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Studies on Citrus Greening Disease in Southern Japan

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Citrus is a major Japanese crop. It was thus necessary to learn whether greening disease was present in the southernmost areas of Japan, where there was some likelihood of its occurrence. Matsumoto *et al.* (7) reported that likubin (greening disease) was widely distributed in Ponkan and Tankan varieties in Taiwan. One of the Ryukyu Islands, which are south of Kyushu, is only 70 miles from Taiwan. The vector of greening disease in Taiwan, citrus psylla (*Diaphorina citri* Kuw.), has been

found distributed on the nearby Japanese islands, where the climate is similar to that of Taiwan (9). These facts, together with the report by Martinez *et al.* (6) that citrus transported from Japan to the Philippines carried the greening pathogen, prompted surveys in 1970 and 1971 to learn whether greening disease occurred in the Japanese islands. In this paper, which reports the present status of the greening problem in Japan, greening and likubin are considered the same disease.

DISTRIBUTION OF CITRUS PSYLLA

Citrus psylla has been found in low populations on the Ryukyu Islands, but it is not known to occur on the mainland of Kyushu. Psylla population

seems to be higher in the southern area of Ryukyu than in the northern area, and heavy infestations have resulted in occasional injuries on new growth.

SURVEYS FOR CITRUS GREENING DISEASE

Three methods were used to diagnose greening: leaf and fruit symptoms in the field (8); grafting to citrus indicator plants (3); and electron microscopy of ultrathin sections of leaf tissues (2, 4, 5).

Field observations. In May, 1970, the authors surveyed citrus orchards in the peninsula of Kagoshima and on the islands of Amami and Okinoerabu south of Kyushu. Citrus varieties in these areas consisted of Ponkan, Satsuma, and certain others grown mostly on *Poncirus trifoliata* (L.) Raf. rootstock and occasionally on *Citrus depressa* Hay. Trees showing abnormalities were mostly those on *P. trifoliata* rootstocks. Ponkan trees on *P. trifoliata* in this area often were low in vigor from some undetermined cause. Symptoms included yellowing of the leaves and leaf veins as well as patterns resem-

bling nutritional disorders (1). Declining trees in some cases were observed to recover and show improved tree vigor after being inarched with another rootstock, such as *C. depressa* or *C. junos* Sieb. ex Tan. Trees in the districts surveyed were mostly young, and distribution of the abnormal trees was irregular.

In November, 1971, the survey was extended to the islands of Okinawa, Miyako, and Ishigaki, where about 1,200 acres of Satsuma, Tankan, and other miscellaneous varieties of mandarins are grown. Nursery trees of Tankan on Sunki rootstock had been imported from Taiwan and planted in several groves on these islands.

In 11 orchards inspected in Okinawa, Miyako, and Ishigaki, symptoms similar to those in trees in Amami, and

resembling those of greening were occasionally seen in Satsuma and Tankan trees. The symptoms were quite different, however, from those of likubin in Taiwan. Fruit of suspect trees were almost normal in size and shape and in seed formation. Samples obtained from these trees were used for electron microscopy.

In citrus orchards in Okinawa, Tankan trees on Sunki rootstocks recently imported from Taiwan developed slight yellowing of the leaves, and were defoliated. Fruit of the declined trees was apparently normal.

Indexing to indicator plants. Five trees in Amami showing suspected symptoms of greening were indexed for greening by bud inoculation into Ponkan and Sunki seedlings. Six months after inoculation, no positive reaction for greening was obtained. An isolate of likubin, obtained from Dr. H. J. Su in Taiwan, and used as a check for comparative observation of symptoms, induced good greening symptoms in indicator plants. All of the Amami suspects carried tristeza virus, as indicated by the Mexican lime test.

DISCUSSION AND CONCLUSIONS

Extensive field observations were made, in the southern islands of Japan, of abnormal citrus trees showing symptoms of nutritional and physiological disorders and, in some cases, symptoms resembling those of likubin or greening. Fruit was normal when compared with those of healthy-appearing trees of the

One-year-old Ponkan trees showing vein yellowing and zinc deficiency-like symptoms were transplanted into pots in a greenhouse. New leaves that developed after transplanting showed no symptoms of greening. These results suggest that the suspected symptoms were probably caused by other than the greening pathogen.

Electron microscopy. Buds from the trees showing suspected symptoms of greening in Amami were budded onto Troyer citrange. New leaves of some plants showed chlorotic leaf symptoms of greening. Ultrathin sections of leaves obtained from these trees were examined under the electron microscope. None revealed the greening or likubin pathogen.

Electron microscopic examination was made of leaves from suspect trees in several orchards in Okinawa and Ishigaki, including trees of Tankan, Satsuma, and two other varieties, and declined trees of Tankan on Sunki roots which had been imported from Taiwan. None of the samples showed positive evidence of the pathogen of greening or likubin.

same varieties. Limited indexing with citrus seedlings indicated that the disorders were nontransmissible.

Electron microscopy of these trees revealed no evidence of the pathogen of greening. It is therefore unlikely that citrus trees of Japan have been contaminated or affected by greening.

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