induced is more common than previously thought (Citrus, Pyrus)

Translocated effects. 1) Sometimes the RS will impart characteristics to the scion: size and growth habit, fruiting (precocity, fruit bud formation, fruit set, and yield), size, quality and maturity of fruit, winter-hardiness, disease resistance, and time of fruit maturity). 2) Effects of the Scion cultivar on the rootstock - vigor of rootstock, cold-hardiness of the rootstock.

Mechanisms for these translocated effects are due to nutritional uptake and utilization, translocation of nutrients and water, and alterations in endogenous growth factors.

Translocated or localized incompatibility - use interstem to compensate for this problem.

Translocated effects. Sometimes the RS will impart characteristics to the scion and vice-versa.

$\frac{A}{B}$ = 0K $\frac{B}{C}$ = OK $\frac{A}{C}$ = DEAD

$\begin{array}{c}\underline{A}\\ \underline{B}\\ C\end{array}$ = OK (LOCALIZED INCOMAPITIBILITY)

$\begin{array}{c}\underline{A}\\ \underline{B}\\ C\end{array}$ = dead (TRANSLOCATED INCOMPATIBILITY

Timing. Most grafting takes place at the time of bud break. Most budding takes place in June. Roses are June T-budded. Pecans are patch budded or whip grafted in the end of March or first of April. Grafting - collect the wood in winter, store moist and cold (32 degrees F).

Splice, whip and tongue, veneer and side grafts, saddle, cleft, cutting grafts, double working, root grafting, bareroot grafting.

ROOTSTOCKS FOR ORNAMENTALS PRODUCTION AND USE IN THE SOUTHEASTERN UNITED STATES.

The following is adapted from a presentation by Dr. J.C. Raulston, NCSU Arboretum, Raleigh, NC, made at the International Plant Propagators Society (IPPS) conference, Charleston, SC, November 8, 1995.

Root survival is perhaps the single most important factor determining adaptation of species to a specific environment. As temperatures rise, respiration rates increase which create a requirement for more oxygen to permit root survival. Sudden flooding of poorly drained soils during maximum temperature periods can create temporary, but quickly fatal, anaerobic conditions for roots at the time of peak oxygen demand. This situation is unique to the southeastern U.S. as soils in southwest and western states are dry (and well aerated) at periods of high temperatures, and central and northeast areas are cooler when rains occur. In addition, modern container production with carefully formulated media of coarse texture and rapid drainage allows simple, successful production of plants with fragile root systems which often cannot be subsequently grown easily in landscape soils of the production region. Prominent examples include many Ericaceous plants and such native and exotic taxa as *Franklinia alatamaha*, *Gordonia lasianthus*, *Ilex* X meserve ("Blue Hollies"), and *Taxus* X *intermedia*.

Grafting is used to produce plants which combine aerial portions of superior ornamentals with adapted and tolerant root systems suitable for the area of production. The majority of such grafting is used in fruit production where an economic product permits the extra costs of such specialty propagation. Very little research has been conducted on potential rootstocks specifically for ornamental plants in the southeastern U.S. due to the lack of commercial grafting operations in the region, the lack of such specific skills among most academic researchers, and the time and expense to conduct such long-term trials on "minor" crops.

Commercial grafting firms in the Pacific northwest and the northeast are not aware of the potential problem and often use rootstocks which work well in those areas, but are failures when planted in the southeastern U.S. A prime example is the use of Abies balsamea or fraseri seedlings for all fir grafting (due to low costs and ready availability as major Christmas tree species). These are the two weakest roots system firs in existence and such grafted plants never survive the first month of wet summer conditions here. In early years after its introduction, *Cornus* X 'Eddies White Wonder' was grafted in the Pacific northwest on *C. nuttallii* which cannot be grown in the Southeast, leading early researchers to believe the scion cultivar could not be grown in the east. Many other such examples exist.

The following list contains theoretical proposed graft rootstock:scion combinations for research and production trials. The listing has been formulated from observation of plant behavior at The NCSU Arboretum, in other gardens around the world, and native habitats of many of the species. The plants listed first (before the hyphen) are taxa which have been observed to have more tolerance to hot, wet southeastern U.S. soils than average species of the genera and therefore have potential for understock use. The plants listed following the hyphen are those which have ornamental value, but have been observed to have survival problems in poorly drained situations and therefore would be the scion stock.

In a few cases, bigeneric combinations have been proposed where tolerant species do not exist within the problem genera. Bigeneric grafts are usually less successful than interspecific grafts, but enough successful combinations have been achieved to warrant trial. An asterisk is used after the proposed combination where promising trial grafting work has been conducted at The NCSU Arboretum or observed elsewhere.

Abies firma - for other Abies taxa*
Acer japonicum or *palmatum* - *Acer circinatum* and *A. macrophyllum*
Acer rubrum - for *Acer pentaphylla**
Acer saccharum - for *Acer griseum**
Arbutus unedo - for *Arbutus arizonica*, *mensiesii*, and *texana*.
Baccharis halimifolia - for *Baccharis pilularis*
Betula nigra - for other *Betula* taxa*
Calycanthus floridus - for *Calycanthus occidentalis*
Ceanothus X *pallidus* or *americanus* - for west coast or Mexico *Ceanothus* taxa

Cercis canadensis or *chinensis* - for *Cercis griffithii*, *occidentalis*
Chamaecyparis pisifera or *thyoides* - for *Chamaecyparis lawsoniana* and *nootkatensis* cultivars
Chitalpa (*Catalpa* X *Chilopsis* hybrids) - for *Chilopsis linearis*
Cornus florida - for *Cornus nuttallii* and C. X 'Eddie's White Wonder'
Crataegus aestivalis - for other *Crataegus* taxa
Cupressus bakeri or *glabra* - for *Cupressus sempervirens* 'Swane's Golden'.
Eleagnus X ebbengii or *pungens* - for *Elaeagnus angustifolia*
Fagus grandifolia - for *Fagus sylvatica* cultivars; trial on *Nothofagus* spp. ??
Garya ovata var. *lindheimeri* - for *Garrya elliptica* 'James Roof'.
Photinia X fraseri - for *Heteromeles arbutifolia*
Ilex X 'Nellie Stevens' - for *Ilex aquifolium* and *I.* X *meserveae* ("Blue Hollies")
Itea chinensis - for *Itea illicifolia*
Kalmia latifolia - for *Kalmia cuneata* and *microphylla*
Magnolia virginiana - for *Magnolia sieboldii* and *wilsonii*
Myrica cerifera - for *Myrica californica*
Picea abies, *omorika*, or *orientalis* - for *Picea brewerana*
Pieris japonica - for Pieris floribunda
Pinus glabra, *pinea*, *sylvestris*, or *virginiana* - for *Pinus edulis*, *muricata* (2 needle pines)
Pinus palustris, *serotina*, *rigida* or *taeda* - for *Pinus albicaulis*, *aristata*, *flexilis*, *torreyana* (5 needle pines
Playtcladus orientalis - for *Microbiota decussata* (unlikely bigeneric graft but only possibility for south)
Pseudolarix amabilis - for *Larix* taxa (unlikely bigeneric graft but only possibility for Larix in south)
Quercus virginiana - for numerous west coast and Mediterranean evergreen *Quercus* species.
Raphiolepis umbellata - for *Raphiolepis indica* taxa
Rhododendron chapmanii - for small-leaved evergreen *Rhododendron* taxa; trial for *Kalmiopsis leachiana*??
Sorbus alnifolia - for other Sorbus taxa
Spirea sp. - for *Holodiscus discolor* (unlikely bigeneric graft, understock suckering impractical also).
Stewartia monadelpha, *koreana*, or *pseudocamellia* - for *Stewartia malacodendron* and *ovata*.
Styrax americanus or *japonicus* - for *Styrax hemsleyana*, *obassia*, *officinalis*, *officinalis californicus*, *platanifolia*, *texana*, and *youngae*
Syringa oblata var. dilatata - for Syringa vulgaris cultivars
Taxus chinensis - for *Taxus* X *intermedia* cultivars
Tsuga canadensis or *sieboldii* - for *Tsuga caroliniana*, *heterophylla* and *mertensiana*

Successful combinations from the above potential grafting/rootstock trials would make possible the successful landscape cultivation many new ornamental plants currently impractical or impossible to growth the the humid, warm climate of the south and southeast. There is an industry conception that grafted plants are a commodity of the past with increasinly unavailable skills needed and greater costs than for cutting production of clonal taxa. This statement is gnerically true for mass market crops, but for a number of plants grafting may be the only feasible way to use certain taxa in this region. Kowledge of graft combination feasibility would create opportunities for development of regional specialty propagation nurseries to fill the potential consumer market for such connoisseur plants.

Releated Literature:

Dirr, Michael A. 1990. Manual of Woody Landscape Plants: Their Identification, Ornamental Characteristics, Culture, Propapagation and Uses. 4th edition. Stipes Publishing Co., Chamapaign, Il. 1007 pp.

Dirr, Michael A and Charles W. Heuser, Jr. 1987. Reference Manual of Woody Plant Propagation: From Seed to Tissue Culture. Varsity Press, Athens, Ga. 239 pp.

Garner, R. J. 1967. The Grafter's Handbook. (2nd Edition) Oxford University Press, New York, NY 263 p

Hillier Nursery. 1991. The Hillier Manual of Trees and Shrubs. 6th edition. David and Charles, England, 704 p.

Hogan, Elizabeth L. (Ed.) 1988. Sunset Western Garden Book. Lane Publishing Co., Menlo Park, CA 592 p.

Vines, Rober A. 1960. Treees, Shrubs and Woody Vines of the Southwest. Univ. Of Texas Press, Austin, TX. 1104 p.