7. Reduction of leaf area for large-leaf type plants is available — i.e. remove approximately half the leaf area.

8. Collection of cutting material should not be done in the heat of the day and the material should not be stored too wet.

9. For small-leaved plants harder wood, as used in semi-hardwood cuttings, is advisable — e.g. callistemons and fine-leaf grevilleas.

10. All cutting material should be clean and come from prepared parent plants and dipped in sodium hypochlorite, 1% solution, and washed in clear water.

11. Individual tubes for hard to strike plants is an advantage and allows more air and space around the cutting.

PROPAGATION OF DECIDUOUS TREES BY HARDWOOD CUTTINGS IN HEATED BINS

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Propagation of woody plants from hardwood cuttings planted directly into the field has been a traditional method of plant production; in fact it was probably the earliest method of cutting propagation. The number of plants which could be propagated in this way was limited and it was useful only for those plants which have a very high potential to form roots. Studies over the last 2 decades have changed the whole picture of propagation by winter cuttings. In general it has been shown that by using more sophisticated technology it is possible to produce a much wider range of plants in this way than was previously the case. In particular it has been demonstrated that suitable cuttings of most deciduous woody plants, given the correct treatment, will generally root in the so-called "winter period". Much of this work has been carried out with fruit tree rootstocks, but similar techniques are now being applied to many ornamental plants as well, and this will no doubt become more important over the years to come.

It is important to point out that this type of propagation requires a rather more sophisticated approach than the traditional one; there is much less room for error. Having said that, I would stress that it does not require anything which is beyond the resources of the competent propagator. Most of the

problems which have been brought to our notice have come about through neglect of basic principles, often in a desire to cut corners. It is, therefore, these basic principles that I wish to stress.

Cutting Selection. It is important to have stock plants which show juvenile characteristics as a source of cutting material. This is generally achieved by a regular programme of heavy pruning each year. Cuttings from an area of the trunk close to the roots generally have the highest potential to root; unfortunately this reduces the number of cuttings which can be secured from a mother plant. East Malling Research Station has developed techniques for producing cuttings of apple and other species on hedges, which is a compromise between the ideal cutting and a reasonable number of cuttings per plant. We are looking at using a similar system with ornamentals. Setting up suitable mother plants takes several years; this could probably be shortened if juvenile material could be secured initially from a central source.

Timing. There are normally two periods at which cuttings of deciduous plants have a high potential to form roots:

(1). About the time of leaf fall in autumn or early winter, usually late April to early May in New Zealand.

(2). About 3 to 4 weeks before bud burst in spring. Since there is little yearly variation in the time of bud burst, selecting an appropriate time to select "spring" cuttings is less difficult than it might at first appear. This function of timing is linked to levels of growth regulator activity in the shoots, particularly to levels of IAA and certain phenolic co-factors (3,4,6). Between the "autumn" and "spring" flushes of these constituents their levels may be quite low and cuttings may have a very low potential to form roots.

Cutting Selection. Thicker, rather than thinner shoots appear to give the best results; this is almost certainly related to the quantity of carbohydrate reserves in the thicker cuttings. As a general guide, the base of the cutting should include the base of the shoot, usually the swollen basal area if possible. There are however, apparent exceptions; some liquidambers and magnolias appear to give best results when the apical end of the shoot is used. Setting up trials for a new species or cultivar should, therefore, include both basal and apical cuttings.

Preparation of the Cuttings. Greater care is needed in the preparation of these cuttings than is done with conventional winter cuttings. The base should be cut cleanly with a sharp knife. Where only the basal part of the shoot is to be used the shoots can be much longer than would normally be required.

This type of cutting can be much longer than we would normally use; at East Malling they generally use 60 cm cuttings for rootstocks. We have tried 60 cm cuttings of maples with good results. I believe that, in part, this may be due to the larger total storage of carbohydrate. Wounding is invariably of assistance in stimulating root formation. We have normally used the simple side wound, removing a slice of bark, and have found that double wounding can produce a two-sided root system, which leads to greater tree stability (1,2). Howard (5) found for the M 26 apple rootstock a 2 cm split in the stem is superior to the conventional side wound. Clearly this is an area worthy of further investigation.

Treatment with IBA can usually enhance root initiation, although excessive concentrations may inhibit root development. Liquid formulations, using a standardised quick-dip treatment, have generally given best results. Concentrations ranging from 1,000 to 5,000 ppm have been used, but obviously the optimum concentration needs to be determined for each individual situation.

Cutting Environment. This is one of the most critical areas of the operation. Generally difficult-to-root cuttings require a period of relatively warm temperature at the base to initiate roots. It is not desirable to have roots emerge at this stage, so the period of warm temperature treatment is relatively short, usually abut 21 days at 20°C. During this time the cutting needs a copious supply of oxygen at the base, and an adequate supply of water which can be absorbed if required. This is generally achieved, overseas, by using relatively deep bins, often about 30 cm deep, containing a peat/grit mixture, with a heating element. The thermostat that controls the heating is located about 15 cm below the medium surface. The bin is well insulated to give constant temperature in the rooting medium; the depth of medium ensures good drainage and hence aeration at the base of the cutting. The cuttings are planted 10 to 15 cm deep, very close together, since roots will not be developed at this stage. Air temperatures are kept cool, to discourage bud burst, probably an over-all temperature of less than 5°C would be desirable. There is a need to avoid low humidity, since this type of cutting can lose water through cuticular transpiration. There may be some problems in securing these conditions, at least in some areas of New Zealand, and we are currently studying the effect of air temperature control by various means. After the period of warm temperature storage the cuttings are removed from the heated bin and held in polythene bags in cool stores until ready for planting.

After planting, bud burst will occur with the onset of rising temperatures and this should be accompanied by root emergence.

It may seem paradoxical that the aim is not to secure root emergence while the cuttings are in the heated bin, but there is a very good reason for this. Deciduous hardwood cuttings must exist on the store of carbohydrates as well as stored minerals. The warm temperatures at the base increase respiration in the cutting, hence reducing the store of carbohydrates. If roots emerge their growth further depletes the store of carbohydrates; if the roots are damaged during transplanting, there may not be sufficient carbohydrate available for both regrowth of the roots and the development of new leaves at bud burst. Failure to remove the cuttings from storage in heated conditions usually results in root emergence, followed by root death, and then death of the cutting. The symptoms are often mistaken for attacks of root decaying pathogens and lead to ineffective measures to combat the non-existent micro-organisms.

In cutting selection I draw attention to the need to have cuttings with a large reserve of stored carbohydrate. The control of the environment around the cutting needs to consist of the minimum amount of heated storage to initiate roots, followed by cool storage to conserve the remaining carbohydrate reserves until conditions are right for bud burst and root emergence.

While this is a desirable objective errors do occur, particularly with spring cuttings, where bud burst may occur before the completion of heated storage. At the New Zealand Nursery Research Center we have found a useful technique is to plant cuttings fairly thickly in containers of medium, which are then stood on a heated bed. If bud burst occurs during the period of heated storage the cuttings are left undisturbed when the temperature is reduced, until each has several leaves actively photosynthesising. At this stage the cuttings can be potted without serious risk of loss due to carbohydrate depletion.

Much of the technology currently being used at NZNRC is based upon the technology used so successfully in Britain, particularly at East Malling Research Station. With the passing of time propagators in New Zealand will no doubt develop individual techniques to suit their particular conditions. I hope that the principles which I have outlined will be of some assistance to you in that process of development.

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BULBS FOR THE FUTURE

TERRY HATCH

Joy Plants

R.D. No. 2, Pukekohe East

Much work has been done collecting and growing bulbs, corms, and tubers of all kinds. The work of raising hybrids from these plants in many cases has progressed slowly and much material has been lost over the years. Hybrids of the smaller scented species gladiolus are a case in point.

Raising hybrids of these types of plant takes many years as each generation may require 4 to 12 years to flower from seeds. Many of the bulb breeders I have met are in the older age bracket, 70 years or more, and many of them are amateurs; much of their work never gets into circulation and disappears when they pass on.

As this is such a vast subject, I shall discuss just two plants that have been studied and are now at the point of commercial production with the advent of micropropagation.

ZANTEDESCHIA SPECIES AND HYBRIDS (CALLA)

These now come in many colours — reds, violets, pinks, yellows, and all shades in between. There is still much opportunity for breeding, however, and following are some specifications for selection:-