Because the sand was deleted completely we had removed all of the abrasive material, stabilised the pH and taken the weight load from working personnel, resulting in greater expediency in the production area. With the advent of polystyrene-foam trays, a box of seedlings has reduced in weight from 5kg to 1kg. For long distance freighting, wooden crates have been substituted with waxed cartons, further reducing labour and freight costs.

With the introduction of various type cell packs and mini punnets I believe that a deal of scope is evident for bedding plant growers to propagate many seed lines for the container growers. There is evidence overseas of bedding plant growers producing started plants of cyclamen, F_1 geraniums, begonias, asparagus ferns and similar plants at attractive prices, in keeping with their mass production and seed raising facilities. Plants could be raised on a contract basis incorporating a forward ordering system. My own nursery operates this system in a limited way.

CAPILLARY WATERING OF CONTAINER-GROWN PLANTS

M. RICHARDS

Massey University
Palmerston North, New Zealand

The importance of using the best possible techniques for watering plants is not always recognised in commercial nurseries, largely because plants have a very considerable ability to survive less than ideal conditions, without showing visible signs of the effects of those conditions. It is only when such plants are compared with plants grown under better conditions that the full effects of poor watering techniques can be appreciated.

Plants use very large quantities of water for growth, yet comparatively little of this water is retained in the plant. In the lower surface of the leaves are the stomata; during daylight hours these are open to permit air to enter the leaf. Inside the leaf the air comes into contact with cells whose walls are bathed with water; carbon-dioxide is absorbed into this water, and passes into the cells, where it is used in photosynthesis. At the same time, water is evaporated from the cell wall and carried outside the leaf in the air current. This process, called transpiration, is an essential part of the uptake of CO_2 by the plant, but it results in a steady loss of water from the plant.

Normally the water lost from the leaves by transpiration is replaced with water which is taken up by the roots. Provided

that the roots can absorb all of the water which is being, or could be, lost by transpiration, all is well. If, however, the roots are unable to supply all the water which could be transpired by the leaves several things happen; the cell walls become less wet, less CO_2 can be absorbed, the rate of photosynthesis slows down and the rate of growth of the plant is reduced. This reduction in growth cannot be detected by any visible signs.

If the rate of water uptake by the roots is further reduced other changes start to occur. The stomata close and the plants start to show signs of visible water stress, such as changes in colour, slight loss of turgidity, etc. and observant growers will apply water. By this time it is too late to maintain maximum growth.

In the container, roots may encounter problems in absorbing water. Water in the growing medium exists as a film in and on the particles of the medium, held there by tension. As the amount of water present in the medium is reduced, the tension by which is is held increases, so that it becomes increasingly difficult for the plant to secure all of the water which it could use.

The work of the roots is further complicated by the presence of substances dissolved in the water. These dissolved substances, including nutrients, create further pressure (osmotic pressure) against which the plant must work to absorb moisture. If we are to provide the high levels of nutrients which the plant can use we must be especially careful that they do not restrict growth by restricting water supply to the plant. The only way in which this can be done is to ensure that there is a large quantity of water present in the root zone to maintain a dilute solution of nutrients.

We must also bear in mind that the roots generally extract water from the root zone more rapidly than they extract nutrients, therefore as water is taken from the growing medium the salt solution becomes more concentrated creating artificial drought.

Bearing these points in mind, the best technique for watering plants can be very easily described. Provide a growing medium with a high water holding capacity. After potting, water the medium until it is holding all of the water it can retail against drainage i.e. it is at container capacity. From then on, as one drop of water is removed by the plant, it should be replaced, so that the medium is maintained at container capacity all of the time.

Capillary watering provides the most practical means by which this can be done. Basically it consists of standing the containers onto a material which provides a reservoir of water.

Under glasshouse conditions, this generally consists of an unsealed bench, on top of which is placed a layer of felt. The felt is kept wet by application of water once or twice a day.

The plants are watered when they are stood upon the felt, this establishes a column of water from the growing medium into the felt. As tension is increased on the water in the growing medium, water is drawn from the felt into the medium to maintain container capacity.

Outdoors, beds of fine sand, over plastic film, have been used to achieve the same results. The sand must be a type which can hold enough water to supply the plants.

Provided the benches or sand beds are not sealed, water can be applied easily without sophisticated controls. We use a time clock to operate a solenoid valve and apply water for 20 minutes, night and morning in summer, once per day in winter. Any excess, above what the reservoir will hold, simply drains away.

When using capillary watering it must be remembered that the normal water flow is reversed so that there can be a build up of salts in the container. To overcome this problem, we water from above the container once per week, using enough water to flush any build up of salts out of the container.

Capillary watering has been shown to give considerable increases in growth when compared with conventional watering techniques. Many nurserymen remain convinced that their existing watering techniques are perfectly adequate. If you are in this group, perhaps you owe it to yourself to try capillary watering on a small area of your nursery.

CLONAL PROPAGATION OF WOODY PLANTS USING TISSUE CULTURE, WITH SPECIAL REFERENCE TO APPLES

J.A. McCOMB

School of Environmental and Life Sciences
Murdoch University
Murdoch, Western Australia 6153

Abstract. A critical review of the published papers on plantlet regeneration of woody species shows that very few reported systems are ideal for clonal propagation. Some depend on use of embryonic, juvenile and endosperm tissues, or on tissues such as the nucellus of *Citrus* that show unusual properties. In others plantlets regenerated from callus have poor vascular connection between roots and shoots and die on transplanting to pots.

Culture methods that induce multiple shoot production from excised shoot tips or axillary buds, and the subsequent rooting of these shoots without the involvement of excessive callus offer greatest potential. One such