feet—are the most acceptable. We discontinued 'E.M. IV' because of its brittle roots. Our finished trees are never sold as whips, but are headed back at approximately 40 inches and are grown on as well-branched 2-and 3-year-olds.

We propagate our stocks as both mound and continuous layers. Our original stock came from Canada. We plant our tree understock in early spring with a mechanical planter spacing them 16 inches apart in rows 42 inches wide. All our budding is done in August. We do not irrigate; the trees develop an excellent root system and heavy caliper in one year through the deep plowing and constant cultivation. For weed control, we cultivate and hoe. However, we have used pre-emerge herbicides succssfully.

We follow a rigid spray program throughout the year. Part of this program includes the use of a dormant spray, Cyprex 65W, for scab and mildew, Rothane 50 for leaf roller; Captan as a fungicide, and occasionally malathion.

For the coming year we are including some of the Malling-Merton types; and if these prove satisfactory, we shall include them in our inventory.

MODERATOR NELSON: You know, 15 years ago—maybe a little longer—any researcher that couldn't answer a question would say it was "physiological". Well now I think the pendulum has turned enough that any time a researcher can't answer a question he sends the problem to a virologist. Dr. Maurice Welch is one of our leading Canadian virologists. It gives me great pleasure to introduce Dr. Welch, Head of the Plant Pathology Section, Canada Department of Agriculture, Summerland, B. C. Dr. Welch:

VIRUS-FREE ROOTSTOCKS

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The problems that viruses provide for nurserymen are typical of the complexities that have been gradually overtaking propagators of fruit trees since the early carefree days when Johnny Appleseed was scattering his seeds along trails in the American wilderness. The complications began, of course, as growers recognized the superiority of certain seedlings and the need to grow them as varieties grafted on rootstocks. Even this was relatively simple for a time, when there seemed a need only for germination of randomly-collected seeds, and their topworking to the desired varieties. Now by contrast, the fruit breeder and the nurseryman must concern themselves with vegetatively-propagated as well as seedling rootstocks, which endow the trees with varying degrees of dwarfing, and provide other useful characteristics. Often a

3- or 4-part tree is required to attain satisfactory tree shape, disease resistance and hardiness. To this must be added all the other precautions necessary to cope with soilborne insects, nematodes, crown gall, root rots and viruses. Not least among these accumulating problems are the proliferating quarantine regulations designed to guard against these pests and diseases; regulations that are restricting the movement of nursery stock from country to country and from region to region.

It seems almost ruthless to select one of these many vexations and stress its complexity and importance. Nevertheless. I have a specific assignment to discuss the significance of viruses in tree-fruit rootstocks and in relation to their propagation.

Most of you by now are familiar with viruses and their characteristics, to the extent that these are now known. It is only in the last 30 years that scientists have been able to study viruses in the laboratory, and by 1967 only a small proportion of the viruses that cause plant diseases can be isolated, purified and characterized. Those that have been so studied are complex nucleoproteins, not unlike some of the native proteins that occur in healthy plant tissues, except that the virus proteins have the ability, when introduced into living host tissues, of multiplying rapidly, upsetting the normal functioning of these tissues, and thus causing diseases. These characteristics of viruses have made them uniquely difficult to deal with. In particular, they are so intimately associated with the plant tissues that they cannot be killed or controlled without killing the tissues in which they occur. As they cannot be controlled by the means we use for insects, fungi or bacteria we must rely almost solely on preventive measures.

The seriousness of viruses in fruit trees can be illustrated by the records of diseases such as *peach mosaic, phony peach* and *little cherry. Peach mosaic* has required the eradication of hundreds of thousands of bearing peach trees in the southwestern United States. *Phony peach* has demanded equally extensive eradication programs in the southeast. The *little cherry* disease eliminated cherry growing in the Kootenay region of British Columbia, and is now known to occur commonly in several European countries, as well as in Australia and in Japan. We may be less familiar with other, even more serious diseases that occur on other continents. *Plum pox* has spread through millions of plum, prune and apricot trees in most European countries, rendering plum fruits unfit to eat. *Apple proliferation,* or *witch's broom,* spreads actively in orchards, occurs in most European apple-growing regions, affects tree growth, and causes fruit and foliage symptoms. The *Pfeffingerkrankheit disease* of cherry debilitates or kills affected trees and is soil-transmitted, so that re-planting with healthy trees is not possible. These are only a few of the viruses that cause obvious diseases, and that spread rapidly in orchards, transmitted by insects, pollen, or nematodes.

In addition to these viruses that cause spectacular diseases in certain regions of the world, there are a number of viruses that are distributed in fruit trees almost wherever they are grown, and are more insidious because they cause no symptoms on most commercial varieties of tree fruits. Usually these viruses do cause serious disease conditions on certain sensitive varieties, and almost all of them have significant, though less apparent effects, in reducing graft and bud union "take" in nurseries, and in reducing production of stoolbeds and seedling plantings. Many of them also reduce the vigor and productiveness of the infected trees.

The plant propagator must be especially concerned with this second group; the so-called "latent viruses". They obviously reduce the efficiency of his nursery operations. Perhaps more important, he is in a strategic position to assist in reducing the incidence of these viruses in orchard plantings. Indeed, unwittingly in the past he has been the most effective disseminator of latent viruses, because the use of infected propagating materials has accounted for most of their spread.

The first responsibility of the propagator is to obtain virus-indexed sources for rootstocks, bodystocks and variety clones. His second responsibility is to adhere to practices that will prevent virus infections occurring in his plantings.

Virus-free clones of most commercial tree fruit varieties are now available, or rapidly becoming available, through State or Provincial nursery improvement and certification programs. In the West there are such programs in California, Washington, and British Columbia. These schemes, designed to provide materials for the nurseryman, are supported by a Repository of virus-free materials, established with U. S. Congressional funds at Prosser, Washington. Virus-tested clones of all useful stone fruit varieties are held there in very strict isolation, and nuclear stocks are provided to Research Stations and Nursery Improvement Schemes in the United States and Canada. Virus-tested apple and pear clones are being added as rapidly as they become available.

Sources for clean understocks are more diverse and scattered. The problems differ for clonal rootstocks and seedling rootstocks. The clonal rootstocks most used are those for apple, which originated at the East Malling Research Station in England. The original Malling stocks were developed in a period when viruses were not known to exist in apple, and most of the more useful Malling stocks have subsequently proved to be virus-infected. When the East Malling plant pathologists became aware of the *apple mosaic, chat fruit* and *rubbery wood* viruses they indexed all their rootstock clones and found it necessary to re-clone a number of them. These were released as 'Malling IIA', 'M .IVA', 'M. VIIA', and 'M. IXA', certified as free from *apple mosaic, chat fruit* and *rubbery wood* virues. More recently, since means have been found to detect additional apple viruses, it has been demonstrated

that 'M. II' and 'M. IIA' carry *chlorotic leaf spot* virus, and that the other stocks carry *chlorotic leaf spot, stem pitting* and *Spy epinasty* viruses. Most of the clonal rootstocks more recently released in England have a cleaner bill of health. 'Malling-Merton 104', 'M.M. 111' and 'M. 26' are characteristically free from known viruses, and 'M.M. 106' is frequently free. However 'M.M. 109' and 'M. XXV' contain *chlorotic leaf spot, stem pitting* and *Spy epinasty* viruses. Among clonal rootstocks for other tree fruits the original releases of 'Quince A', Myrobalan B', 'St. Julien A', 'Brompton' and 'Mazzard F12/1' have proved to be free from detectable viruses.

In recent years a new technique has been developed, by which viruses can be eliminated from plant tissues without killing the plant. Infected trees can be exposed to dry heat continuously for periods of several weeks. The buds that survive can be removed and applied to virus-free rootstocks. With luck, a few of the buds are then found to have been freed from virus infection. Such treatment has been given to the infected rootstock clones at various Stations in England and North America. It is a slow business but is proving rewarding. At one or more of these Stations there are now clean clones of all the Malling and Malling Merton series except 'M. IV' and possibly 'M. XXV'. 'M. IV' is now being subjected to treatment at the Plant Quarantine Station at Saanichton, B. C. Unfortunately, for various reasons, there is likely to be an interval of several years before any of these clean clones can be made available in quantity to the trade.

For seedling rootstocks there must be a clear distinction between apple on the one hand, and pear and most of the stone fruits on the other. The difference is in the occurence of virus transmission through seeds and pollen. So far, such transmission has not been demonstrated for viruses infecting apple, except one that seems to have little importance. Therefore viruses can be essentially ignored in selection of seed sources for apple roostocks. By contrast, in stone fruits, viruses of the *ringspot* and *sour cherry yellows* group are commonly transmitted through seed and pollen. In pear, at least one virus (*vein yellows*) is transmitted through the seed. This means that the only assurance of virus freedom in stone fruit and pear nursery trees lies in establishing special seed source orchards, planted with trees that are free from viruses, and indexed periodically to ensure that they remain healthy. A few such seed source orchards have been established in eastern, mid-western and western states. In British Columbia, seeds from virus-indexed 'Van' cherry trees are being propagated under the Budwood Certification Scheme, for use of commercial nurseries.

After the nurseryman has secured suitable sources of virus-free propagating materials there are several precautions that he must adopt to prevent infection of his plantings. One is to avoid doing any topworking in stoolbeds, and thus risk

contaminating them. Another is to avoid re-budding of rootstocks on which buds have failed. Bud-failure is often a sign of virus infection in bud or rootstock, and in any case the second budding doubles the chance of introducing viruses. Stoolbeds and other nursery plantings should be kept far enough from older fruit trees to avoid the risk of root grafting, and thus of transmission of viruses through the grafts. He should avoid interplanting tree fruit materials with ornamental stock, especially ornamental *Prunus, Pyrus* and *Malus,* because these can serve as hosts for many of the same viruses, and usually have received less careful indexing. Finally the recent demonstrations that stone fruit viruses are transmitted in pollen makes it necessary that all blossom buds be removed each year from seed source and scion source trees.

A talk on viruses in tree fruit clones must include mention of regulatory measures, and the complications that they are providing for U. S. and Canadian nurserymen. Quarantine regulations and restrictions, of course, are designed to prevent the entry of new and serious diseases to a country or region. Many of our most destructive diseases and pests have entered North America in shipments of plants or trees from other continents. We have to be prepared to pay a price to ensure that we do not introduce additional virus diseases such as *plum pox, apple proliferation, Pfeffinger krankheit* of cherry, *chlorotic leafroll* of peach and apricot, and other equally devastating virus diseases that, so far, have not gained entry to the United States or Canada. For this reason the quarantine authorities in both countries have been tightening their import regulations during the last several years. During 1966 and 1967, U. S. authorities have been adding to their precautions still further by placing restrictions on the movement of tree fruit nursery stock from Canada to the United States. They have specified that the Canadian materials entering the United States must be certified by Canadian Plant Protection Division officials to be free from all the serious virus diseases occurring on other continents, and that apple stocks must also be free from the more commonly distributed *rubbery wood* virus. Some of the other commonly distributed latent viruses are not specified in the quarantine regulations. Apple stocks infected with *chlorotic leaf spot, stem pitting* and *Spy epinasty* viruses can still enter the United States from Canada. In addition, the Canadian nurseryman must practice all the various precautions I have mentioned in the operation of his nursery before his stock can be approved for entry into the United States. We must assume that if these precautionary measures are required for nursery stock being imported to the United States from Canada, there will be increasing pressure for the adoption of all the same precautions by U. S. nurserymen producing stock for domestic and export sale.

In Canada we are now taking an additional precaution to ensure that the nurseryman receives clean varieties and

rootstocks. The Tree Fruit and Grape Quarantine Station that was set up primarily to screen materials imported to Canada from other continents, also provides a service to Canadian plant breeders. All new proven varieties derived from their breeding programs can be submitted to the Quarantine Station for indexing to ensure that they are free from viruses at the time of their release to the trade.

Viruses provide one other serious hazard for the propagator. This lies in the susceptibility of certain kinds of rootstock to viruses that are commonly distributed—but symptomless—in commercial varieties. This has been especially true of crab seedlings used as rootstocks, and crab varieties used as hardy body stocks. Recently we discovered at Summerland that the risk extends to seedlings of some commercial apple varieties, when we encountered *stem pitting* symptoms in a high proportion of 'Delicious' apple seedlings that were top-worked with infected apple varietal material. The Ottawa Research Station has responded to this danger by co-operating with us at Summerland in screening to ensure that its new hardy size-controlling rootstocks are resistant to the common latent viruses occurring in apple.

The objective of plant breeders and plant pathologists is to eventually make available to nurserymen and orchardists a range of rootstocks that are not only virus-tested but also virus-resistant. Until this goal is attained there is urgent need for nurserymen to take all reasonable precautions for production of clean nursery stock. Obviously this is necessary, not only to protect the nurseryman and the fruitgrower from virus hazards, but to keep nursery stock moving freely between our two countries and the regions within them.

MODERATOR NELSON: Thank you, Dr. Welsh for a most interesting talk. We will move on with our program to the next speaker, who I met for the first time this morning, but I've read his writings and who, I am sure, does not need an introduction to the Western Region members. He is one of the workhorses in the organization, because anybody who is the Editor just has to be a real worker. I am sure the Editor puts long hours into preparing the wonderful Proceedings that comes out of our organization. So with that, I'd like to introduce Dr. Hudson Hartmann, Department of Pomology, University of California, at Davis who is going to speak on root initiation in hardwood pear cuttings. Dr. Hartmann: