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Survey and Indexing for Citrus Exocortis and Other Viroids in Sichuan Province

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ABSTRACT. Citrus production is an important industry in the rural economy of Sichuan Province. Citrus exocortis and other viroids have become one of the obstacles to citrus production in the province and its control has been neglected in the past. During surveys conducted for exocortis and other viroids from 1986-1990, viroid symptoms were found in 44 out of 58 counties. Upon further inspection, 911,500 plants of sweet orange or lemon grafted on trifoliolate orange rootstock were inspected in 36 counties and 8.8% of the trees showed viroid symptoms. Viroid infection was confirmed by indexing on citron indicators in seven of 21 samples collected in six counties. The yield of citrus infected with exocortis and other viroids was 73.6% lower than that of healthy trees. Propagation using virus-free budwood is recommended for viroid control.

Key words. Indexing, inspection, viroid incidence, yield reduction.

Sichuan is the main citrus-producing province in China, with more than 60 million trees of bearing age planted over 166,667 ha in 172 counties. During 1987 to 1990, the average annual yield reached about 700 thousand tons, worth more than 500 million yuan (U.S. \$60 million) value. Citrus production is an important industry for the rural economy in Sichuan, however, the threat and control of citrus virus and virus-like diseases for the improvement of this industry has been neglected in the past.

Exocortis and other viroids cause severe diseases which damage citrus propagated on trifoliolate orange, citrange and Rangpur lime rootstock. Viroids are widely distributed in citrus-producing areas in the world and are spread mainly by propagative material and contaminated tools. Typical symptoms of exocortis and other viroids have been found in Sichuan, Guangxi, Zhejiang, Hunan, Hubei and Guangdong Provinces on varieties introduced from other countries, and also in some native cultivars (2). In Sichuan, the navel orange was introduced from the U.S.A. in 1930's; Valencia orange and blood orange in the 1940's; and Washington, Sanguine, Cadenera, etc. were introduced from Morocco in 1960's. Most trees of these intro-

duced varieties show viroid symptoms if propagated on trifoliolate orange. Some trees of native sweet orange also showed symptoms in the field.

The trifoliolate orange has been the recommended rootstock since 1960 and it is now used in more than 40% of the planted trees. Meanwhile, a large number of budlings and budwood infected with exocortis and other viroids were circulated and has resulted in the spread of these diseases throughout Sichuan.

To determine the distribution of exocortis and other viroids in Sichuan, the project "Inspection and Indexing of Exocortis Viroid in Sichuan Province" was carried out cooperatively by the Provincial Plant Quarantine Station, Whuhan Institute of Virology, Plant Protection and Quarantine Station of different counties and the Propagation Station of Fruit Crops of Sichuan in 1986 to 1990. The results of this project are reported here.

The general field observations of citrus in Sichuan Province revealed that viroids existed in 44 of the 58 counties inspected. Detailed field inspection was done in 36 counties located in the important citrus producing areas of Sichuan from 1987 to 1989. The total citrus area was 77,289 ha and three orchards from

each county were inspected tree-by-tree. This involved 8,498,671 trees in an area of 11,460 ha and included 911,500 trees on trifoliolate rootstock which were more than 5-yr-old. Scaly bark of the rootstock and dwarfing were the criteria used for recognizing trees infected with viroids. Viroid symptoms were found only on citrus trees with trifoliolate orange rootstock, and never on seedling trees or trees on other rootstocks.

Viroid symptoms were found on 79,972 trees in 30 counties, or 8.77% of the trees inspected in 36 counties, whereas 69,005 trees with trifoliolate orange rootstock in six counties were symptomless. The highest incidence of exocortis for sweet orange in a single county was 40.1%, and for lemon it was 80.0%.

In addition to determining the incidence of viroids in some areas of 36 counties, their effect on plant growth and productivity was evaluated by comparing growth parameters of 697 diseased and 666 healthy trees in eight counties. The height of diseased trees was reduced by 50.7 cm as compared to healthy trees, which constitutes a dwarfing rate of 23.5%. The trunk circumference was reduced 4.8 cm and averaged 22% less than healthy trees. The canopy diameter of diseased trees was reduced 50.2 cm in an east-west direction as compared to healthy trees, and 56.3 cm in a south-north direction; a reduction of 22.7% and 25.3%, respectively. The mean canopy volume of diseased and healthy trees was 2.7 m³ and 6.3 m³, respectively, for a 58.3% reduction in canopy volume. The number of leaves on diseased trees was reduced by 13,021 and the leaf surface was reduced 29.4 m² per tree as compared to healthy trees for a reduction of 69.9%. Root growth of healthy trees had eight main roots with a total length of 426 cm, 21 lateral roots with a total length of 348 cm, and numerous fibrous roots. Dis-

eased trees had four main roots which totaled 175.5 cm, seven lateral roots which totaled 207.5 cm, and a few fibrous roots. The fruit number of diseased trees was reduced by 77.4 fruits as compared to healthy trees; a reduction of 68.1%. The fruit weight was reduced 21.1% and total productivity was reduced 73.6%.

Etrog citron Arizona 861-S1 was used as the indicator plant for the indexing of exocortis and other viroids. Twenty-one samples of eight citrus cultivars were collected from symptomless trees planted in six of the most important citrus-producing counties. These were indexed from 1987 to 1989 and the results revealed that seven samples representing four cultivars were confirmed to be infected with viroids.

Since viroids are distributed in most citrus areas and trifoliolate orange is an important rootstock in Sichuan, the propagation and distribution of virus-free budlings and budwood should be emphasized in the control of exocortis and other viroids. The citrus virus-free propagation project was organized by the Department of Agriculture and Animal Husbandry of Sichuan provincial government in 1986 with cooperation by the Citrus Research Institute and other institutes and universities (1). A virus-free mother block was established in a Huanglongbing-free area. Progeny plants of 28 superior lines of important citrus cultivars in Sichuan were obtained by shoot-tip grafting and confirmed to be exocortis and tatter leaf-free by indexing on indicator plants. Ten nurseries were developed in different counties, and 70 million budlings have now been distributed from this project.

In some cases where viroid-free material is not available, tolerant rootstock such as tangerine are used.

Inarching with a tolerant rootstock was practiced in some areas by

farmers to recover diseased trees. Since the recovered tree remains an

inoculum source inarching is not recommended as a general practice.

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