use fuel. Could you start the plants earlier and carry them over at a colder temperature? If so, how would you do it?

RICHARD ALLRED: I have not tried that. I might store them at 35°F and then jump the temperature up in January.

VOICE: We germinate about 300,000 perennials in flats and transfer to 2¼ inch pots in the summer. In the fall we put them in cold storage and take them out for shipment in the spring.

DICK CROSS: Brian Humphrey, do you keep your *Juniperus* and *Picea* understocks on the dry side?

BRIAN HUMPHREY: Yes.

VOICE: We do it just the opposite. We wet the understock before placing them in the grafting case.

BRIAN HUMPHREY: That just shows that we must not be dogmatic when talking about propagation.

VOICE: What is the optimum temperature for spruce or pine graft callus formation?

BRIAN HUMPHREY: I would guess that they are low temperature response plants.

Tuesday Afternoon, November 28, 1978

The afternoon sessions convened at 1:30 p.m. with Joerg Leiss serving as moderator.

THE TREE FRUIT VIRUS-TESTED STOCK PROGRAM IN ONTARIO, CANADA

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Virus diseases of fruit crops are worldwide in distribution. Some of these diseases cause great reduction in yield and/or fruit quality. Others result in a rapid decline and death of plants; still others are much less dramatic in their effects but over a period of time take a steady toll. Because of this most of the major fruit producing countries in the world now have virus-tested stock programs.

In Ontario the first attempts at setting up a special block of virus-tested trees for budwood purposes was made in the late 1940's by Dr. G.H. Berkeley of the Plant Pathology Laboratory in St. Catharines and Dr. W.H. Upshall of the Horticultural Re-

search Institute of Ontario at Vineland. They were interested in sweet and sour cherries that were free of Necrotic Ringspot and Sour Cherry Yellows. These were the first virus diseases observed in *Prunus* in Ontario. The first budwood was distributed to Ontario growers about 1952.

WHY VIRUS INDEX

Since 1952 we have learned that virus diseases are much more common than originally thought, that a given virus can infect a much wider range of plants than was originally thought possible, and that some of them can be present without producing dramatic symptoms. Those viruses that induce no recognizable symptoms in our commercial cultivars are generally referred to as "latents". Actually they do reduce growth and yield to a degree and over the life of a tree can result in considerable loss. However, if you do not have a "healthy" tree for comparison you may never realize that the growth or yield is subnormal.

Since these latent virus diseases do not attract attention, infected trees remain in the orchards and natural spread from one tree to another occurs. Also, as an infected symptomless tree is often used as a budwood source, these latent viruses become more and more prevalent over the years. On the other hand, those viruses that kill trees or deform fruit soon have the growers calling for help and steps are immediately taken to eradicate them. The reservoirs of such viruses are usually quickly recognized and appropriate steps are taken to eliminate them. Hence diseases with recognizable symptoms are less common.

There are then two main reasons for virus indexing. One is to detect those viruses that are known to occur in Ontario. The establishment and use of budwood trees free of these diseases will gradually improve the tree fruit industry in Ontario. The second, and equally important, reason is to prevent the introduction of serious virus diseases known to be present in other parts of the world. This is the reason for restrictions on the importation of stock from outside Ontario.

ONTARIO'S PRESENT BUDWOOD PROGRAM

The present virus-tested budwood program was prompted by our increasing awareness of the number and severity of virus diseases that affect tree fruits throughout the world. In 1969 it was agreed that the Agriculture Canada Research Station at Vineland Station would establish a block of thoroughly indexed *Prunus*, *Malus* and *Pyrus* stock which would contain 2 to 3 trees of each commercial cultivar and important breeding lines. Budwood was to be distributed only in small quantities for research purposes for the establishment of budwood blocks by re-

search stations and reliable nursery organizations and to accredited research institutions or nurseries in foreign countries. The Horticultural Research Institute of Ontario at Vineland Station would maintain larger budwood blocks of all major cultivars for distribution in larger quantities to nurseries. All budwood trees would be periodically re-indexed for possible virus contamination.

THE VIRUS INDEXING METHOD

Initially we collected samples of all the *Prunus*, *Malus* and *Pyrus* cultivars grown in southern Ontario. Then we "indexed" these selections. What is indexing? Indexing is the technique used to test a cultivar selection for the presence or absence of viruses. The process is dependent on two factors. First, that the virus can be transferred from one plant to another. Usually T-budding is used. Second, every virus that we are concerned with produces distinct, easily recognizable symptoms in some hosts. Host plants that react with specific symptoms we call "indicators". So, for our program, we selected a group of indicators that would detect all the viruses that concern us (Table 1). Naturally this list changes from time to time as more sensitive indicators are found and also when previously unknown viruses are detected. For each crop type the indicators are divided into two groups. The basic group of indicators detects those viruses most commonly encountered in Ontario and some of the more serious ones from a production standpoint. The secondary indicators are used to detect less common viruses. These indicators are capable of detecting at least 16 *Prunus* viruses, 19 *Malus* viruses and 8 *Pyrus* viruses.

Table 1. Virus indicator plants.

Prunus	**Malus**	**Pyrus**
Basic	*Basic*	*Basic*
'Shirofugen' cherry	'Virginia Crab' apple	'Bosc' pear
'Kwanzan' cherry	'Spy 227' apple	Pyrus communis
Sam cherry	*M.* × *platycarpa*	'Virginia crab' apple
Italian plum	'Lord Lambourne' apple	*Pyronia vietchii*
Pozegaca plum	'R 12740-7A' apple	'Spy 227' apple
Secondary	*Secondary*	*Secondary*
'Bing' cherry	'Gravenstein' apple	'Hardy' pear
'Shiro' plum	'Golden Delicious' apple	'Lord Lambourne' apple
Peach sdlg.	'Cox's Orange' apple	'Golden Delicious' apple
'Wenatchee' apricot	'Boskoop' apple	quince

To index any selection we take buds from that selection and by normal methods insert these into one-year-old whips of the indicator. We use two or three indicator trees and insert three buds into each.

VIRUSES DETECTED IN ONTARIO

Some of the reactions induced by viruses that we have detected are as follows:

Green Ring Mottle Virus. This virus is most often found in peach selections. In *Prunus serrulata* 'Kwanzan' this virus produces a very marked leaf epinasty; that is, backward rolling of leaves accompanied by vein necroses and mottling. Growth is much reduced.

Necrotic Ringspot Virus. This virus is common in all *Prunus* species, particularly cherry. It can be readily recognized by its localized reaction in *Prunus serrulata* 'Shirofugen'. Three or four weeks after the insertion of diseased buds into this indicator a severe gumming develops around the buds. When the bark is removed a severe necrosis of the wood is seen.

Peach Rosette Mosaic Virus. Peach seedlings inoculated with buds carrying this virus develop a very rosetted (bunched-up) growth caused by extreme reduction in twig growth (elongation). A faint mottle can be seen on the leaves in the spring.

Prunus Stem Pitting Virus. In peach seedlings this virus induces extensive pitting in the wood under the bark.

Apple Chlorotic Leaf Spot Virus. This is the most common virus in apple selections that we have tested. It induces a very sparce, much delayed development of the indicator in the spring. Leaves of infected trees are rolled, mottled and may have distinct chlorotic rings and lines. The indicators, Russian seedling ('R 12740-7A'), *Malus* × *platycarpa* and 'Spy 227', all react much the same to this particular virus. Affected trees are very stunted.

Apple Stem Pitting Virus. It is detected by 'Virginia Crab'. Small distinct pits develop in the wood with corresponding pegs in the inner bark. This virus also induces an uneven, lopsided development of the fruits of 'Virginia Crab'. This is not the same virus that produces stem pitting in *Prunus*.

Apple Stem Grooving Virus. This virus is also detected in 'Virginia Crab' but here the symptom is an elongated groove quite distinct from the small pits of apple stem pitting. There is no fruit deformity.

Ring Russet Virus. Symptoms develop on the fruits of a number of indicators such as *Malus sylvestris* 'Golden Delicious' and 'Cortland'. We have seen beautiful symptoms on 'Cortland' and on *M.* × *platycarpa*.

Scaly Bark Virus. This apple virus has been reported only from Europe but we recently detected it in the cultivar 'Raritan'.

Blisters develop on one-year-old wood of *M.* × *platycarpa*. The cracking and scaling becomes more and more pronounced in older wood. Normal bark, of course, is smooth and a light yellow-brown.

Stony Pit Virus. This common virus in pear produces a very distorted fruit in susceptible cultivars. Below the pits are extensive stone-cell areas. *Pyrus communis* 'Bosc' is the most sensitive cultivar.

Pear Vein Yellows Virus. This is the most common virus in pear. In *Pyrus communis* 'LA62' it produces a marked yellow banding of leaf veins. Later red flecks develop along the veins.

By careful indexing we hopefully can prevent the importation of serious virus diseases that we know occur elsewhere. A few examples of these are: Peach Wart Virus, which produces a severe raised warty growth on the surface of fruits making them very unattractive. Necrotic Rusty Mottle of cherry is a very severe disease that kills trees in a very short time. Apricot Ring Pox results in unsalable fruit. The Little Cherry Virus has nearly wiped out the cherry industry in some parts of British Columbia.

HEAT TREATMENT

When all sources of a particular cultivar are found to carry one or more viruses we have to try to eliminate the viruses by a process called "Heat Treatment". To date, our work has been mainly with apple. We grow healthy apple seedlings in 5" clay pots. We select strong, well rooted year-old seedlings that are growing vigorously. Buds of the diseased cultivar are chip budded into the lower stem of the seedling. We usually put three buds on each. After one week in the greenhouse these budded trees are placed in a special treatment room under 24 hr light and low humidity (25 to 40% RH). The starting temperature is 22°C (72°F). Over a period of 10 days the temperature is raised to 37.5°C (100°F). This temperature is maintained for at least 30 days, then the seedling stock is cut back to the inserted buds to force growth. As soon as new growth is ¾" long it is cut off and cleft grafted into a small vigorously growing seedling rootstock. The hope is that the new growth produced under conditions of high temperature will be free of viruses. We have had very good success in getting these little grafts to grow. We do not know yet if we have any clean plants. Trees produced in this way must index negative for virus over the next two years before they can be declared free of known viruses.

VIRUS-INDEXED STOCK ON HAND

At the present time we can offer Ontario nurserymen small

amounts of material from 168 named cultivars or species. This includes 37 apple, 6 apple rootstocks, 16 ornamental *Malus*, 4 pear, 9 tart cherry, 18 sweet cherry, 17 plum, 4 plum rootstocks, 6 apricot, 4 nectarine, 30 peach, 3 peach rootstocks and 15 ornamental *Prunus*. It is available for the asking and free of charge.

MYCORRHIZAL FUNGI IN RELATION TO SOME ASPECTS OF PLANT PROPAGATION

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The symbiotic association between a plant root and a mycorrhizal fungus is termed mycorrhiza. The specific types of mycorrhizal associations have been described in previous issues of the IPPS Proceedings (2,4). Mycorrhizal fungi are naturally occurring organisms in over 80% of the plant taxa. The vast majority of vascular plants have evolved to a dependency on mycorrhizae either for survival or to flourish. In many instances, mycorrhizal fungi facilitate increased growth and/or selective nutrient uptake and accumulation; tolerance to environmental stresses, such as drought, temperature extremes and soil acidity, and function in protecting roots from pathogenic infection. In addition, mycorrhizal fungi are also known to produce enzymes, vitamins and growth hormones that increase root size and longevity as well as rooting of cuttings.

Because the mycorrhizal state is a universal, natural association, its importance in nursery crop production may only become apparent when we disrupt the natural soil environment. Advances in the use of fertilizers, pesticides, steam sterilization or fumigation, soilless mixes, etc. to increase crop productivity have simultaneously diminished or eliminated the indigenous beneficial soil-borne mycorrhizal fungi. Consequently, severe stunting, special nutritional requirements, poor survival and/or growth, and increased disease susceptibility are often attributed to deleterious characteristics of a plant species or a failure of cultural practice, rather than absence of mycorrhizal fungi.

In order to benefit from mycorrhizal fungi in the nursery industry, we must be concerned with plant-fungus specificity, differences among fungal isolates producing specific effects

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