The Citrus Clonal Protection Program

Walter Reuther

Refinements in disease detection and plant propagation have led to faster, cheaper methods of producing disease-free budwood.

During the past 50 years, virus diseases of citrus have become a major problem restraining vigor and productivity of orchards in all of the major citrus producing regions of the world.

Fifty years ago no virus diseases of citrus had been identified. Psorosis or scaly bark, for example, was a common disorder in Florida, California, Spain, Brazil, Argentina, South Africa, Australia, and most other established citrus growing regions of the Old and New Worlds. Its cause was then unknown, but its effect was to severely reduce yield and vigor of mature bearing trees. Young trees were rarely affected. In those days it was common to find mature orchards, especially of oranges, with 25 to 35 percent of the trees in various stages of decline due to scaly bark or psorosis. This situation can be found in some older orchards in some Mediterranean countries even today. Shell bark, a complex disorder commonly associated with exocortis (a bud-transmitted pathogen), fungal lesions, and inherited weaknesses, ravaged lemon orchards in California in those early days even more severely than did psorosis of oranges.

In 1932 the late Professor Howard S. Fawcett, the father of citrus pathology, reported that psorosis was due to a virus infection. His grafting and budding experiments demonstrated that the disease could be transmitted by use of budwood from infected trees and could be avoided by using budwood from lesion-free mature trees. Also, he showed that it had a long period of latency; that is, the scaly bark symptoms often did not appear until the trees were in full bearing, even though infection took place when the trees were budded in the nursery. At the time of his discovery, knowledge of plant virus diseases was in its infancy, and this was the first indication that citrus trees were subject to virus infections.

About 35 years ago, Fawcett and Wallace showed that tristeza or quick decline was a bud-transmitted virus infection devastating to certain scion-stock combinations but benign in others. The virus was shown to be transmitted not only by budding, but also by several aphid species. Beginning in the 1930s, this disease wiped out millions of trees on sour orange stock in Brazil, Argentina, California, and many other areas.

In rapid succession, exocortis, cachexia, greening, satsuma dwarf, citrange stunt, cristacortis, stubborn, and several other maladies were shown to be caused by virus, virus-like, or other pathogens, all transmitted by diseased budwood and some also spread by insect vectors.

Spread of viruses

Among tree crops, citrus is typical with respect to virus disease problems. During the past half century, the trend has been to plant fewer and fewer varieties concentrated in larger and larger areas of contiguous orchards. These conditions favor rapid spread of virus and other diseases when undisciplined and unsanitary mass-propagation techniques are used to produce nursery trees. Spread by insect vectors is also favored in vast-area plantings that approach monocultures. In addition, the nearly universal commercial practice of using rootstocks (for disease and nematode tolerance) widely differing genetically from the scion increases the virus hazard. The great increase in the speed and ease of transportation has resulted in more rapid movement of both infected vegetative material and vectors from one region to another, especially by airplane.

In the past, the prime vector and spreader of virus and virus-like diseases of fruit trees has been man, and especially the nurseryman. Unfortunately, we did not fully appreciate this until about 25 years ago. In the early period, confusing factors impeding progress in understanding such diseases were: (1) the profound influence of stock-scion combination on susceptibility or tolerance; (2) the long period of latency with some, but not all, virus diseases; and (3) inadequate basic knowledge of plant virus diseases generally, especially bud-transmissible ones.

Situation in early 1950s

By the early 1950s it became increasingly clear that many conclusions drawn from earlier citrus rootstock experiments, especially with orange tops, were not valid due to undetermined and random virus infections in the original planting stock. Whether conflicting data among experiments regarding the merits of certain stock-scion combinations were due to soil and climatic differences or to absence or presence of bud-transmitted diseases was not clear.

In addition, experimental plantings by J.W. Cameron and R.K. Soost comparing nucellar strains of common commercial varieties with the old parent line strains often showed the nucellar strains to be strikingly superior in yield and vigor. A major part of this difference was due to freedom from virus disease in nucellar strains, which are produced by seedlings arising from the nucellus and are genetically identical with the mother plant. With minor exceptions, virus diseases are not transmitted through the seed of common citrus varieties and species.

Thus, as early as 25 to 30 years ago, it was evident that virus or virus-like diseases were restraining yields of California citrus orchards, perhaps as much as 25 percent overall but much more severely in certain orchards. Also, it was abundantly clear that, if the problem were not contained, it would grow steadily worse.

These developments caused researchers, growers, and nurserymen alike to address

Indicator plants being inspected at Rubidoux for virus disease symptoms.

themselves to the problems of virus and similar diseases in commercial as well as experimental plantings. In common with most plant virus diseases, no practical control measures were available once the plant became infected. Avoidance through use of disease-free budwood, reinforced by regulations to limit movement, sale, and use of infected budwood or planting stock, were the principal control measures.

Founding of CCPP

The University of California's Citrus Research Advisory Committee (composed largely of prominent growers and nurserymen) asked the University to assume primary responsibility for developing and maintaining healthy germplasm banks, which were called "primary foundation blocks." The objective was (and is) to provide nurserymen, growers, and researchers with primary sources of disease-free budwood of desirable, true-to-name citrus scion and rootstock varieties under regulatory discipline of the Seed and Nursery Service of the California Department of Food and Agriculture.

The Citrus Variety Improvement Program, as it was then named, was funded and got under way in 1958. It was renamed the Citrus Clonal Protection Program (CCPP) in 1977 to indicate its functions more precisely and make clear that the program is not concerned with variety testing and breeding, except to provide and maintain healthy germplasm of promising clones.

The program

This program was organized as a joint effort of the departments of Plant Pathology and Horticultural Science (now Botany and Plant Sciences). It was planned in consultation with the Seed and Nursery Service and operates in close coordination with their Citrus Registration and Certification Program. Invaluable support in organizing and implementing the program was provided by the University of California Cooperative Extension, the county departments of agriculture, the U.S. Department of Agriculture, and the California Citrus Nurserymen's Society.

Broad policy of the present Citrus Clonal Protection Program is set by a committee, which includes members of the University departmental staffs concerned, Cooperative Extension, the U.S. Department of Agriculture, and the California Department of Food and Agriculture. The writer served as chairman of this committee for the first 15 years.

The physical resources of this program include the isolated greenhouses and screenhouses of the Rubidoux facility, the main foundation planting at the Lindcove Field Station, and small auxiliary plantings at Riverside and Lindcove. The program (excluding the seedling yellows tristeza work) has shrunk from about 5.5 to 6 man-years 10 years ago to about 3.5 to 4 man-years at present. Two highly skilled staff people, C.N. Roistacher and E.M. Nauer, have devoted a major part of their time to the project since its inception. Professor E.C. Calavan, project leader until recently, has been principal technical architect.

Estimates indicate that the University of California at Riverside has invested at least $1 million in this program over the past 22 years, excluding costs of structures, land, and other fixed facilities. Perhaps one-half of this cost could be appropriately charged to research and development and the rest to industry service. Since 1967, the service component has largely been funded by grants from the Citrus Advisory Board or its predecessor, the California-Arizona Citrus League. Both organizations are (or were) funded by levies on cartons of citrus fruit sold.

Research accomplishments

From the outset, research and service phases of the program were integrated as much as possible. The reduction from laboratory theory to practise revealed many inadequacies and defects in techniques as well as gaps in knowledge. Over the past 22 years, a great many refinements were developed, leading to cheaper, more rapid, and more positive indexing (virus detection) techniques and better methods of growing and maintaining the plant materials required. Perhaps the greatest advance, supported in part by personnel and research facilities of the CCPP, was the development of the heat therapy and shoot-tip micrografting techniques for rapidly obtaining pathogen-free clones from diseased clones. Previously, it was necessary to grow nucellar clones from seed to maturity to remove virus and virus-like diseases, a method that might require 10 to 15 years or more to produce usable disease-free budwood for commercial propagation. With monoembryonic varieties like the pummelos and Temple orange (a tangor), the old method could not be used, because seedlings are all zygotic, that is, genetically different from the mother plant.

Commercial impact

Most commercial orchards planted in California in the last 15 to 20 years have been established with nursery trees using budwood originating directly or indirectly from CCPP sources, or at least with budwood from trees judged to be free of most of the many newly identified bud-transmissible diseases. These newer, more uniform and productive orchards, now forming the major portion of the state's 300,000 acres of citrus, are almost entirely

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free of such debilitating diseases as psorosis and quick decline of oranges and exocortis of lemons. New plantings are perhaps 50 percent more productive, in tons per acre, than were orchards only 25 years ago.

Most of the quick-decline-infected orange orchards on sour orange rootstock are gone, as are older orange orchards infected with psorosis. Likewise, older lemon orchards riddled with shell bark have been pulled and replanted or converted to housing tracts. Hence, only older citrus people of my generation (World War II) can visualize the dramatic transformation that has taken place.

Of course, the current high average yield enjoyed by citrus growers cannot be entirely credited to the use of healthy CCPP budwood. Better cultural practices, denser plantings, and better disease-tolerant stocks are major factors. However, unless the orchards are planted with disease-free nursery stock, none of the potentials of the improved practices and tolerant rootstocks can be fully realized. Modern citrus production truly begins in the nursery.

The CCPP is now regarded worldwide as the model program to ensure the commercial production of disease-free nursery stock. Adaptations of this program have been established in most of the major citrus-producing countries.

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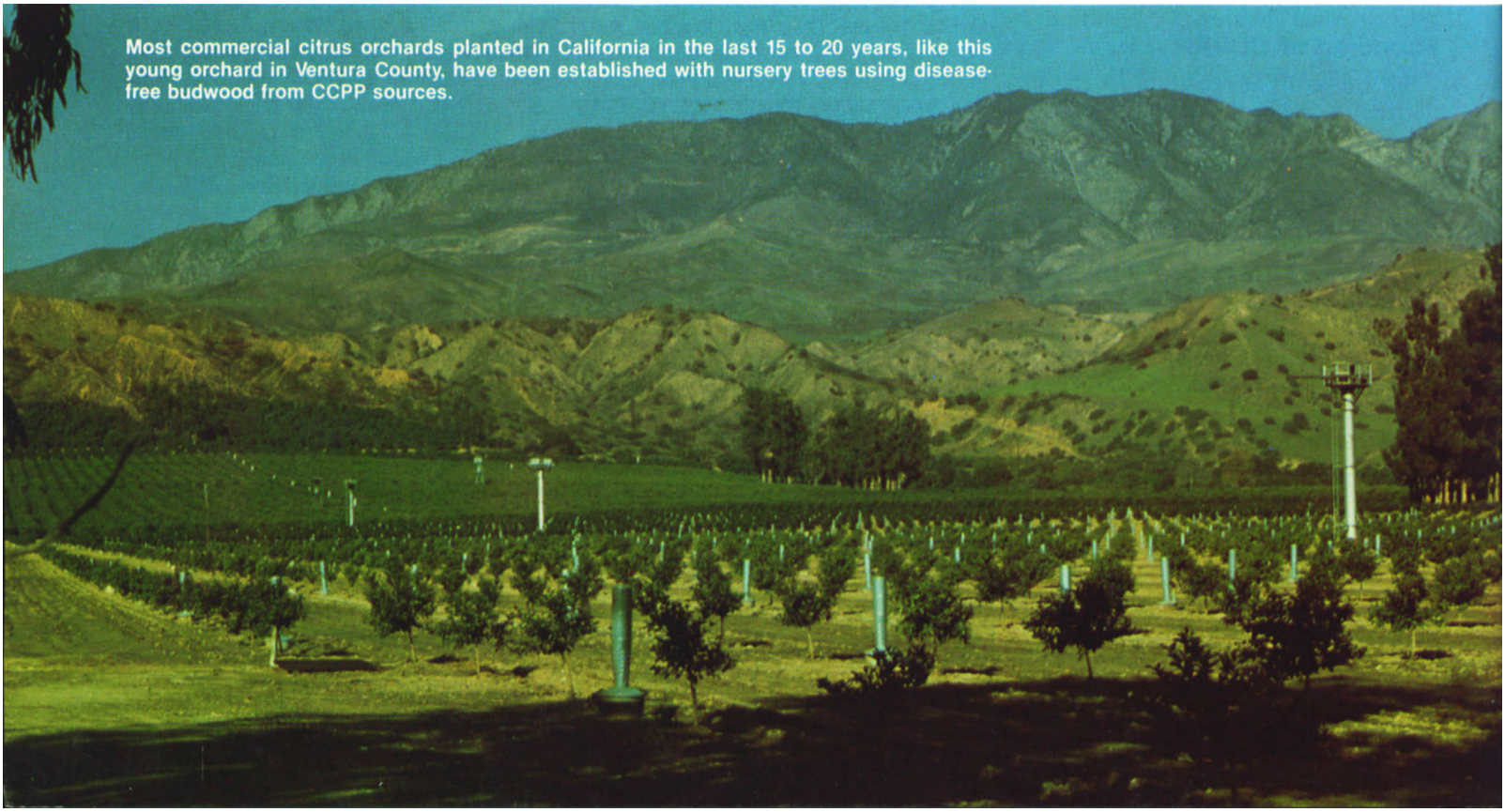

Most commercial citrus orchards planted in California in the last 15 to 20 years, like this young orchard in Ventura County, have been established with nursery trees using disease-free budwood from CCPP sources.