b) Flexibility was needed in the control of the misting and weather conditions had to be watched at all times.

c) Cuttings were more successfully rooted when taken from young trees — up to 5 years old.

d) The time of greatest danger was in the weaning process, where the cuttings must be subjected to only one shock at a time.

It should be emphasised that we are orchardists rather than nurserymen and this system of propagation was used to propagate cheap, healthy trees for our own use because of our particular requirements.

It has been successful because:

a) Large quantities of stock were available close to the propagation centre.

b) Trees were being produced on their own roots at a reduced cost.

c) The method was relatively simple and did not require expensive equipment or great expertise.

PREPARATION AND USE OF LIQUID ROOTING HORMONES

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The auxin group of plant hormones were identified in the 1930's. By the late 1940's they had shown activity in a number of different horticultural applications, including the rooting of cuttings. The discovery that basal application of auxins to cuttings improved their strike rate had a major impact on commercial nursery practice, greatly increasing the range of plants which could be propagated by cuttings..

A number of naturally occurring and synthetic auxins have been used to induce the rooting of cuttings but only two are in common use. These are indole-3-butyric acid (IBA) and 1-naphthaleneacetic acid (NAA). Rooting hormones are generally applied to cuttings as either powders, using talc as a carrier, or in solution. Hartmann and Kester (4) offer some arguments in favour of the use of hormone solutions.

Early experiments with hormone solutions used relatively dilute solutions (0 to 200 mg/litre), in which the cuttings were soaked for periods up to 24 hours. This technique has largely

been replaced by the quick-dip method where more concentrated solutions (500 to 10,000 mg/l) are used. Higher concentrations than these have been successfully used on difficult-to-root plants. Chong (1) describes the use of IBA solutions of 40,000 mg/l. Howard (5) suggests that for the quick-dip technique, a shallow 5 second dip is adequate.

Purchase and Storage of Hormones. If you wish to prepare your own rooting hormone solutions and be able to prepare the largest range of working concentrations, then purchasing the pure forms of IBA and NAA will be the most satisfactory. Most suppliers of laboratory chemicals carry a range of auxins.

In the solid form both IBA and NAA are relatively stable but IBA is best stored at temperatures between 0 and 5°C. NAA is quite stable at room temperature (3).

Preparation of Stock Solutions. In order to have the maximum flexibility in the preparation of rooting hormone solutions, prepare concentrated stock solutions of each hormone you intend using. These stock solutions can then be diluted to working strength concentrations as required. The stock solution will have to be more concentrated than the strongest working strength solution you are likely to need. As a guideline, a suitable stock solution concentration would lie between 10,000 and 20,000 mg/l. The procedure for preparing a stock solution is as follows.

a) Calculate mass of hormone needed; e.g. to prepare 500 ml of 20,000 mg/l IBA you will need 10,000 mg IBA (10 g).
b) Weigh out the hormone crystals. If you do not have access to accurate balances your local pharmacist may be willing to assist.
c) Dissolve the crystals in 50% (v/v) alcohol. The auxins are only very slightly soluble in water and alcohol can be used as a solvent. Methylated spirits is also suitable (7). For the preparation of stock solutions more concentrated than 20,000 mg/l you may need to use 95% (v/v) alcohol as the solvent to prevent the hormone from precipitating out at low storage temperatures (1).

In recent years, some attempts have been made to find better solvents than alcohol for rooting compounds. Interest has particularly focused on solvents which might give better hormone penetration of stem tissue. Products have been marketed in the U.S.A. using dimethyl sulfoxone (3) and dimethyl formamide (9) as solvents.

Storage of Stock Solutions. In concentrated solutions both IBA and NAA will be stable but storing them in brown glass

bottles in a refrigerator or some other cool area is a worthwhile precaution (2).

Preparation of Working Solutions. Once stock solutions have been made up, the preparation of working strength solutions is relatively simple. If you are intending to prepare slow-dip solutions (0 to 200 mg/l) then stock solutions can be diluted using water. For quick-dip solutions (500 to 10,000 mg/l), 50% (v/v) alcohol is used as the dilutent (4).

To calculate the amount (ml) of stock solution required you will need to know the concentration of the stock solution (mg/l), the concentration of the working solution you wish to prepare (mg/l), and the volume (ml) of working solution you intend to prepare.

Fit these values into the following formulas:

$$\text{volume of stock solution} = \frac{\text{volume of working solution (ml)} \times \text{concentration of working solution (mg/l)}}{\text{concentration of stock solution (mg/l)}}$$

$$\text{volume dilutent needed} = \text{total volume of working solution} - \text{volume of stock solution}$$

A working example is given below:

Concentration of stock solution: 20,000 mg IBA/l

Concentration of working solution to be prepared: 5,000 mg IBA/l

Volume of working solution to be prepared: 100 ml

$$\text{Volume of stock solution needed} = 100 \times \frac{5{,}000}{20{,}000} = 25 \text{ ml}$$

Volume of dilutent (50% alcohol) needed = 100 −25 ml
= 75 ml

IBA/NAA Combinations. If you wish to make up working solutions containing two or more active components, for instance IBA and NAA combinations, then the rules to follow are essentially the same. First, calculate the volume of each hormone stock solution needed to give the correct hormone concentrations in the working solution. Use exactly the same formula as given for single hormone solutions. Then, to calculate the volume of dilutent required, add together the two stock solution volumes and subtract this total volume from the volume of working solution you wish to prepare. A worked example is given below:

Stock solutions: 10,000 mg IBA/l
8,000 mg NAA/l
Working solution to be prepared: 1,000 mg IBA and
500 mg NAA/l
Volume of working solution to be prepared: 250 ml
Volume of IBA stock solution required = $\frac{250 \times 1{,}000}{10{,}000}$
= 25 ml
Volume of NAA stock solution required = $\frac{250 \times 500}{8{,}000}$
= 15.6 ml
Total stock solution volume = 40.6 ml
Volume 50% alcohol required = 250 — 40.6 ml
= 209.4 ml

A point worth remembering here is that where IBA/NAA combinations are being prepared, your stock solution concentrations may need to be higher. Stock solutions of 20,000 mg/l of hormone will allow you to make working solutions up to 10,000 mg/litre, which will cover most requirements.

Use of Hormone Solutions. Soak solutions, because they are dilute, are likely to be unstable and can become ineffective after a few days due to microbial destruction of the hormones (4). Because these solutions are made up in water they can also spread pathogens if hygiene is not good (6). However, the 50% alcohol used to dilute the quick-dip solutions will kill microbial contaminants and thus quick dip solutions are more stable and do not present the same potential for spreading disease (4). Use of quick-dip solutions in very hot weather may result in increased hormone concentration through loss of solvent but, with IBA at least, there is a reasonable tolerance of plant response to auxin concentration (3).

If the propagator wishes to use a fungicide treatment of the cutting in addition to the auxin treatment, cuttings are best dipped in the fungicide as a separate treatment after the auxin has dried (4).

A quick check for the activity of auxin preparations can be made using leaves of tomato as a bioassay material (4).

Safety. As with the use of any chemical, some caution should be exercised when handling preparations of potentially toxic materials. In one sense the liquid preparations of auxins are safer to use than powders because the risk of inhaling dust is reduced, but when we look at available toxicological data the risks do not appear to be great. NAA, for instance, has an acute oral LD50 for rats of 1000 mg/kg body weight (8). Extrapolating this data to the human, an assumption that is not

entirely valid, a 75 kg propagator would need to ingest something of the order of 75 gm of NAA to reach this dose. Made up as a 1000 mg/l solution he or she would have to drink 75 litres of solution. The rooting hormones deserve to be treated with respect but seem not to present any great danger to the careful user.

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SOME PRINCIPLES OF GRAFTING FOR THE PRODUCTION OF WEEPING TREES

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Plants may be grafted in a multitude of ways for many different reasons, but grafting is usually employed for one of the following reasons:

a) To propagate plants which are difficult to propagate by cuttings;

b) To join plants, the roots or shoots of each being selected for special purposes such as disease resistance and/or adaptability to special conditions such as soil or climate;

c) To invigorate weak plants, or repair damage;

d) To allow one root system to support more than one cultivar;