HEAT THERAPY: METHOD AND APPLICATION TO CONTROL PLANT VIRUSES

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Viruses multiply within the cells of plants and may be found in all the vegetative tissues. Seed transmission, which occurs with some viruses, is the exception rather than the rule, but all vegetative parts of plants used for propagation may contain virus and give rise to infected progeny. Many cultivars of plants such as fruit trees, berry fruit, grapes, carnations, chrysanthemums, and bulbs, have become extensively infected with one or more viruses because infected parent plants have been used as a source of propagating material. Further infection has occurred by the working of healthy cultivars on to diseased rootstocks or by top-working of orchard trees.

Intensive investigations into virus diseases of pip and stone fruit trees in New Zealand commenced about 20 years ago. In early investigations, work centred around diseases which were readily apparent in the orchard such as mosaic, green crinkle and ring spot of apple, stony pit of pear, and line pattern (formally mosaic) of plum. In later years, reports from other countries suggested that pip and stone fruit trees could be carrying a number of virus diseases in a latent form. These diseases were detectable by the use of special indicator species and cultivars, or by the mechanical inoculation to herbaceous hosts in the glasshouse. An extensive indexing programme made by Plant Diseases Division showed that there was a high incidence of these diseases in New Zealand trees, particularly in apples and sweet cherries. It seems likely that almost all apples and sweet cherry trees grown in New Zealand are infected with a number of virus diseases. Pears, plums and apricots are infected to a slightly lesser extent, and only a small incidence of infection has been found in peaches and nectarines. Clonal rootstocks, particularly those which have been used in New Zealand for many years, are extensively infected.

Because of the extent of infection found in New Zealand trees, control measures for the virus diseases were required. Pioneer work in North America by Kunkel in 1935 showed that some virus diseases could be eliminated from peach trees by growing the trees for a period of time in a high temperature environment.

These methods were therefore adopted to try to eliminate the virus diseases present in pip and stone fruit trees in New Zealand. Several methods were used in early work such as dipping scion-wood in hot water for short periods or by the longer term process

of growing plants in a high temperature cabinet for periods of approximately 28 days. Some success was achieved with these methods in eliminating diseases such as apple mosaic, *Prunus* necrotic ringspot and plum line pattern. However, these methods were not successful with most other diseases. Accordingly, a method first developed in England in 1962 by Campbell was adopted and this has proved to be the most successful procedure for virus elimination from both pip and stone fruit.

The present heat treatment of pip and stone fruit at Plant Diseases Division is carried out in a heat treatment room, which has been converted from an existing glasshouse unit. Internal dimensions of this room are 4 m long, 2.5 m wide and 2 m high. Walls of the room are insulated and painted white for light reflection. Triple layers of glass in the roof provide further insulation but allow natural daylight penetration. Mercury vapour lights boost natural light on dull days and continue through most of the night. Humidity of the room is kept at about 60%, and the CO_2 content of the room is slightly increased during daylight hours. Potted plants for heat treatment are placed in metal trays on slotted wooden benches 75 cm above floor level.

Clay pots have been found to be more successful than plastic pots for heat treatment. A potting mixture composed of equal quantities of peat and fine sand with added lime and nutrients is used. Plants with a well established root system have been found to withstand the heat treatment temperatures best. Potted seedlings are therefore budded with the cultivar to be treated in the season prior to heat treatment, and the root system of the potted plant left undisturbed in the intervening winter.

When growth commences in spring, the potted plants are brought into a cool glasshouse for a short period before being transferred to the heat treatment room where they are maintained at a temperature of 32°C for 7 to 15 days. Extension growth during this 32°C period is rapid and carries through into the final heat treatment period at 38°C. The treatment temperature of 38°C has been selected as it is close to the temperature limit at which pip and stone fruit will survive without heat damage. Even so, heat damage usually occurs after about 21 days and tip grafts are usually taken prior to this. Plants near to collapse at the termination of the 38° period recover quickly once the temperature is returned to 32°C and rapid extension growth is again made. Thus it is possible to give selected plants several alternating 32°C and 38°C heat treatment periods during the season and this has proved to be an effective method of eliminating some of the more difficult viruses.

Tips 1 to 2 cm long cut from extension growth at the termination of the 38°C period are grafted without delay to potted seedlings of their respective species. A simple wedge graft is made,

where possible at a node on the seedling, as this appears to provide more stimulus for union. Best results are obtained when both the tip and the seedling stem are of just sufficient maturity for the tip to be held firmly in place without falling out. Medical adhesive plaster has been found the most effective material for holding the graft in place till union is achieved. A strip 1.3 cm wide and 4 cm long is folded partially back on itself, slid around the graft union and gently firmed in place, care being taken that the union is not forced apart.

After grafting, the shoots are covered by a plastic bag supported in such a way that the plastic does not touch the grafted tip. The bag is left partially open at the base for aeration and to avoid the high humidity which favours fungal infection, particularly *Botrytis*. The bag is removed when new growth develops from the tip, indicating that the graft union has been successful.

Tip-grafted plants are kept in a cool glasshouse for 4 to 6 weeks and then placed outdoors. At this point there is no way of determining if the tip-grafted plant is completely free from virus infection and it is necessary to test the plant with both herbaceous indicators in the glasshouse and woody indicators in the nursery. The nursery indicators are normally grown and observed for 3 years before it can be certain virus elimination has been successful. Heat treatment is thus a 6 year process. When the cultivars are considered to be free from known viruses, propagation material is released to the commercial trade.

This method of heat treatment plus tip grafting has proved successful in the elimination of most virus diseases found in pip and stone fruit trees in New Zealand. Similar methods are used to heat treat grape vines, although the heat treatment period is longer and the tips taken from treated vines are established on their own roots, rather than being tip-grafted to other vines. As all vegetatively-propagated plants may be carriers of virus diseases it is probable that these heat treatment methods could be successfully used with a number of other species.

The advantages of using pip and stone fruit propagation material free from virus diseases include improved growth and fruit yield, the elimination of some stock-scion incompatibilities and a possible improvement in fruit quality. Fruit from grapevines propagated from free-from-known-virus material are earlier ripening than those from diseased vines; the fruit has a higher sugar content and the colour of red wines is improved.