WEDNESDAY AFTERNOON SESSION

September 3, 1969

VICE-PRESIDENT BRIGGS: The moderator for the second session of our meeting will be Dr. Harry Lagerstedt, who is now a horticulturist with the USDA stationed at Oregon State University, Corvallis. Dr. Lagerstedt will also start the session off by giving the first talk. Harry:

GRAFTING: A REVIEW OF SOME OLD AND SOME NEW TECHNIQUES

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The technique of grafting is over 2,000 years old, so it might be presumptous to assume that something new can be added. Yet the wheel, which is thought to be over 5,000 years old, is continually being improved as new materials are developed. There can be no change in the basic design of the wheel, only in its size or the materials utilized. In the same way, there can be no change in the basic principles involved in grafting, only in the tools, materials, or methods used in preparing the grafts. It is the objective of this paper to review certain grafting techniques and to present some materials and methods which have improved nut tree grafting success. This will be done while considering the basic principles involved in grafting.

History:

Grafting involves joining a stock and scion in such a way that they will unite and grow. It is a practice that has been subject to much folklore and misconception. Grafting was first recorded by the Greek philosopher Aristotle (384-322) and his pupil, Theophrastus, the "Father of Botany" (370-287 B. C.) (2). Their casual mention of grafting suggests that it was already a well-established and common practice during their time (5).

Virgil (70-19 B. C.) the Roman poet (2) wrote of grafting in the following terms: (1)

"But thou shalt lend
Grafts of rude arbute unto the walnut tree.
Shalt bid the unfruitful plane sound apples bear,
Chestnuts the beech, the ash blow white with pear,
And, under the elm, the sow of acorns fare."

We are now aware that grafts of such distantly related tree types are impossible. What the ancients had construed as a graft was probably the germination and growth of a tree seed in the crotch of a mature tree. It is presumed that this observation and that of naturally occurring grafts was the basis for the first true grafting attempts (3).

Pliny "The Elder" (23-79 A. D.), a Roman naturalist (2) wrote, "It is a point most religiously observed, to insert the graft during the moon's increase" (1). This was a common misconception associated with ancient grafting. Pliny may have contributed more factual information when he asserted, "A graft should not be used that is too full of sap, no, by Hercules, no more than one which is dry and parched" (1).

During the Dark Ages grafting knowledge became the secret possession of a few practitioners, and little in the way of improvement was added to the technique for several hundred years. Some of the veil of mysticism was lifted from grafting with the writing of herbals, approximately 1475-1625, and the establishment of botanical gardens in the 16th and 17th centuries (11).

One of the first illustrations of grafting occurred as a crude woodcut by P. Crescintiis in 1548 (11). By 1672 Sharrock's "History of the Propagation and Improvement of Vegetables" showed and described most of the kinds of grafting and budding that are known today (1).

As a young man George Washington was an avid gardener and grafter. Washington's detailed diary states that in March, 1760, he grafted 165 trees of cherry, pear, and apple (6).

The development of new grafting techniques is rarely recorded, yet there is one improvement attributed to an American, Joseph Curtis. In 1802, as a young nurseryman, he was acquainted with the common forms of budding and grafting. When seedling apple rootstocks were in short supply, he tried short pieces of root from an apple tree his father was removing. These grafts produced sturdy trees and the technique of piece-root grafting was quickly and widely adopted by nurserymen. Curtis later developed the collar or crown grafting technique where scions are joined to the rootstocks at the ground line. Later still, he developed nurse-root grafting where grafts are planted deep to promote scion rooting (6).

Grafting Principles:

The major principles involved in grafting are:

1. Use stocks and scions having a close genetical relationship.
2. Match the cambiums of stock and scion.
3. Promote rapid callusing of the graft union.
4. Prevent drying of the graft union.

These principles will be examined individually to determine where improvements might be made within their framework.

1. *Genetical Relationship:*

Generally speaking, all trees of the same "kind" intergraft satisfactorily. Botanically speaking, this means that most varieties of a given species will intergraft. Many species within a given genus will also intergraft. For example, most of the species of the walnut (*Juglans*) intergraft satisfactorily, but one combination, *J. regia* on *J. hindsii,* sometimes fails. This graft incompatibility is known as "blackline" and may take 40 years or so to express itself. Grafting between two genera of a plant family is frequently unsuccessful, and grafting between two families is always unsuccessful. The closer the botanical relationship of stock and scion, the greater are the chances of obtaining a functional union.

An attempt to employ this knowledge has been made in grafting the filbert tree. The orchard filbert tree is trained to a single trunk, but in nature it is a large shrub consisting of many stems which arise from underground suckers. These suckers sprout throughout the growing season, and their continual removal consumes a great deal of time and effort annually. A suckerless rootstock would be an obvious solution to this problem, and several species within the filbert genus (*Corylus*) have been tried with limited success. A glance at the taxonomic chart below shows the filbert to be a member of the birch family which consists of two sub-groupings called tribes (8, 9). The sub-groupings suggest that there is a closer genetical relationship between the genera of the tribe *Coryleae* than between their genera and those of the tribe *Betuleae.* The possibilities for intergeneric grafting of the shrub forms of *Corylus* with the tree forms of *Carpinus* and *Ostrya* are now being investigated.

A taxonomic classification of the birch family, Betulaceae:

Tribe I.	Betuleae	Tribe II.	Coryleae
Genus	A. *Betulus*	Genus	A. *Corylus*
	B. *Alnus*		B. *Carpinus*
			C. *Ostrya*
			D. *Ostryopsis*

2. *Match Cambiums*

The principle of matching the cambium of the rootstock and that of the scion is absolute. This principle limits commercial grafting to plants which have a continuous cambium. In all the plant kingdom only a relatively few plants meet this criterion. None of the lower plants possess a continuous cambium and of the higher plants, only the gymnosperms and dicotyledonous angiosperms have it. Thus, for all practical purposes, grafting is limited to the cone-bearing plants and the members of true flowering plants.

3. *Promote Rapid Callusing of the Graft Union:*

Sitton showed that the optimum temperature range for promoting callus tissue formation on black walnut grafts was from 70°-85° F. (13). In Oregon, where cool spring temperatures prevail, successful field grafting of walnuts is frequently a problem. Nurserymen have sought to increase the temperature by tying a brown paper bag over the graft. This technique not only increased daytime temperatures, but provided some frost protection and has become a standard practice.

The idea of "hot caps" used by tomato growers was enlarged upon by the contruction of long plastic tents over portions of grafted walnut nursery rows. For each of seven weeks starting March 19, 1969, 50 walnut trees were grafted of which 25 were covered by a plastic tent 2′ wide, 2′ high, and approximately 40′ long. Hygrothermographs were placed inside and outside the tent to obtain a continuous record of humidity and temperature. Humidity differences were slight, but averaged somewhat lower for the tented grafts. The striking difference was the influence of tenting on temperature. The hours of temperatures over 70° F. were added for a seven-week period. Tented grafts totaled 331 hours while grafts in the open totaled only 59 hours. The grafting success varied from 28 to 100 percent and was strongly in favor of the tented trees during the first, fifth, sixth and seventh weeks of the experiment. The percentage difference was very slight the other three weeks. The influence of tenting on growth, height and uniformity of grafts was striking. Tented grafts leafed out sooner and were several inches long when the buds on grafts in the open were just beginning to swell. Ultimately, the tented trees were taller and more uniform in height than those grafted in the open.

When bench grafting deciduous fruit or nut trees in the fall, before the rest period of the buds has been broken, a heating cable has been used to promote rapid callusing of the union. The heating cable was laid in moist sawdust and covered with sawdust. The roots of the stock were heeled-in and covered by more sawdust. This technique provided protection for the root system, left most of the stem tissue exposed to normal outdoor temperatures, and applied heat only to the union. If done too late in the season, the buds forced, but done in early fall this method of promoting callusing was highly successful.

In 1914, Lowther and Worthington (10) described the use of paper cones to protect pecan grafts in southern United States where excessive heat may retard callusing. Sitton (13) has shown that the rate of callusing decreased as the temperature exceeded 85° F. In 1966, Romberg and Madden (12) combined aluminum foil and polyethylene bags to shade the graft union while maintaining a high humidity. The combination foil-and-bag seal usually resulted in more growing scions than where the conventional wax seal was used.

In addition to various methods used to modify temperature, applications of plant growth regulators have occasionally been used to promote rapid callusing. While a few successes have been reported, there are as yet no reports of a "hormone" which has broad general application or provides consistently good results.

4. *Prevent Drying of the Graft Union:*

One of the most important principles in biology states, "Where there is no moisture, there can be no life." The fourth principle of grafting is based on this fact. The ancients were aware of this requirement and prepared a mixture of clay and cow dung called a grafting "pug" (3). The pug was molded around the graft union and bound with strips of cloth. Since this had serious limitations as a sealing compound, the pug was eventually replaced by waxes which continue to be used to this day. An important requirement of a sealing compound is that it must be elastic enough to stretch as growth occurs beneath it. Waxes often crack, allow air to enter, and drying to occur. Some waxes have too high a melting point and injure tissues when applied; others have too low a melting point and tend to melt in sunny weather.

Now there are polyvinyl acetate paints available which are water soluble, non-phytotoxic, and elastic. These paints do not require heating and are applied as they come from the can. They are available in various colors and are used for pruning cuts and other tree injuries as well as to seal graft unions. Experiments are now in progress combining these paints with plant growth regulators to promote rapid callusing.

Smooth cuts on both the stock and scion insure a close fit of the union without gaps where air can enter. Use of small stems and long cuts makes the union more pliable and provides for a closer fit. Firm binding of the union not only provides support, but helps bring the two cut surfaces into tight contact.

Rubber grafting bands remain one of the best materials available for binding the graft union. They provide a constant pressure yet will stretch with growth. If successive turns of the band are overlapped they form a moisture-tight seal which may not require waxing. However, rubber grafting bands may deteriorate slowly and frequently need to be cut off the union. String, raffia, various adhesive tapes, plastic strips and even nails have been used to hold stock and scion together.

A paraffin film sold by biological supply houses for use in laboratories has also been tested for binding grafts. A small square of this film is commonly used to seal test tubes. The heat of the hand causes it to seal. Being a thin film of soft wax, it has some elasticity when warmed in the hand during application. Successive wraps around the union make a firm binding. Subsequent removal is not necessary because the binding breaks and drops off as the union grows.

The opposite of the grafts "drying out" is having grafts which "flood" or "drown". This occurs in certain plants, such as the walnut, which "bleed" excessively in the spring. "Bleeding" is believed to be due to several causes: a lack of formaion of ttyloses, bladder-like cellular intrusions which block water-conducting vessels (4); a combination of root pressure, abundant soil water supply, and a lack of transpiration (7).

Walnut nurserymen in California sever the tops of the rootstocks a day or two prior to grafting. This technique permits some advance "bleeding" to occur and will improve the percentage take. Frequently nurserymen cease grafting all together during periods of active "bleeding".

An Oregon walnut nurseryman, Mr. Scott Parrott of Newberg, discovered a technique to solve the graft "flooding" problem. He drilled a 3/16″ hole through the rootstock a few inches above the groundline. This acted as a "safety valve" in that "bleeding" occurred from the hole and not at the union. This technique allows grafting to proceed uninterrupted through the entire spring and improves the percentage of successful grafts.

The above illustrates that new ideas, new techniques and new materials are continually being employed to improve grafting. All the possibilities and opportunities for improving grafting have not been exhausted. All that is required is some imagination or the ability to see a new application for a familiar item.

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MODERATOR LAGERSTEDT: Our next speaker this morning is also from Corvallis and is with the USDA Forest Service. Dr. Donald Copes will talk on: "External Detection of Incompatible Douglas-fir Grafts", Donald: