well save one year besides the extra handling. The technique will be tried with other plants, such as *Spiraea*, where similar results might be expected.

MODERATOR.SHUGERT: Thank you very much, Dick, for a very delightful discourse; your slides and the side remarks certainly helped the presentation. It was an excellent paper and it was fascinating to see what is being done in England in ornamental hardwood vegetative production.

I know you are anxiously awaiting the next paper that has the intriguing title of, "Can Grafting be Mechanized?" It will be presented by the Secretary-Treasurer of the Western Region, Curtis Alley, from the Department of Viticulture and Enology, at the University of California, Davis. Curt Alley, "Can Grafting Be Mechanized?"

CAN GRAFTING BE MECHANIZED?

C. J. ALLEY
Dept. of Viticulture and Enology
University of California
Davis, California

By grafting, for this report, I will refer to benchgrafting rather than field grafting. Propagators that produce plants vegetatively by small cuttings are indeed fortunate. This is completely different from what the nurseryman who grows grapevines has to do. Many parts of California have no nematode or phylloxera problems so it is possible to grow grapevines on their own roots. However, the nurseryman must resort to rooting a cutting that is at least 16 to 18 inches long. In the Coachella Valley of California, where the early maturing table varieties are planted and where the soil is very sandy, growers are not satisfied with cuttings only 18 inches long. A few prefer to have them 3 feet long. This is because they dig a hole 2 feet deep and then bury the cutting so that only the top bud remains above the soil. The lower 1 foot of the cutting is bent over at a right angle at the bottom of the hole to provide a greater surface for root development. However, in many parts of California (along the coast), and in practically all of France, it is not possible to grow grapevines on their own roots because of phylloxera.

French nurserymen probably have developed benchgrafting to its highest level. In the early vineyards of France most grapevines were planted on their own roots. However, because of problem soils, such as those with high lime, a few of the more enterprising growers found that

from the southern part of the United States they could obtain rootstocks from native, wild, *Vitis* species that were resistant to these high lime soils. They were happy to get such valuable rootstocks. However, unknowingly, along with the importation of such stocks resistant to these conditions, they also imported the grape-root louse known as phylloxera. It practically wiped out the French vineyards. To combat this malady they then had to resort to the use of phylloxera-resistant rootstocks, and primarily to benchgrafting in order to develop their vineyards. Incidentally, the French later got even with the Americans. The French immigrants to the United States then brought their premium quality vine stocks with them to California and established phylloxera in this state in the coast counties. Practically this entire coastal region of California must now use phylloxera-resistant rootstocks. However, this is not the full story. In the central valley of California, where the soils are sandy, phylloxera does not thrive. Instead there is another soil pest — the nematode. So the grape grower must then use resistant-rootstocks that can ward off the ravages of nematodes. Also there are a few areas where there are not only phylloxera but also nematodes. This necessitates the use of still another type of rootstock.

With this necessity of having different rootstocks for different types of soil pests and conditions, the only way to develop such plants on resistant rootstocks is to resort primarily to benchgrafting or field budding. How can benchgrafting be mechanized? Let us consider the various phases involved in the developing of a benchgraft and see where mechanization is possible.

The first phase is the collection of understock as well as scion wood. This generally requires hand labor and shears. However, mechanization is possible in pruning by using pneumatic shears to facilitate the operation. Actually the shears operate so rapidly that there is a tendency for the pruner to cut first and think afterwards — where he made a cut — possibly the wrong one. The pruner learns very quickly not to have his free hand close to the operating shears. After the pruning wood has been collected, generally in bundles of 100, it is then placed in large fruit bins 4 x 4 x 3 feet high in moist wood shavings until time for benchgrafting. At the time the propagating wood is collected it should be graded according to caliper, as this will facilitate and speed the benchgrafting operation.

The resistant rootstocks have a bad tendency to sucker. To prevent this they must be disbudded. The disbudding operation precedes the actual benchgrafting operation. The rootstocks are cut to the desired length of about 12 inches and disbudded. Disbudding may be accomplished by shears, knives, or if one wants to become mechanized, by the use of a benchgrinder having wire wheels on either end to rub off the buds. Following disbudding, the cuttings are graded, if this is not already done, and made ready for benchgrafting.

Benchgrafting: This is already mechanized. There are several different types of machines available. A German machine involves the use of a motor having a double shaft and a series of saw blades and spacers or milling cutters and spacers on each end, to cut the slots in the ends of the stock and scion about ¼ inch deep. Stock and scion then will fit together very closely. This does not allow very much space for tying the benchgrafts together with budding rubber or other tying materials. With such a machine the benchgrafts have to be handled very gently to prevent their breakage.

There are two types of French grafting machines available. Both employ the use of knives which make cuts that are very smooth and clean. One machine cuts a very short whip graft. This, too, is very hard to tie in order to hold the two parts together. The best machine that I have seen so far is a French machine that cuts a deep saddle notch or "V" graft about ¾ to 1 inch long. This graft is long enough to tie very easily with budding rubber or raffia and, once tied, is very strong and can be handled roughly. The use of budding rubber requires cutting at a later stage, otherwise it will girdle the graft union. Some growers have used staple guns to staple the stock and scion together and this, too, is satisfactory. The understock and scion should be matched as closely as possible to the same diameter. However, if this is not possible, then the scion is generally the smaller and matched to that side of the scion having the bud.

After the benchgrafts are made they must be callused. In France, and some of the other European countries, extremely cold winters usually occur. Nurserymen in these countries resort to the use of hot-room callusing. This can be easily accomplished and mechanized by placing the newly made benchgrafts in large fruit bins as previously mentioned. During the filling of the bins with grafts, moist wood shavings are placed in the bins and sheet plastic on top to prevent drying. The bins can then be easily moved by fork lifts into hot rooms maintained between 70° and 80° F. The benchgrafts are allowed to remain for 2 to 3 weeks. During this time callusing begins. After this time the bins are removed and placed at lower temperatures to permit the benchgrafts to continue callusing but to prevent the top bud from pushing until the grafts are planted. Where growers make smaller quantities of benchgrafts, rather than using the large fruit bins, callusing boxes may be used. A callusing box is a large box that is approximately 18 inches wide, 16 inches deep and 22 inches long and has a side that is hinged. This permits the placing of the benchgrafts into the callusing box and covering with moist wood shavings. These boxes can then be easily placed on pallets and moved into the callusing rooms.

In California, where winter temperatures are mild, hot-room callusing is not used. The common practice is to make the benchgrafts which are placed in bins, boxes or stacks, then covered and

packed with moist wood shavings and allowed to callus slowly inside a barn or storage shed. Benchgrafting starts by the end of January, and continues through February and part of March. Planting is done from the end of March through April.

The planting of benchgrafts is an arduous, labor-consuming process. Generally trenches are made in the ground and the benchgrafts are planted deeply so that just the graft union is above the surface of the soil. At planting time the union should be well-callused with some evidence of roots at the base of the stock; the shoots should be starting to push or even developed up to ¾ inch. The entire benchgraft must be covered with a mound of loose soil that will not pack.

Although the planting operation has not been mechanized this should be possible. Planting machines are available. A common type of planter is a machine-drawn sled on which the planter is seated with his benchgrafts. He operates directly behind a goosefoot plow which opens a furrow. The benchgrafts can be placed in the furrow directly behind the goosefoot. After the goosefoot passes, the soil then falls in around the plants. The union should be slightly above ground level. Another type of machine that has been successful in planting grape seedlings is a single-row tomato planter. This is a revolving wheel that operates directly behind the goosefoot plow. The wheel has a series of two small arms which lightly contact the stem of the tomato plant or grape seedling. As the wheel revolves directly behind the goosefoot it places the base of the seedling root or benchgraft, if used, gently into the soil to a depth of 2 to 3 inches. After this has been done the arms open and release the plant to remain in place as it continues to rotate in its upward position. Following the planter is an over-the-row tractor which carefully fills soil in — and around on either side and over the benchgraft to a depth of 1½ to 2 in. above the top bud of the scion. In California this covering depth of the scion seems very critical. Generally if the soil is not maintained greater than ½ inch above the buds, they tend to dry out. If the bud is deeper than 2 inches below the soil surface the shoot has difficulty in reaching the surface.

After the vines have been planted they are allowed to grow until the shoots reach a height of 10 to 12 inches; this generally occurs in California around the middle of July. The grafts are then uncovered for the first time and any scion roots are removed. Actually scion roots are very beneficial during the early development of the graft; they support the shoot until a good union occurs between the scion and the stock. However, once a union does occur then the scion has to be encouraged to develop upon the understock rather than on its own roots. After scion roots and budding rubbers, if used, have been removed the vines must be recovered with soil to the original height in order to prevent the burning of the etiolated shoot tissue that was under the soil. The vines are uncovered for a second time about the middle of September. If there are scion roots again, they are

removed. The vines are now left uncovered in order to harden the basal part of the plant to withstand winter conditions.

As far as digging is concerned, this operation is mechanized just as most nursery operations. Following digging, grading is primarily done by hand labor except where bins can be used to carry the material from one area to another.

Benchgrafting is a successful operation with grapevines and it certainly seems such an operation could also be used with certain types of fruit trees requiring special types of asexually-propagated understock. The present procedure with such fruit trees is to root hardwood cuttings or produce stool bed layers the first year and then take the second year to develop the tree after either budding or grafting. If the rootstocks will root easily as hardwood cuttings, it seems quite probable that an operation similar to that used with grapevines could be used whereby the grafted trees could be produced in one year from grafted cuttings, as is the case with grapevines, rather than the two years presently required for this operation.