The Cause of Stem Pitting and Small Fruit in Natsudaidai Trees

H. OMORI and H. MATSUMOTO

THIS PAPER is concerned with a severe disease of natsudaidai—next to satsuma, one of the most important varieties of citrus in Ehime Prefecture. Growers have given it the name "ishidama-mikan," meaning stone-like fruit, because fruit on affected trees are depressed in growth after the June drop and their rind surface becomes abnormally smooth, lustrous, and hard (Fig. 1). The small

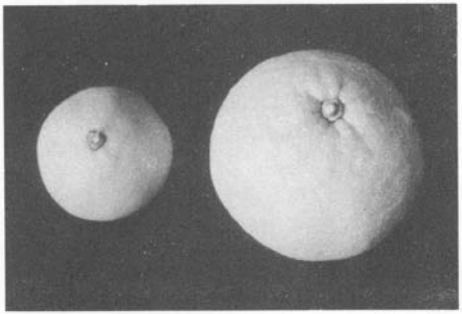

FIGURE 1. *Fruit from an affected (left) and a healthy natsudaidai tree.*

fruit are very similar to those found on dwarfed trees of the Kawanonatsukan, one of an early variety of natsudaidai, in Ooita Prefecture (2) and on hassaku trees affected by hassaku dwarf (4, 5). They are found on 10–40-year-old trees in southern parts of the prefecture and are responsible for considerable decrease in yield.

Procedures and Results

FRUIT SIZE.—The transverse diameters of 223 fruit of an affected 20-year-old tree and of 187 fruit of a healthy one were measured at harvest time, 1 December 1967. Fruit from the affected tree ranged in diameter from 3.0 to 9.6 cm, with a mean of 7.45 cm and a standard error of 0.04. Those from the healthy tree ranged in diameter from 8.3 to 10.2 cm, with a mean of 9.27 cm and a standard error of 0.02. Thus, the difference between the maximum and minimum sizes is greater for fruit from an affected tree than the difference between these sizes of fruit from a healthy tree.

TABLE 1. OCCURRENCE OF STEM PITTING IN TWIGS FROM AN AFFECTED NATSUDAIDAI TREE

Age of twig (years)	No. twigs examined	Percentage of twigs with stem pitting of various degrees of severity			
		None	Mild	Moderate	Severe
1	408	34.1	52.9	13.0	0
2	443	2.9	39.3	43.6	14.2
3	246	3.7	24.0	44.7	27.6
4	100	0	33.0	31.0	36.0

A characteristic of the disease is that only 1–4-year-old twigs develop pitting. However, growth of the crown of affected trees seems normal, and, with the exception of somewhat small leaves, no specific syndromes, such as curling or malformation of leaves or ropy trunk, are found. The disease occurs in trees on their own roots and in trees on yuzu and trifoliate orange rootstocks.

Since the cold winter of 1963, the disease has become prevalent in most of the natsudaidai-growing areas of Ehime prefecture—mostly the southern part—where approximately 4,000 hectares are devoted to natsudaidai groves. About 3 per cent of the groves are affected. Many severely affected groves have been replanted to other citrus varieties.

STEM PITTING.—Observations of pitting in a variable number of twigs 1, 2, 3, and 4 years old—from the affected tree mentioned above—were also made on 1 December 1967 (Table 1). About 66 per cent of the 1-year-old twigs had pitting, but the severity of pitting was usually mild. Almost all 2-, 3-, and 4-year-old twigs were pitted, and the severity of pitting ranged from mild to severe. No pitting was, however, observed in the large vigorous

branches and trunks of affected trees. In contrast, trees affected by hassaku dwarf develop very severe pitting even in old branches and have many furrows or concavities in their trunks. Field observations in many citrus-growing districts indicate that almost all healthy appearing natsudaidai trees have no pits in their branches and trunks, or very mild pits.

INOCULATION OF INDICATOR PLANTS. —Indicator plants were inoculated to test for the presence of an infectious agent in trees affected by ishidamamikan. Small, potted 2-year-old seedlings, selected for uniformity, of Mexican lime, Eureka lemon, rough lemon, marumera, natsudaidai, standard sour orange, Valencia sweet orange, shiikwasha, and calamondin were inoculated by budding with buds from 4 severely affected natsudaidai trees and 3 healthy ones growing in various locations in Ehime Prefecture. Three seedlings of each cultivar were inoculated. As controls, buds of a dwarfed tree of Kawanonatsukan from Ooita Prefecture and of a hassaku tree severely affected by hassaku dwarf, HDV-34, from Hiroshima Prefecture were grafted into comparable indicator plants. The indicator seedlings, growing in an insect-proof glasshouse, were cut back to a height of 15 cm immediately before inoculation in March 1969. They were observed for symptoms in September 1969 and March 1970.

Sap from the leaves of the affected natsudaidai trees mentioned above was used to inoculate white sesame and Satisfaction kidney bean plants since they are the best indicator plants for satsuma dwarf virus (1, 3), and they react to the causal virus of natsudaidai dwarf found in Yamaguchi Prefecture (6).

Symptoms appeared within 6 months in the Mexican lime seedlings inoculated with buds from both healthy and affected natsudaidai trees, the dwarfed Kawanonatsukan trees, and the dwarfed hassaku trees. They consisted of mild to severe vein clearing, no to severe vein corking, moderate to severe stem pitting, and no to severe stunting. Only the seedlings inoculated with buds from the healthy appearing natsudaidai trees failed to develop vein corking and to become stunted. The evidence indicates that all the affected natsudaidai trees carried a severe strain of tristeza virus and that the healthy appearing natsudaidai trees carried a mild strain.

Seedlings of marumera inoculated with buds from the affected natsudaidai trees and the dwarfed Kawanonatsukan trees also developed vein clearing, vein corking, and stem pitting. Almost all seedlings of Eureka lemon, rough lemon, natsudaidai, standard sour orange, Valencia orange, shiikwasha, and calamondin developed vein clearing and stem pitting 6–12 months after inoculation, but no other symptoms. None of the inoculated seedlings of white sesame and Satisfaction kidney bean developed symptoms.

Conclusions

The results lead to the conclusion that ishidama-mikan of natsudaidai is caused by a stem-pitting strain of tristeza virus and that it is different from satsuma dwarf and natsudaidai dwarf. The fruit symptoms of affected natsudaidai trees are similar to those of dwarfed Kawanonatsukan trees in Ooita Prefecture and of hassaku dwarf. Evidently these 3 diseases are caused by similar strains of tristeza virus.

Literature Cited

1. KISHI, K., and TANAKA, S. 1964. Studies on the indicator plants for citrus viruses. II. Mechanical transmission of the virus causing Satsuma dwarf, to sesame (Sesamum indicum L.). Ann. Phytopathol. Soc. Japan 29: 142–48.
2. NAKAMURA, S. 1965. Dwarf on Kawanonatsukan. Kazyu-Engei 18: 38–40.
3. TANAKA, S., and KISHI, K. 1963. Studies on indicator plants for citrus viruses. I. Mechanical inoculation on leguminous plants with sap from satsuma dwarf tree. Ann. Phytopathol. Soc. Japan 28: 262–69.
4. TANAKA, S., and YAMADA, S. 1964. Studies on hassaku dwarf. I. Symptomatology and the causal virus. Bull. Hort. Res. Sta., Japan, Ser. B, 3: 67–82.
5. TANAKA, H., YAMADA, S., and KISHI, K. 1968. Cross protection tests on the tristeza virus strains carried in satsuma mandarin and hassaku trees. Bull. Hort. Res. Sta., Japan, Ser. B, 8: 79–90.
6. YAMADA, S., and TANAKA, H. 1968. Virus diseases of the citrus and researches conducted on them in Japan. Japan Agr. Res. Quart. 3: 10–14.