A DEVICE FOR HOT CALLUSING GRAFT UNIONS OF FRUIT AND NUT TREES[1]

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Hot callusing is a method used in grafting to expose the graft union to elevated temperatures for a short time to accelerate cell division. Trees to be hot callused usually involve dormant scions grafted to rootstocks that are either bare-root or potted. Hot callusing is often achieved by plunging the grafted tree into warm, moist media, by using a special grafting case (double glass) or by just bringing a potted plant into a warm greenhouse. For limited production, some propagators have placed grafts in barrels of heated media that are placed out-of-doors or in a cool room. The disadvantage of these methods is that the elevated temperatures designed to callus the graft union also cause the scion buds to break dormancy and begin leafing out.

To avoid bud break, propagators have tried grafting and hot callusing in October or November, before the chilling requirement of the scion buds has been satisfied (3). Once callused, the grafted trees are placed in cold storage to satisfy the rest period, then planted to the nursery in the spring. This timing has met with varying success, partly due to scion mortality during the long storage period. Also, the callused graft unions are fragile and easily broken during handling. Another limitation on fall grafting is early availability of rootstocks because, ideally, leaf drop should occur before the rootstocks are dug.

Hot callusing is most frequently done in the spring, prior to planting, but this timing also has its problems (1). Forced buds are tender, require special handling care and dessicate readily. Cool, wet weather may prevent ground preparation so that planting is delayed and additional bud forcing may occur. Since timing is so critical with spring hot callusing, there is a relatively short period of time during which it can be done successfully. This places a serious limit on the number of grafted trees that can be produced by this method.

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To overcome some of these problems and achieve a faster turnover of trees in the hot callusing location, some nurserymen allow only 7 to 14 days of heat treatment. This is sufficient time to get the callusing process started, but is insufficient time to cause bud elongation. It is really a compromise in time and efficiency, sacrificing a well-callused graft union for reduced scion growth.

Spring nursery grafting of the Persian walnut (*Juglans regia* L.) has been improved, both by delaying the time of grafting until ambient air temperatures have increased and by tenting nursery rows to increase air temperatures by trapping solar radiation (4,8). In the Pacific Northwest, walnut nurserymen tie brown paper bags over the grafted scions to raise the temperature and promote callusing of the union (7,8). Unfortunately, both tenting and bagging accelerate not only callusing, but growth of the scion buds as well.

Over 50 years ago Sitton discovered that the optimum temperature for callusing black walnut grafts was 27°C (9). Filbert trees also have been shown to have a marked callusing response to temperature. Uniform sized wounds were made on potted trees which were then subjected to 16, 21, and 27°C. There was a 16% increase in callus growth as the temperature was increased from 16 to 21°C and a 67% increase in callus as temperatures of 16 and 27°C were compared (5). The conclusion reached in this study was that the optimum callusing for filbert trees exceeded 21°C. As a group, most temperate zone nut trees are difficult to graft with consistent success. This could be related to the possibility that their optimum temperature for callusing is higher than that of temperate zone fruit trees (6). For example, apples and pears have been reported to callus at 4.5°C (2,8). At such low temperatures, most nut tree grafts would exhibit very little callusing and chances for their survival would be minimal.

In an effort to improve the grafting success of dormant fruit and nut trees, a device for hot callusing has been developed (7). The device has been in operation for two seasons and used with a variety of plants.

METHODS AND MATERIALS

The basic member of the hot-callusing device is PVC pipe, 38 mm (1½″) inside diameter. Slots, varying in width from 7 to 10 mm were routed into the pipe, perpendicular to its length (Fig. 1). The pipe usually comes in 6.1 m (20′) lengths with each length accommodating about 240 slots. The grafted unions of trees are placed in the slots. The source of heat for the hot callusing device is a thermostatically controlled electric heating cable. The strands of the heating cable must be physically separated to prevent short circuiting. This is accomplished by taping them to a smaller 7 mm (½″) PVC pipe which is inserted into the larger slotted pipe (Fig. 2). This inner pipe has been filled with water and capped to provide better heat stabilization. The thermostat sensor is placed in one of the slots in the same position as one of the graft unions. The thermostat is usually able to maintain the temperature of the pipe at 24 to 28°C.

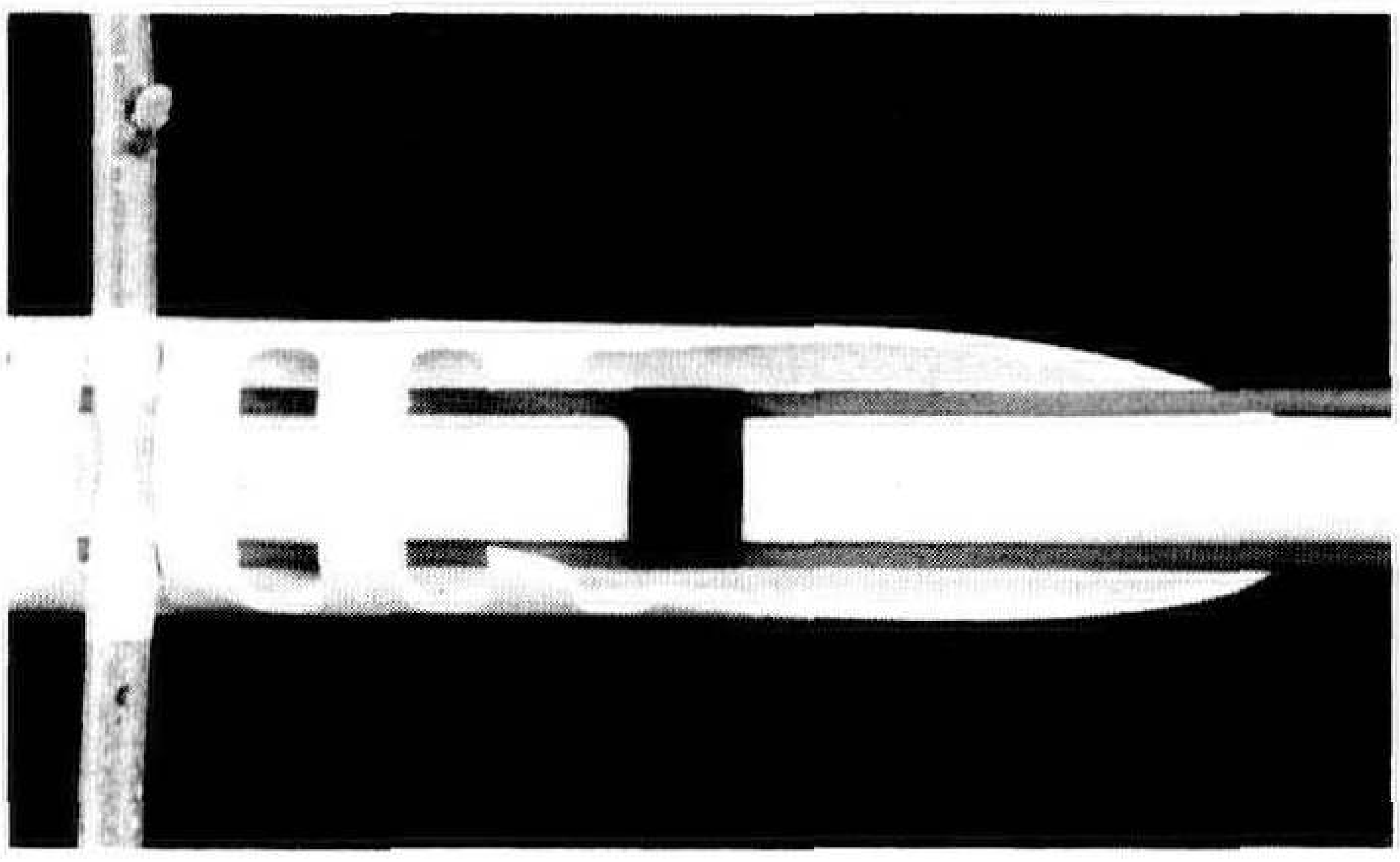

Figure 1. Top view of the hot-callusing device showing the slots routed across the outer PVC pipe and one graft union in place. A smaller, inner pipe can also be seen with the two strands of a heating cable taped to its sides.

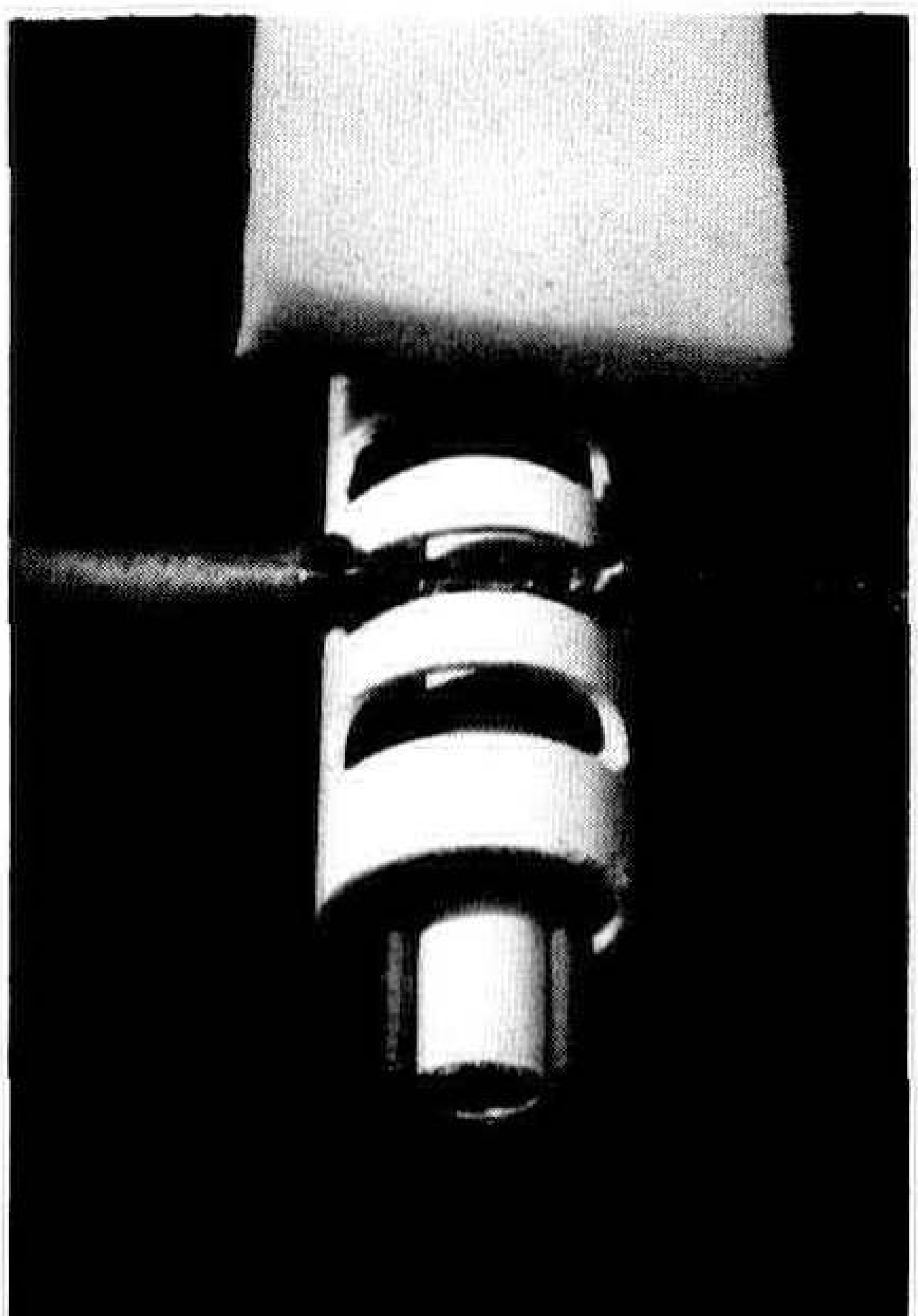

Figure 2. A cross section of the hot-callusing device with a graft union in place. The arrangement of inner and outer PVC pipes and the heating cables are shown. A strip of foam rubber is used on top of the graft unions and slots to retard heat loss.

With the grafted trees in place across the pipe, the scion buds will be exposed to ambient air temperatures and the root systems of the rootstocks can be heeled into sawdust. A strip of foam rubber 10 cm wide should be placed over the unions to retard the escape of heated air (Figure 2). Scrap lumber can be used to prevent the foam rubber from blowing off. The hot-callusing device can be located out-of-doors or in an unheated structure. The only requirement for the device is an electrical outlet for a source of electricity. The device has no moving parts. It is relatively simple to construct and simple to maintain.

In 1980 the device was tested from January to April with filbert trees only. In 1981, apple, pear, prune, peach and Douglas fir grafts were evaluated in addition to those of filbert. Also tested were different types of tying materials and several different types of grafts. Graft evaluations were always made during the summer, several months following planting.

RESULTS

An Omega grafting machine was used to graft the first trees to be placed on the hot-callusing device January 24 and February 4, 1980. The trees were hot callused 40 and 29 days, respectively, and planted directly to the nursery, March 4. Grafting success, evaluated during July, was 91 and 82%, respectively (Table 1). In a separate experiment, field grafts of the filbert were made comparing the hand-made whip and tongue graft to that made with the Omega machine. Twenty grafts of each type were made at bi-weekly intervals from May 13 to July 8. The whip and tongue grafts averaged 93% success as compared to 2% for the Omega grafts. The poor results with the latter were due to the relatively small area of tissue available for forming a union with the machine-made graft, and the use of the filbert as the test plant. Being slow to callus under outdoor conditions, the smaller cuts of the Omega graft became a limiting factor with the filbert. By contrast, when the hot-callusing device was used to heal the Omega-made unions, grafting success nearly equalled that of hand-made grafts. Though the area for union formation was small, the Omega grafts were completely callused (Fig. 3). When scion buds began growth, a translocation system was available to prevent scion déssication and death. This is the major advantage of the hot-callusing device in its use with difficult-to-graft trees.

A second 1980 grafting experiment produced 100% success for hot-callused trees as compared to 7% for those not so treated (Table 1). Another experiment, initiated April 3 as the

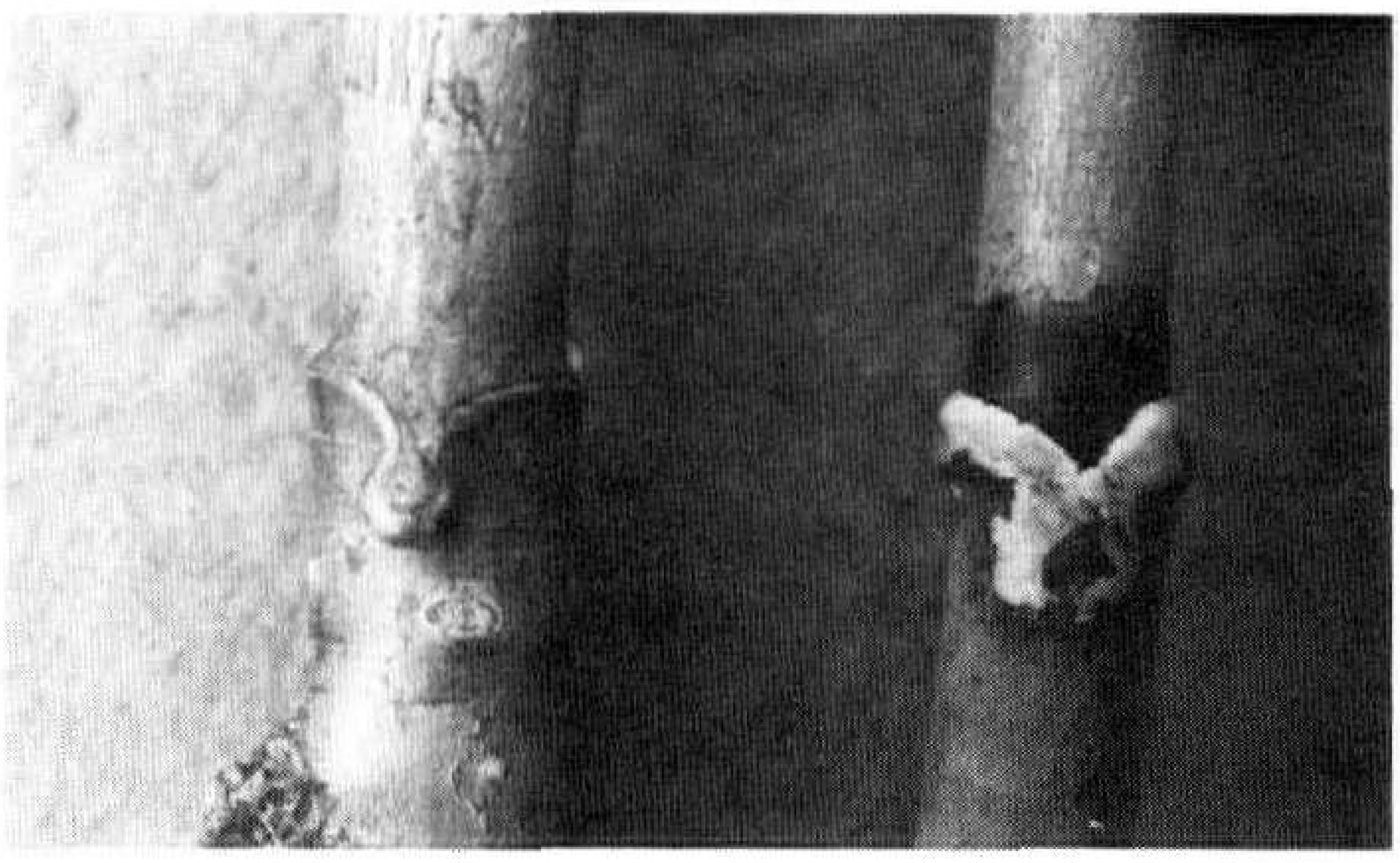

Figure 3. Two Omega-grafted filbert trees following 28 days on the hot-callusing device.

growing season was starting, yielded 77% success after only 14 days of hot callusing. At the time of planting, scion buds were enlarging, and transplanting conditions were less than ideal.

Table 1. Evaluation of Filbert Trees Grafted and Hot-Callused During 1980.

Date of Grafting	Date of Planting	Percentage Grafting Success
Jan. 24	Mar. 3	91
Feb. 4	Mar. 3	82
Feb. 29	Feb. 29*	7
Feb. 29	Mar. 28	100
Mar. 20	Apr. 17	96
Apr. 3	Apr. 17	77

* Trees were planted directly to nursery following grafting. These trees were not hot-callused.

After two seasons of experience, it has been noted that overall grafting success and subsequent tree growth is more dependent on root system quality and time of planing than it is on the hot callusing process per se. When graft unions are lifted from the hot callusing device, nearly 100% of them have a satisfactory union formed. Subsequent failure of the union was often found to be due to breakage of the delicate union during handling or planting. Failure of the tree was most often due to a poor root system, but also to late planting. The latter had a pronounced effect on tree growth. Growth analysis of an apple grafting trial, where 100% success was obtained regardless of the time of grafting or time of planting, shows that late-planted trees produced fewer lateral branches and less total stem growth than trees planted earlier (Table 2).

In 1981, the primary experiment involved a comparison between filbert and apple grafts. All trees were wedge-grafted by machine to reduce any variability that might occur from hand-grafting. Table 3 shows that all apple grafts grew regardless of treatment, but that only hot-callused filbert trees were successful. Relatively little or no callusing of filbert grafts

Table 2. Stem Growth of Grafted Apple Trees Planted from February Through April, 1981.

Treatment	Total Number* of New Stems	Total Cm Stem Length	Average Cm Stem Length
1. Not hot-callused, planted Feb 24 or 25	85[bc]	2181[a]	25 7[a]
2 Hot-callused 28 days, planted Mar 26	112[a]	2822[a]	25.2[a]
3 Not hot-callused, planted Mar. 26	86[bc]	2067[a]	24.0[a]
4. Hot-callused 28 days, planted Apr 14	66[c]	276[b]	4.2[b]
5. Not hot-callused, planted Apr. 14	73[bc]	489[b]	6.7[b]

* Values in a given column followed by different letters are significantly different from each other at the 5% level.

Table 3. 1981 Evaluation of Grafted, Hot-Callused Filbert and Apple Trees.

Treatment*	Percentage Grafting Success**	
	Filbert	Apple
1. Not hot-callused, planted out the same day as grafted.	0	100
2. Hot-callused 28 days, and planted out to the nursery.	94	100
3. Not hot-callused, plant out 28 days after grafted	3	100
4. Hot-callused 28 days and planted out in April.	91	100
5. Not hot-callused, planted out in April	0	100

* All apple trees were grafted Feb. 24 and filbert trees Feb. 25, 1981. Treatments 2 and 3 were planted in the nursery March 25. Treatments 4 and 5 were polanted to the nursery April 14. Treatments 3, 4, and 5 were heeled into sawdust, out-of-doors, until time of planting. Each treatment involved 35 grafted trees for each plant type.

** Grafting success evaluated in June, 1981. Filbert trees were 'Ennis' on 'Daviana ' Apple trees were 'Golden Delicious' on 'Malling-Merton 111.'

occurred at ambient air temperatures, resulting in only 1 of 105 grafts being successful.

To determine the universal use of the hot-callusing device for other fruit trees, several types were grafted during 1981. Hot-callused grafts of 'Bartlett' pear on Calleryana rootstocks averaged 76% success. In this instance a few losses were noted as being caused by direct contact between the heating cable and the graft unions. The strands of the cable were not adequately taped down and several loops of cable caused overheating of the union. 'Brooks' prune scions were grafted on both Myrobalan and *Prunus besseyi* rootstocks with an average of 73% success. The 'Sandoz' filbert was grafted to both 'Daviana' and 'Barcelona' rootstocks with 93 and 84% success, respectively.

Bare-root grafting of a conifer was also tried using Douglas-fir seedlings as rootstocks and CT-25, a Christmas tree selection, as the scion. The trees were veneer grafted, tied with rubber grafting bands and hot callused with the scion placed uppermost in the slot of the PVC pipe. Both large and small scions were used with the effect of needle removal being evaluated. There were no differences due to scion size or needle removal and overall grafting success was 84%. After hot callusing, the grafted trees were either field planted or potted and brought into the greenhouse. Of the latter, half were placed on a greenhouse bench and half were placed under mist. The misting promoted fungus growth on expanding buds of both the stock and scion, causing their death in nearly every instance.

DISCUSSION

The greatest benefit of the hot-callusing device lies in the quick formation of a callus union between scion and rootstock. As shown int he Omega machine grating trial, when conditions are less than ideal or plants difficult to propagate are used, hot callusing can serve as a means to successful propagation. With proper use of the hot-callusing device, the subject plant is essentially obliged to form callus in response to the localized heat stimulus. The uniqueness of the device lies in its ability to direct that heat to the graft union to the exclusion of other plant parts. In effect, it causes selective plant growth so as to provide greater control over the grafting process by the propagator.

While most hot-callused graft unions result in a union being formed, the process can not substitute for other factors that may limit success. Poor grafting technique, tying unions too tight or leaving gaps, poor quality scion wood, a lack of good root systems, rough handling, and late planting may each nullify the potential success of a properly hot-callused union. Most of the grafting losses observed following two seasons of hot callusing work were caused by either failure of the rootstock or late planting.

The greatest promise for the hot-callusing device is probably associated with plants that are difficult to propagate. With trees such as apple that have the ability to produce callus at low temperatures, the device may only offer limited benefit. As shown in Table 2, early planting of apple trees was more important to subsequent growth since all grafts callused regardless of temperature. However, the hot-callusing device could serve to permit earlier tree planting. Time of tree planting will have to vary with location. In western Oregon, where these trials were conducted, the mild winter climate permits planting trees directly to the nursery as they complete the hot-callusing process. When, this system is used in colder climates, other timing schedules or techniques would have to be implemented. Also, the slot size in the pipe may have to be made larger or smaller to better fit the size of the plant being propagated if different from those mentioned.

It appears that a wide variety of fruit, nut and ornamental plants can be propagated by use of the hot-callusing device. It is, of course, limited to those that can be grafted and is best suited to those where scionwood with long internodes can be produced. It is desirable to separate the scion buds as much as possible from the heat source. To do this, a 3- or 4-bud scion is used and the lower 1 or 2 buds are removed. Usually, 2 lateral stem buds are retained and they would be located farthest away from the pipe.

More trials need to be carried out with hot callusing bare root conifers. Conifer grafting usually involves potted, root-bound rootstocks. If bare root conifers such as the Colorado blue spruce could be propagated via the hot-callusing device, significant economic advantages might be realized. It was especially valuable to learn that needle removal had no detrimental effect on subsequent scion growth. With needles removed and only scion buds remaining, the conifer scion not only resembles the scion of a deciduous trees, but can be handled in much the same manner for propagation purposes.

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