Analysis of the Devastation of Leaf-Mottling (Greening) Disease of Citrus and Its Control Program in the Philippines

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Leaf mottling, or greening disease, of citrus was first noted in 1957 in Batangas, Philippines (Nora, 1961). The citrus industry of Batangas and surrounding provinces declined thereafter, severely affected by the disease. The origin of the disease is not known but prior to 1957 introductions of citrus plants from the Peoples Republic of China, Nationalist China, and India were reported (Benemerito, 1956). We believe the disease spread to other parts of the country by many planting materials that were shipped from Batangas during the time when other areas, like the Bicol Region, expanded their citrus industry.

The symptoms of leaf mottling on Philippine citrus varieties have been described (Salibe, 1966; Martinez and Wallace, 1969; Salibe and Cortez, 1968). Vein-phloem degeneration in Indonesia, dieback in India, and greening in South Africa exhibit similar symptoms (Frazer, 1967; Calavan, 1968; Schwarz, 1968). The second author of this paper observed in 1967 that mandarin trees in Taiwan affected with likubin disease displayed symptoms similar to leaf mottling in the Philippines. Leaf mottling is characterized by yellow-green patterns on old leaves, similar to deficiencies of zinc, manganese, iron, boron and other trace elements. This makes field diagnosis difficult. According to Gonzales (1960), diseased trees will not respond to corrective sprays with any minor element and become uneconomical within a few years. Young infected trees come into early bearing at the age of three to five years. In mature trees one of the indications of serious infection is heavy fruiting. In either case, severe leaf mottling and dieback of twigs and branches follow, the trees become uneconomical and ultimately die.

Catling (1968) observed in Los Banos, Laguna that the vector, *Diaphorina, citri,* also breeds on *Murraya exotica,* a citrus relative. No other noncitrus host of the vector has been recorded in the Philippines.

The objectives of this paper are to evaluate local and foreign findings and observations, assess the effects of leaf-mottling on the citrus industry, and discuss the rehabilitation and development program in the Philippines.

ECONOMIC IMPORTANCE

Statistics recorded by the Bureau of Agricultural Economics, Department of Agriculture, Republic of the Philippines show that the area in mandarins and sweet oranges has decreased tremendously. In 1961, the mandarin area was 19,330 hectares for the entire country. By 1965, this dropped to 12,010 hectares; by 1970 it fell to 7,080 hectares and by 1974 it was only 4,840 hectares. The sweet orange area was highest in 1962 at 5,750 hectares. By 1965 it was 5,330; it fell to 4,600 hectares by 1970 and in 1974 was estimated at 3,470 hectares. Pummelo hectarage was greater than sweet orange; it was 6,910 hectares in 1962, 5,720 in 1965, 5,220 in 1970, and 4,200 in 1974. The pattern of calamondin was different; the area rose to 5,620 hectares in 1966 from 2,220 in 1960. In 1970 it was down to 4,380 but by 1974 had risen to 6,670 hectares.

It can be safely assumed that the major factor in the reduction of the area

planted to citrus, particularly mandarin and sweet orange, was leaf mottling. The severity of the disease was fully realized after a field survey of established orchards in Batangas in 1960 and in Bicol Region in 1961. It was in these areas where a great reduction in the area planted to mandarins and oranges occurred.

This reduction did not occur right after 1961. The diseased and uneconomical trees remained for sometime and were included in the total area planted. There have been some new plantings in many declined areas.

EVALUATION OF STUDIES AND FIELD OBSERVATIONS

Nature of the disease and its insect vector. Leaf-mottling disease is both bud and insect transmissible. Latest findings indicate that the cause is a mycoplasma-like organism and not a virus (Laflèche and Bové, 1970; Martinez *et al.*, 1971). The vector of the disease was confirmed as citrus psylla, *D. citri*, a jumping plant louse (Celino *et al.*, 1969).

Disease-vector relationships. In severely infested areas where the population of the insect vector is very high at certain times of the year, particularly during the rainy season or the flushing period, the disease spreads rapidly from one orchard to another. However, in some citrus areas where the population of the vector is very low, especially during the preflushing period, the spread of the disease is very slow, particularly when plantations are far apart. Martinez and Wallace (1967) demonstrated that it requires fairly large numbers of the vector to obtain much transmission of the disease. Citrus psylla is an inefficient flier (Catling, 1968; Bindra, 1970). Relevant to this, Gonzales (1969) observed that the insect is incapable of infesting an orchard 2 km away. The above are factors to consider in controlling the vector and in keeping trees free from leaf-mottling infection.

Behavior of citrus types when infected. Gonzales (1971) observed that 10-year-old Szinkom-Ladu mandarin hybrid trees in an infected area kept flushing and producing normal fruits every year in spite of the presence of varying amounts of infection. Viñas and Honrade (1974) observed similar reactions on full-grown, bearing trees of calamondin, lime and lemon in orchards in an infested area. Other varieties growing under similar conditions progressively declined and became unproductive. No insect vector was observed in the experimental orchards because of regular spraying. When citrus budlings were planted adjacent to severely infested orchards with high vector populations, they declined at an early age.

Possibly the ability of some kinds of citrus trees to withstand infection depends upon the low concentration of the pathogen in the plant system. In the presence of a high population of the insect vector there may be an intensification of natural transmission thereby increasing the population of the pathogen and leading to rapid decline. Further investigation is needed to confirm this theory.

CONTROL

The following control measures have been devised: (1) in 1969, a quarantine measure, through an administrative order by the Secretary of the Department of Agriculture, was issued to prohibit entry of citrus planting materials into non-infested areas; (2) several insecticides tested and used locally in a citrus spray program appeared effective in controlling the vector (Celino and Molino, 1971); (3) treatment of citrus budwood with tetracycline compounds inactivated the leaf-mottling pathogen (Martinez *et al.*, 1971); (4) the resistance of different citrus varieties was tested. Martinez and Wallace (1969) tested 45 citrus varieties and relatives under greenhouse conditions. Observations revealed that varieties of lime, lemon, grapefruit, and pummelo showed mild to moderate symptoms. Trifoliate orange and its hybrids had no foliar symptoms although

recovery tests for the presence of the pathogen gave positive results. Mandarin and sweet orange varieties grafted on trifoliates and its hybrids developed symptoms of leaf mottling after inoculation. Gonzales *et al.*, (1969) tested the resistance of 110 citrus cultivars. They noted that calamondin, lime, lemon, and some kinds of pummelo and mandarin hybrid trees remained mildly infected after three years exposure to natural infection. Eventually, after other types of citrus trees declined, these trees also declined following the build-up of high vector populations.

PROGRAM FOR REHABILITATION AND DEVELOPMENT

Disease-free trees of commercial varieties of citrus, mostly promising mandarins and their hybrids, pummelos, and sweet oranges, still exist in certain citrus growing areas of the Philippines. Selection of scion sources has been based on the following criteria: tree vigor, freedom from any visible symptoms of leaf mottling or other graft-transmissible diseases, regular yields of quality fruits, trueness to type, freedom from undesirable bud mutations, and freedom of adjacent trees from any visible leaf-mottling symptoms. Selected trees were subjected to short-term indexing for noninsect-transmissible diseases. Those that passed were tagged as mother trees and served as sources of scions for the Rehabilitation and Development Program.

The Bureau of Plant Industry Experiment Station at Lipa City was chosen as the starting point and center for this program because of its site, which is surrounded by wide areas of sugar cane plantations (sugar cane is now grown in areas previously planted to citrus wiped out by leaf mottling). Progeny budlings of different cultivars from selected mother trees will be planted at this station to serve as a scion-grove source of disease-free propagative materials. A commercial type orchard will also be established for demonstration. With present knowledge of the disease, a healthy, normal orchard can be grown.

The program aims at reviving and developing the once multimillion dollar citrus industry. In order to attain this objective, the following guidelines or strategies have been developed.

Batangas province task forces have been created to undertake an information drive for the total eradication of known diseased trees in existing orchards.

Prerequisites for the establishment of scion groves and new commercial orchards in the diseased areas are the elimination of existing sources of inoculum, isolation of new plantings, and restruction of plant materials without certification papers. A rigid periodic spray program will be undertaken throughout the year to control the population of the insect vector.

The program requires that all citrus nurseries in the citrus development areas shall be guided by and registered with the Bureau of Plant Industry. Registered citrus nurseries will be required to abide by the following operational procedures: (1) isolation of nursery site, including freedom from sources of inoculum or infected trees within a radious of 1 km; (2) maintenance of rootstock liners and nursery stock free from insect vectors from germination to disposal of the budlings; (3) proper training and guidance in detecting the common symptoms of leaf-mottling disease and other bud-transmissible diseases; (4) certification of budwood from the source of origin (scion groves) by the BPI technician of the citrus development program; (5) treatment of budwood for propagation with tetracycline in the presence of BPI technicians; (6) a regular spraying program, as soon as budlings start growing, to prevent infestation by the insect vector, other pests, and diseases.

The above procedures will prevent infection in nurseries from germination to the time that budlings are released to commercial growers.

Prospective citrus growers will be requred to notify the Director of Plant Industry, who in turn will send technical men to inspect their site for suitability to

citrus culture. To qualify, the orchard site and surroundings for 1 km must be free of leaf mottling-infected trees.

Both nurserymen and orchardists will be required to use the periodic spray program under strict supervision and guidance of BPI fieldmen assigned to their respective areas. These fieldmen will conduct biweekly inspection of their nurseries and/or orchard trees for any occurrence of insect pests and diseases and recommend the appropriate chemicals.

Special quarantine measures will be adopted to regulate the movement of citrus plant materials from one area to another. All citrus for planting will be required to carry certification papers from the point of origin for verification in inspection centers and quarantine stations throughout the citrus growing areas of the country.

This program will also provide incentives to citrus growers who participate in the rehabilitation and development efforts, i.e., technical and credit assistance, subsidized inputs and marketing assistance.

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