

cuttings are inserted, they are given a good watering—almost to flooding the plants—with a hosepipe and fine rose nozzle. The frames are covered with shading material and, during the initial stages, light is given only during the early morning and late evening.

When the cuttings start to callus (around six weeks) the second covering of polythene is removed and the bottom heat reduced to around 60° F., also some air is given during the early morning and evening. Supplementary light is given from mid-July to early October for three hours per day. The bottom heat is further reduced and completely turned off during the winter. Hand watering is carried out twice daily as required. Any aphid problems are solved with *Metasystox*.

During the spring the plants begin to grow and will give a batch of early cuttings in late May. If the bottom heat is turned on these cuttings can be rooted very early. After these first cuttings are removed we allow the plants to grow again prior to planting them into well-prepared frames during July, at about 9" spacing. Second year plants can be sold or containered and usually make 18 inch selected plants in the third year

## THE DISTRIBUTION OF VIRUSES IN ORNAMENTAL MALUS AND THEIR EFFECT ON GROWTH

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Many nursery catalogues list between 10 and 20 ornamental *Malus* species, and with the introduction of new cultivars, usually from America or Holland, the popularity of this group of trees seems to be increasing

Few other ornamental shrubs or trees have such valuable attributes and, although ornamental *Malus* are primarily grown for their spring flowers, many are attractive at other times of the year. Some, for example *Malus x. purpurea* 'Lemoinei' and *M. tschonoskii*, have interesting coloured foliage throughout the summer, while others have highly coloured fruit and foliage in the autumn.

The trees are usually sold after 3 or 4 years in the nursery as standards or half-standards. Seedling crab rootstocks are commonly used because propagation difficulties have increased when clonal rootstocks are used. The problems have taken the form of bud failures with some cultivars, while in others the growth rate has been unsatisfactory and dieback has been common.

One of the main factors causing these difficulties has been shown to be viruses in the propagating material. The same viruses are

common in most dessert and culinary apples and in many of the older series of clonal rootstocks where they usually show no disease symptoms.

Experiments have been in progress at Long Ashton since 1967 to examine the propagating material being used in the nurseries and to improve it where necessary.

## VIRUS DISTRIBUTION IN NURSERIES

Budwood of 21 *Malus* cultivars was obtained from six of the leading nurseries in the summer of 1968. The material was virus tested on seedling apple rootstocks using the double budding technique commonly used for fruit trees. The virus indicators used and the viruses they show are as follows:

Sensitive indicators	Virus disease
Lord Lambourne	Mosaic, rubbery wood and chat fruit
Russian R12740-7A	Chlorotic leaf spot
Spy 227	Epinasty and decline
Virginia Crab	Stem pitting and stem grooving
<i>Malus platycarpa</i>	Chlorotic leaf spot and scaly bark

It can be seen (Table 1) that virus infections were common and that trees from many sources were infected with more than one virus (Bottom figure shows number of sources tested, top figure number infected). In general, the green-leaved cultivars were more virus tolerant but, although they looked more healthy, they were often carrying several viruses. The red-leaved cultivars, by contrast, were often virus sensitive and, since infected trees often died, budwood was only available from healthy sources.

The budwood obtained from some nurseries was considerably better than that from others and, in several instances, virus-free selections were found. The virus incidence in 65 sources of 21 cultivars was as follows:

Virus	No. of Infected Sources
Mosaic	0
Rubbery wood	1
Chat fruit	0
Chlorotic leaf spot	18
Epinasty and decline	24
Stem pitting	17
Stem grooving	3
Scaly bark	5

No evidence was seen that apple mosaic or chat fruit viruses were present in any of the material tested and subsequent experiments have shown that none of the sources were likely to have been infected with star crack virus.

Table 1. Virus infections found in various ornamental *Malus* plants obtained from different sources.

Ornamental Malus	Virus Indicators				
	Lord Lambourne	Russian R12740-7A	Spy 227	Virginia Crab	Malus platycarpa
'Aldenhamensis'	0 / 6 *	1 / 6	1 / 6	1 / 6	1 / 6
'Dartmouth Crab'	1 / 1	1 / 1	1 / 1	1 / 1	0 / 1
'Eleyi'	0 / 1	0 / 3	0 / 3	0 / 3	0 / 3
'Exzellenz Thiel'	0 / 1	1 / 1	1 / 1	1 / 1	0 / 1
<i>floribunda</i>	0 / 5	2 / 5	5 / 5	1 / 5	0 / 5
'Golden Hornet'	0 / 5	0 / 5	0 / 5	0 / 5	0 / 5
'Hillier'	0 / 3	3 / 3	3 / 3	3 / 3	3 / 3
'John Downie'	0 / 5	1 / 5	3 / 5	2 / 5	0 / 5
'Lemoinei'	0 / 4	0 / 4	0 / 4	0 / 4	0 / 4
<i>magdeburgensis</i>	1 / 6	3 / 6	4 / 6	4 / 6	2 / 6
<i>prunifolia</i>	0 / 2	2 / 2	2 / 2	2 / 2	0 / 2
'Profusion'	0 / 5	1 / 5	1 / 5	1 / 5	0 / 5
<i>purpurea</i>	0 / 5	1 / 5	1 / 5	1 / 5	0 / 5
<i>sargentii</i>	0 / 4	0 / 4	0 / 4	0 / 4	0 / 4
<i>tschonoskii</i>	0 / 6	2 / 6	2 / 6	0 / 6	0 / 6

Others tested: —

*arnoldiana*, *hupehensis* 'Rosea', 'Gibbs' Golden Gage', 'Wisley Crab', 'Simcoe' and *robusta*.

(One source of each tested and found to be free from infection)

\* First figure —no. of sources infected  
Second figure—no. of sources tested

## VIRUS DISTRIBUTION IN OLDER TREES

In order to test the virus infection level in twenty-year-old trees of ornamental *Malus*, two museum collections were examined in the same way as the nursery sources. The results indicated that more than half of the trees were infected, usually with chlorotic leaf spot and stem pitting viruses, either in combination or singly. No evidence was



found that any of the other viruses were present. The results also suggest that little spread of these diseases occurs after planting and that nearly all the distribution is through the use of infected scions or rootstocks. Similar results have been obtained with this group of viruses in dessert apples and the vectors, if they occur, are either very uncommon or inefficient.

Experiments have shown that these viruses are not transmitted through the seed, therefore the use of seedling rootstocks for ornamental *Malus* has helped to prevent a wider distribution of the diseases. If infected clonal rootstocks had been widely used the virus distribution would have been at a higher level.

## VIRUS SENSITIVITY

The sensitivity of 12 *Malus* species and cultivars to 9 different known virus infections was examined by inserting an inoculation bud into 4 trees of each *Malus* species. The effect of the inoculation, as

Table 2. The sensitivity of twelve *Malus* species and cultivars to nine pome fruit viruses.

Ornamental <i>Malus</i>	† Virus Sensitivity								
	AM	RW	EDV	CLSV	SPV	VY	QSV	QSRV	RPM
'Cowichan'	VS	VS	S	VS	VS	T	S	T	T
<i>floribunda</i>	S	S	VS	T	S	S	T	T	T
<i>glaucescens</i>	S	VS	VS	S	S	S	S	S	S
'Hopa'	S	S	T	S	S	T	T	T	S
<i>hupehensis</i>	S	T	T	S	S	T	T	T	T
'Lemoine'	VS	VS	S	S	VS	T	T	T	S
<i>prunifolia</i> 'Rinki'	T	T	VS	S	T	T	T	T	T
'Purple Wave'	VS	VS	VS	VS	VS	T	T	T	S
'Robert's Crab'	VS	VS	S	S	VS	S	T	T	S
<i>sargentii</i>	VS	S	VS	S	S	T	T	T	S
<i>sikkimensis</i>	VS	T	T	T	T	T	T	T	T
<i>toringoides</i>	T	T	T	S	T	T	T	T	S

† Key to viruses —

AM = Mosaic  
 RW = Rubbery wood  
 EDV = Epinasty and decline  
 CLSV = Chlorotic leaf spot  
 SPV = Stem pitting  
 VY = Vein yellows  
 QSV = Quince stunt  
 QSRV = Quince sooty ring spot  
 RPM = Ring pattern mosaic

\* VS = Very sensitive  
 S = Sensitive  
 T = Tolerant



measured by the height and weight of the trees produced in two years, is given in Table 2.

It can be seen that the *Malus* cultivars differed greatly in their sensitivity to apple and pear viruses. Since these diseases often occur in groups and different strains are recognized, it is not surprising that the results from each nursery were different.

The virus symptoms begin to appear in the spring soon after infection. Some stock / scion combinations fail completely and the bud dies away slowly. (Fig. 1). Others produce a small rosette of leaves which remain alive for a few weeks, often in a distorted condition, then gradually die back (Fig. 2). Sometimes cultivars produce a weak primary shoot and the virus symptoms can be seen as a ring or line pattern, usually chlorotic, on the leaves which are often malformed and distorted (Fig. 3). The tips of shoots may also die back and become stunted so that a weak worthless tree is produced, often with bark



**Fig. 1. Virus symptoms: Failure of stock-scion combination and bud death. Left. *Malus* 'Purple Wave' — healthy. Right. *Malus* 'Purple Wave' — infected with apple mosaic virus.**





**Fig. 2. Virus symptoms: Leaf distortions.** *Top left. Malus 'Hopa'—healthy. Top right. Malus 'Hopa'—infected with stem pitting virus. Lower left. Malus prunifolia—healthy. Lower right. Malus prunifolia—infected with epinasty and decline virus.*





**Fig. 3. Virus symptoms: Leaf patterns.** *Left. Malus glaucescens. Center. Malus 'Cowichan'. Right. Malus floribunda. All the above show chlorotic leaf spot virus symptoms.*



**Fig. 4. Virus symptoms: Shoot dieback.** *Left. Malus floribunda — healthy. Right. Malus floribunda — infected with epinasty and decline virus.*



breakdown and a poor union with the rootstock (Figs. 4 and 5). Infected trees allowed to continue growing will later produce undersized flowers and fruits which often show considerable distortion and russetting.

### THE PRODUCTION OF HEALTHY PROPAGATING MATERIAL

Clones of a number of cultivars have been shown to be free from all virus infections after tests on five indicators and these have been multiplied for distribution. Where no virus-free sources could be found heat treatment has been carried out to inactivate the viruses.



Fig. 5. Virus symptoms: Shoot dieback. *Left*. — healthy. *Right* — infected with three viruses: chlorotic leaf spot, stem pitting, and epinasty and decline. *Malus x micromalus*.

The methods used are similar to those employed with fruit trees, and consist of growing young plants in pots in a hot air chamber at 37° C. (98° F.) for 4 weeks. This is followed by wedge grafting the tip



(1/2 inch) of the young shoot on to an apple seedling. The new plant is later virus-tested thoroughly before final multiplication for distribution. The stages of this process as they apply to fruit trees and ornamental *Malus* are shown in Fig. 6.

Small quantities of budwood of a number of virus-tested clones of ornamental *Malus* cultivars have been available to nurserymen from Long Ashton Research Station since 1970. The number of cultivars has continued to increase as heat treatment and tests at both East Malling and Long Ashton are completed and in the summer of 1972 the cultivars in Table 3 will be available as budwood from Long Ashton. In addition, mother trees of some of these have been raised and will be released through the Nuclear Stocks Association (Tree Fruits) as soon as virus tests have been completed.

Although the use of virus-tested clones will improve the standard of growth of ornamental *Malus* in many nurseries, other cultural factors are also important. Many cultivars, for example, are

**Table 3. Virus Tested Ornamental *Malus* species available as budwood from Long Ashton Research Station in mid-1972.**

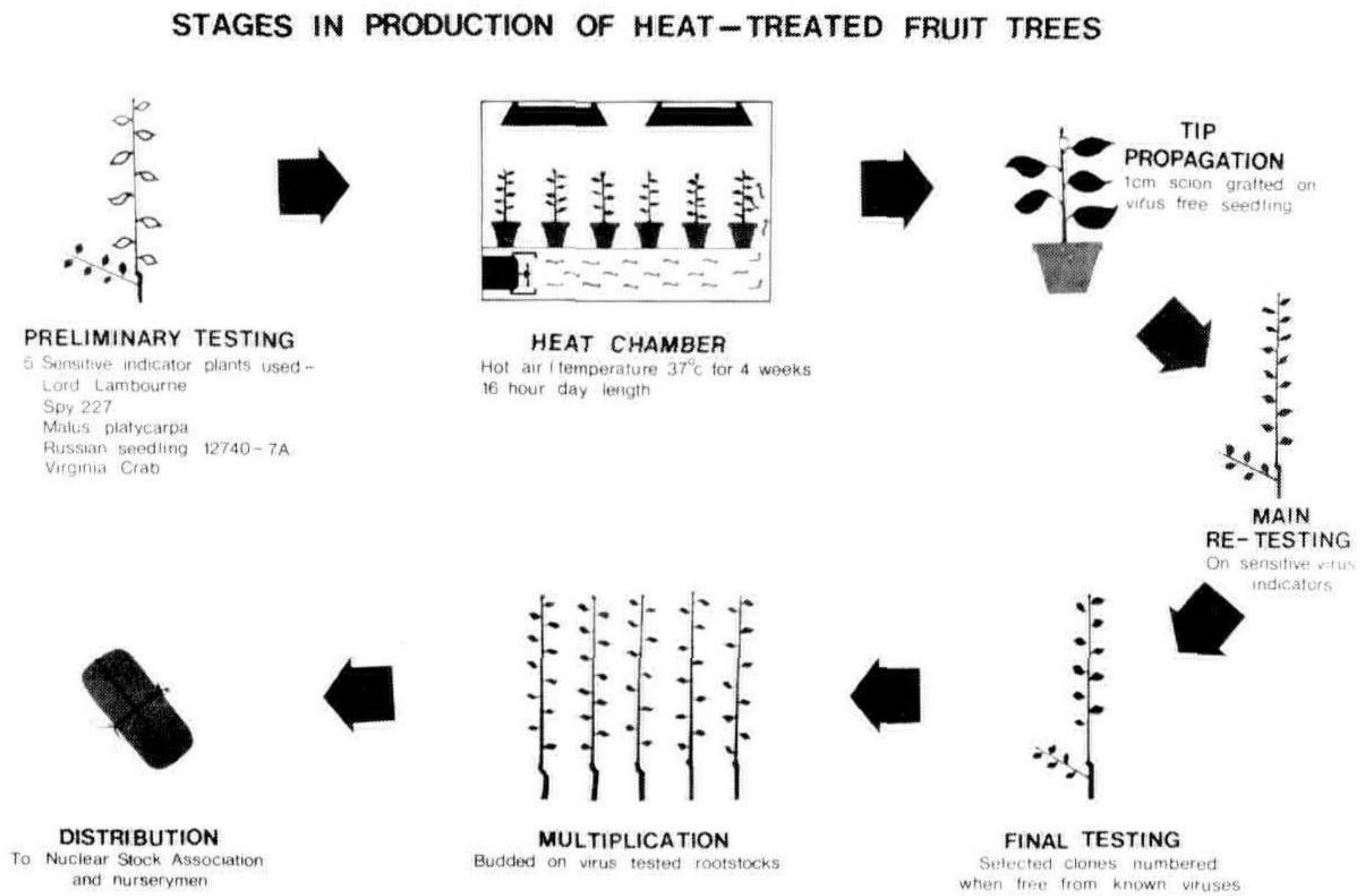
<i>M. x purpurea</i> 'Aldenhamensis'	<i>M.</i> 'John Downie'
<i>M. x arnoldiana</i>	<i>M. x</i> 'Lemoinei'
<i>M.</i> 'Almey'	<i>M. x magdeburgensis</i>
<i>M. x atrosanguinea</i>	<i>M.</i> 'Makamik'
<i>M. coronaria</i> 'Charlottae'	<i>M.</i> 'Oaks'
<i>M. coronaria</i> 'Nieuwlandiana'	<i>M. x purpurea</i>
<i>M.</i> 'Cowichan'	<i>M.</i> 'Purple Wave'
<i>M.</i> 'Dorothea'	<i>M.</i> 'Red Glow'
<i>M. x purpurea</i> 'Eleyi'	<i>M.</i> 'Red Jade' (weeping)
<i>M.</i> 'Elk River'	<i>M. x robusta</i> 'Erecta'
<i>M.</i> 'Gibbs' Golden Gage'	<i>M. sargentii</i>
<i>M.</i> 'Golden Hornet'	<i>M.</i> 'Simcoe'
<i>M.</i> 'Golden Gem'	<i>M. toringoides</i>
<i>M.</i> 'Henry F. DuPont'	<i>M. tschonoskii</i>
<i>M.</i> 'Hopa'	<i>M.</i> 'Veitch's Scarlet'
<i>M. hupehensis</i>	<i>M.</i> 'Wisley Crab'
<i>M. hupehensis</i> 'Rosea'	

susceptible to apple mildew and scab and a more efficient spraying programme will often ensure a considerable increase in tree growth. Difficulties have also been experienced by some nurserymen in budding some of the red-leaved cultivars such as *M. x purpurea* 'Lemoinei' and *M. x purpurea* 'Eleyi'. This is not likely to be a virus problem if strong budwood is available, and the "inverted T" method of budding has given good results with these cultivars at Long Ashton.

More uniform trees of many of the ornamental *Malus* have been raised on a number of the semi-dwarfing EMLA clonal rootstocks such



as M.26, MM.106 and MM.111 and these might be of value where smaller trees more suitable for the garden are required.



**Fig. 6. Stages in the production of virus-tested fruit trees and ornamental *Malus* trees.**

## PROPAGATION OF CLEMATIS

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**Grafting.** The *Clematis vitalba* rootstocks are lifted and laid in thinly in the autumn. Stock plants of the scion varieties should be chosen carefully because only strong healthy plants are suitable. These are potted into 5 in. pots using John Innes 3 compost and set up in a house with temperature of 55° F. at the end of December. By the end of January they will have made about four feet of growth and grafting may commence. Rootstocks should be washed as clean as possible. A single side-graft is used; the length of the scion cut exceeds slightly that of the cut on the rootstocks, as the tongue of scion wood protruding below the tie of fine raffia assists scion rooting.

After grafting, the plants are potted as deeply as possible into 2½ in. pots in John Innes seed compost, so that only the leaf and bud is left above the soil. The plants are set into a closed case with a bottom heat of 70-80° F. and watered well. After 2 or 3 weeks callus will form on the top of the stock and the bud will start to grow; the grafts can then be placed on an open bench with house temperature of 60° F. When 6 in.