membership committee can have a chance to process them. Then you can be accepted as a member as of this meeting. Otherwise, you'll have to wait until next year because this is the only time during the year that the membership committee meets.

To continue our program, now, we have Dr. Converse from Oregon State University, who will speak to us on viruses in strawberries.

THE PROPAGATION OF VIRUS-TESTED STRAWBERRY STOCKS

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Small fruits are important in Pacific Coast agriculture. In 1971 strawberries ranked seventh among the crops grown in Oregon, eighteenth in California, and twenty-sixth in Washington. The strawberry industry, of course, depends on vegetative propagation of its cultivars. It is my purpose here to describe some of the procedures and problems of commercial strawberry-plant propagation on the West Coast.

Strawberry plants for the commercial industry on the Pacific Coast are grown by a few specialized nurserymen in four areas in Washington and California. There are 13 nurserymen involved, raising 1,200 acres of strawberry plants worth about $ 6,000,000 annually.

The Washington and California State Departments of Agriculture each administer their own strawberry certification programs. In both cases, the programs are designed to provide the public with adequate supplies of strawberry cultivars that are true to name, of good horticultural quality, and free from serious pests and diseases, including viruses.

Disease control has played a major role in locating strawberry nursery production where it is today in Washington and California. There are four or more viruses that seriously weaken strawberry plants and are spread by strawberry aphids on the Pacific Coast. Nurserymen have found that they cannot produce essentially virus-free stocks in the major strawberry fruit-producing areas of California, Oregon or Washington because of rapid infection of plants by the tremendous populations of virus-infected strawberry aphids present in these areas. As a result, strawberry nurserymen

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have moved to areas where strawberries were not previously grown to raise their certified plants. The valleys of the Cascade range just west of North Cascades National Park; the Nisqually Sands area east of Olympia, Washington; the upper Sacramento River Valley in California; and the upland area southeast of Mt. Shasta at McArthur, California have all become specialized strawberry nursery-production areas. In each place, there were no commercial strawberry plantings when the nurserymen moved in.

In order to raise strawberry plants that are virtually free from viruses, however, nurserymen must also start with clean planting stock and prevent its subsequent infection by aphids.

The development of clean strawberry planting stock provides a good example of cooperation between nurserymen, regulatory officials, and research people.

Take two examples: Until recently 'Northwest' has been the major strawberry cultivar grown in Oregon and Washington. In terms of acreage, it has been one of the most extensively grown strawberry cultivars in the world. 'Northwest' was first released carrying aphid-borne viruses of the strawberry yellows virus complex. Drs. P. W. Miller and R. O. Belkengren at Oregon State University succeeded in 1963 in obtaining clones of 'Northwest' that were free from yellows complex viruses. They did this by cutting out strawberry meristems and culturing them into plants on agar. The clones thus developed were increased in screenhouses and distributed. The Washington State Department of Agriculture and the Washington State University Research and Extension Center in Puyallup have cooperated in maintaining, retesting, and distributing this stock to Washington nurserymen. Today virtually all of the 'Northwest' stock grown comes from these meristem clones.

In California a similar program was undertaken by Dr. S. H. Smith and Miss Ruth Hilton at the University of California at Berkeley to rid California strawberry cultivars of viruses by meristem culture. The work was supported by California Strawberry Nurserymen's Association. New clones of all of the major California strawberry cultivars have been produced from meristem culture. They have been shown to be free from all viruses, including pallidosis, crinkle, and mild yellow edge, three viruses that were both common and difficult to eradicate in standard California strawberry stock. Clean clones are being increased in screenhouses belonging to the California Strawberry Nurserymen's Association and have recently been put out for field increase.

Not only must strawberry nurserymen pay great attention to the quality of their nuclear planting stock, but they must also guard against reinfection of this stock by viruses and often by other diseases and pests.

Strawberry nurserymen routinely fumigate their fields with

methyl bromide-chloropicrin mixtures under plastic tarpaulins or with dichloropropene under plastic tarpaulins or followed by a water seal. This eliminates nematodes and some fungus disease problems in the strawberry nursery. Thereafter, pest management consists mainly of insecticide applications to control aphids that could spread viruses in the strawberry plantings. Several systemic and contact insecticides approved by the FDA are used for this purpose. Many nurserymen prefer to rotate use among a group of pesticides to avoid building up insect resistance to any one — such as occurred in Oregon and southern Washington when the common strawberry aphid became resistant to endosulfan.

One fungus disease problem that strawberry nurserymen still have not completely solved is strawberry red stele root rot. The fungus causing this disease, *Phytophthora fragariae,* is very long-lived in the soil. Once a field becomes infested with this fungus, it cannot be safely used for strawberry nursery production thereafter. Both California and Washington have an official zero tolerance for red stele disease in certified strawberry plants. Nurserymen who find the disease in their fields can at best dig only part of these fields for plants — sometimes none at all. The selection of land thought to be free from red stele disease is a major problem for strawberry nurserymen. We need to know more about possible wild hosts of this fungus, such as *Potentilla* species, which may harbor it in previously uncultivated land.

We have spoken so far mostly about management procedures for strawberry plant production. The detection of viruses in strawberry involves unusual procedures that are of intrinsic interest to students of propagation methods.

It is an axiom among virologists that all plant viruses and mycoplasma-like diseases should be graft-transmissible. (We will lump these all under the term "viruses" hereafter.) Although some of the strawberry viruses are easily transmitted from infected to healthy plants by aphids, many strawberry viruses are transmitted experimentally only by grafting. Research workers in Europe and North America have developed a number of strawberry clones that are particularly susceptible to strawberry viruses. This work has recently been brought to a high degree of refinement by Dr. N. W. Frazier of the University of California at Berkeley. He has developed several strawberry indicator clones that will produce symptoms characteristic of the various strawberry viruses and their mixtures after inoculation. The method of inoculation now widely used in strawberry virus indexing is an ingenious petiole-insert graft technique developed by Professors Bringhurst and Voth at the University of California at Davis. Petioles of the indicator plant to be grafted are slit longitudinally, and a long spear-shaped petiole with attached terminal leaflet from the plant to be tested is inserted into this slit. The graft is then bound with self-cohering

elastic tape, and the indicator plant is held for symptom development on the greenhouse bench for 2 — 8 weeks. In the past, several donor leaflets were grafted from a source plant to a single indicator plant to assure transmission. Recent work from the University of California indicates, however, that equally reliable and more rapid results can be achieved if all of the leaves are cut off the indicator plant at the time of grafting, leaving the donor leaflet to be the only leaf tissue left on the indicator.

Leaf-grafting procedures are now used by researchers to check for freedom from virus in new strawberry selections and improved stocks of old cultivars, as well as for detailed studies of the virus diseases themselves. Regulatory officials in California routinely check the virus content of sample strawberry daughter plants by leaf grafting in order to evaluate the virus freedom of the mother plants, which are maintained clonally.

As you can see, research and regulatory personnel and strawberry nursery growers are spending a great deal of time and effort in ridding strawberry stocks of viruses and keeping them that way as far as possible. It is proper for the question to be asked in closing, "Of what value are all these precautions to the commercial strawberry growers?" A number of research studies have been designed to answer this question and to demonstrate the amount of growth and yield increase that can be attributed to the use of virus-tested, certified strawberry plants. In one field study I compared growth and yield of 'Northwest' strawberry free from known viruses with those of plants naturally infected with a combination of crinkle, mottle, and mild yellow edge viruses. This combination of viruses is very common in established plantings in Oregon. We found that plants free from known viruses produced 103% more runners and yielded 51% more fruit than virus-infected plants.

Therefore, both the initial growth of essentially virus-free certified strawberry plant stock and subsequent yield from such fields can be demonstrated to be markedly increased when compared to the performance of field-run virus-infected stocks.

RICHARD SMITH: Would you describe one of the mycoplasma-like diseases and tell how you identify them?

RICHARD CONVERSE: That's almost a political question these days among plant pathologists because it's a very highly controversial field. About four or five years ago, the Japanese discovered what they feel is a new class of plant pathogenic organisms. Just where they fit in the scheme of things and how many kinds there are aren't quite clear yet. Some people feel that this group of so-called mycoplasma-like organisms belongs to a closely allied group of the already established animal mycoplasms

and some of the saprophytics. There has been recent work just reported in our meetings at Mexico City that there may even be spirochete-like organisms, lacking cell walls, that are involved in this type of mycoplasm disease. This whole group of diseases usually causes deformity and yellows-type symptoms and are very often spread by leaf-hoppers. People talk about mycoplasmologists now — so we apparently have a brand new field of investigation.

PRESIDENT MAIRE: Thank you very much, Dr. Converse. Let me give you your certificate here in appreciation for your being with us today and sharing this information with us.

MODERATOR McNEILEN: To start this next session, Jay Allison of the Weyerhaeuser Company will tell us about control of freeze damage in their forest tree seedling nurseries. Jay Allison:

FREEZE-DAMAGE CONTROL IN FOREST NURSERIES

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In 1967, the Weyerhaeuser Company established the Washington Forest Seedling Nursery. This was the first in a series of six major nursery units to support the company high-yield forest regeneration requirements. The Washington Nursery is 160 acres in size and is located about 15 miles southwest of Olympia at the south end of an open prairie. The site slopes gently to the south and has a mean elevation of 140 feet.

By 1969 the nursery had over 53 million seedlings in three age classes; 1-0, 2-0, and 2-1. In October of that year, an unexpectedly severe freeze occurred that killed or seriously damaged about 12 million seedlings, mostly in the 1-0 age class.

In September of 1970, another early freeze occurred. The 1-0 blocks were protected by sprinkling, and losses were minimal. Well capacity was not adequate to sprinkle the 2-0 beds and they were extensively damaged. Although the incidence of mortality in the 2-0 stock was low, the quality was poor and subsequent field performance of the seedlings produced was below standards.

It was apparent that, if the nursery was going to meet production objectives, a more effective means of reducing freeze-damage was needed. Before making a substantial investment for