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Citrus Virus Diseases in Japan

IN JAPAN, studies of citrus virus diseases have been initiated only recently and the role of viruses is, therefore, not clearly understood. We would like, however, to describe the progress we have made in our studies of seven disorders in citrus in Japan, which appear to be caused by viruses.

Satsuma Dwarf

Satsuma dwarf (Fig. 1A, B), previously reported by Yamada and Sawamura (11), has been known in Japan for 20 years. It is widely distributed and causes severe damage in some groves but is less severe and sometimes not apparent in other groves.

Since 1956 we have been carrying out extensive indexing of Satsuma orange trees to Mexican lime and sour orange seedlings (8). The indexing has shown that nearly all trees, except very young seedlings, are infected with tristeza virus. Our tests included trees from all the popular clonal strains of Satsuma orange. Some inoculated limes and sour oranges also showed leaf flecking and oak-leaf zonation characteristic of psorosis (9). We have almost always found the leaf symptoms of psorosis on Satsuma orange trees showing symptoms of dwarf disease. On lime seedlings affected by inoculation with buds from severely diseased Satsuma trees, the newly developing shoots were small and yellowish, and soon dropped off. This symptom resembled seedling yellows (5), but Eureka lemon seedlings inoculated with buds from the same Satsuma

trees developed no symptoms typical of seedling yellows. There was evidence, however, of tristeza virus strains, which ranged from mild to severe on Mexican lime. We have not found definite symptoms of stubborn disease on the trees infected with Satsuma dwarf.

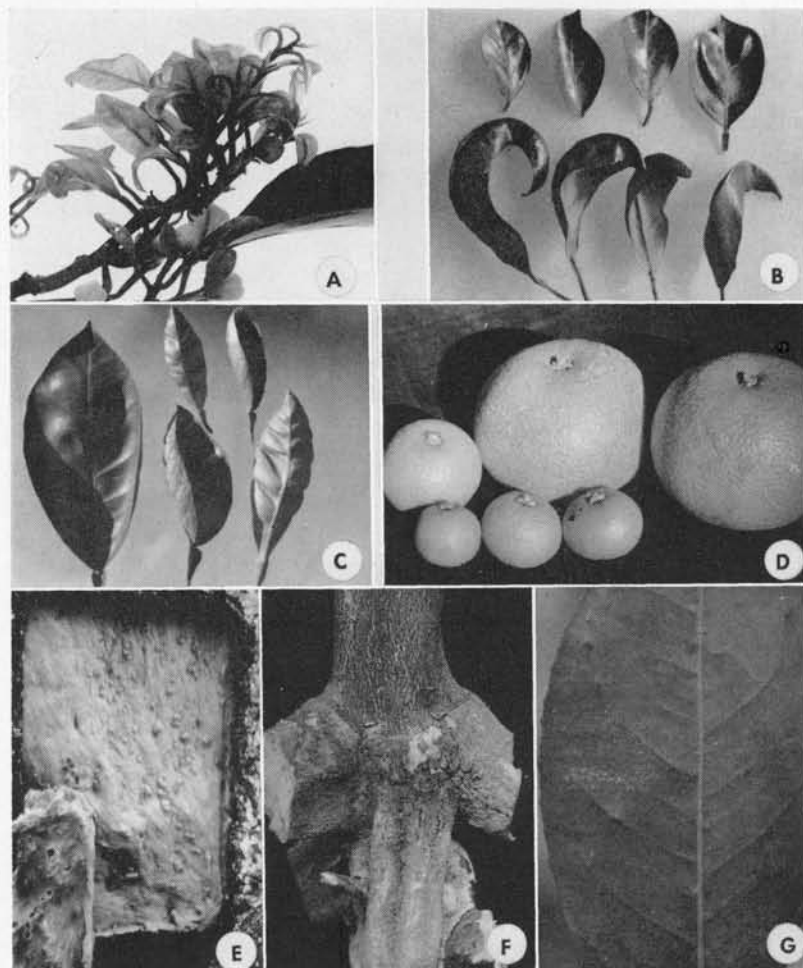


FIGURE 1. A. Satsuma dwarf; symptoms on young fruit. B. Satsuma dwarf; symptoms on mature leaves. C. Hassaku dwarf; leaf symptoms. D. Hassaku dwarf; symptoms on mature fruit. E. Inverse pitting on Satsuma. F. Exocortical-like symptoms on trifoliata rootstock under Satsuma. G. Vein enation on standard sour orange inoculated with Satsuma dwarf.

Oleocellosis-Like Symptoms of Satsuma Orange

Oleocellosis-like symptoms of Satsuma fruits have been reported from Wakayama Prefecture where they have been thought to be due to a graft-transmissible disease (6). In our experience, the symptom on fruits makes its appearance on trees that also show severe symptoms of Satsuma dwarf and leaf zonation of psorosis. In the lime test, severe vein clearing and stem pitting appeared, showing that the Satsuma trees were infected with tristeza virus. It appears that the oleocellosis-like symptoms of Satsuma orange may be caused by an undescribed virus or virus complex. In view, however, of the resemblance of the fruit symptoms to the concentric ring blotch caused by mite infestation in South Africa (4), the Satsuma fruit disorder may prove to be caused by mites.

Hassaku Dwarf

Hassaku (*Citrus hassaku*) is the third most popular variety of citrus in Japan. A dwarf disease has been noticed on Hassaku for 30 years. It causes fatal damage within 15 to 20 years after planting. Symptoms of this disease make their appearance on leaves, trunks, branches, and fruits (Fig. 1,C and D). Leaves of infected trees are small, pale in color, and crinkled, but they are not mottled. Internodes are abnormally short. Leaf blades fold upward along the midribs. The number of abnormal small leaves increases year by year. On the trunk and branches, bark is rough and sometimes warty, and usually exhibits narrow longitudinal furrows or concavities. Sometimes furrows or concavities on the old trunk are very much like those of concave gum psorosis, but no oak-leaf zonation appears on the leaves. When the bark is cut off, stem pitting or deep furrows are seen on the woody tissue. A gummy substance or resin is excreted at concave lesions. Such symptoms are more conspicuous on the trunk than on small branches. The whole tree is reduced into quite a dwarf form within 20 years. Fruits are very small in size, with thick rinds, not juicy, but no speckles on the skin. They are often malformed, but not acorn-shaped. The fruit symptoms are somewhat like those of stubborn disease, but neither the color of the albedo changes into blue nor is special odor of rinds noticed. The affected trees bloom abundantly but most of the blossoms drop prematurely.

The above-stated symptoms are generally seen when *Trifoliata* is used as a stock, when Summer orange (*Citrus natsudaidai*) is used, but very rarely on self-rooted Hassaku.

Virus obtained from dwarfed Hassaku trees causes severe vein clearing, vein corking, and stem pitting on Mexican lime, and it also causes mild vein clearing on Daidai, or Japanese sour orange, and standard sour orange. No psorosis-like leaf zonation was found on either lime or sour orange seedlings inoculated with buds from the diseased Hassaku trees.

Judging from symptoms of naturally-infected trees as well as the results of the inoculation experiments, Hassaku dwarf appears somewhat like tristeza in nature, but rootstock relations are quite different because Hassaku trees on Trifoliata rootstock are very susceptible to this disorder. Since all affected trees tested so far have yielded tristeza virus and the trees show wood pitting symptoms like those of grapefruit stem pitting, indications are that Hassaku dwarf may actually be caused by tristeza virus.

Summer Orange Dwarf

Summer orange (*Citrus natsudaidai*) is the second most important variety of citrus in Japan. This variety is generally very vigorous and almost free from tristeza virus under natural conditions. The senior author, however, found what appeared to be Satsuma dwarf symptoms on several trees of this variety in Yamaguchi Prefecture in May, 1960. Inoculations made with buds from these trees caused striking vein clearing and stem pitting on lime seedlings, whereas inoculations with buds from healthy Summer orange trees caused no reaction or only slight vein clearing and stem pitting in the lime test.

Bark Pitting (Inverse Pitting)

Recently, severe defoliation of Satsuma orange occurred during the season from late fall to early spring in various areas in Japan. No virus-like symptoms have been seen on those shedding trees, but the greasy spots caused by *Mycosphaerella horii* were often found on the leaves. When the bark of those trunks was cut off, distinct pits were seen on the cambial face of the bark and tiny pin-like pegs on the wood quite similar to the symptoms of bark pitting described by Childs (3) or inverse pitting by Reichert (7) (Fig. 1,E). Inoculations to lime seedlings caused rather distinct vein clearing. Thus it was demonstrated that tristeza virus

was present, but we have not proved that the affected trees carry xyloporosis virus.

Exocortis-Like Symptoms

The authors found another virus-like disease on Satsuma orange on Trifoliata rootstock in Hiroshima Prefecture. However, it is not widespread in Japan. Its symptoms (Fig. 1,F) resemble those of exocortis, but we have failed to prove it to be true exocortis by means of the color test described by Childs, Norman, and Eichhorn (2). It may be similar to the one with exocortis-like symptoms which was reported by Calavan, Soost, and Cameron (1).

Vein Enation Symptom

In September, 1959, some apparently healthy buds of Miyagawa strain (Wase-Satsuma) and also Eureka lemon were budded on standard sour orange. In April, 1960, vein enation, like that reported by Wallace and Drake (10), appeared on young leaves of sour orange (Fig. 1G). The affected sour orange had often weakened in its growth, but when the same scions were budded on Mexican lime and also on two varieties of lemon, Eureka and Villafranca, no symptoms were produced on these test plants. Moreover, when Satsuma orange affected with Satsuma dwarf or bark pitting and apparently healthy Washington Navel orange were budded on Daidai (Japanese sour orange, *Citrus aurantium* forma *Kabusu*), vein enation developed on Daidai. At the same time, inoculations with buds from trees showing Satsuma bark pitting and from apparently healthy Washington Navel orange caused slight vein clearing on Daidai. On the other hand, Hassaku dwarf caused no vein enation on Daidai.

In view of the results of those experiments, it is suggested that some strains of Satsuma, Eureka lemon, and Washington Navel orange may carry vein enation virus and that Daidai, Japanese sour orange, is useful as an indicator plant for this virus.

From these preliminary studies it is evident that the viruses of both tristeza and psorosis are common in the citrus of Japan. It is also evident that much experimental study will be required to determine the role of these and other viruses as causal agents of the disorders that we have tried to describe in this report.

PROCEEDINGS of the IOCV

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