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 Oita 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.

**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

<table>
<thead>
<tr>
<th>Age of twig (years)</th>
<th>No. twigs examined</th>
<th>Percentage with stem pitting</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>None</td>
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<tr>
<td>1</td>
<td>408</td>
<td>34.1</td>
</tr>
<tr>
<td>2</td>
<td>443</td>
<td>2.9</td>
</tr>
<tr>
<td>3</td>
<td>246</td>
<td>3.7</td>
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<tr>
<td>4</td>
<td>100</td>
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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 ishidama-mikan. 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 ob-

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 Ya-
maguchi Prefecture (6).

Symptoms appeared within 6
months in the Mexican lime seed-
lings inoculated with buds from both
healthy and affected natsudaidai
trees, the dwarfed Kawanonatsukan
trees, and the dwarfed hassaku
trees. They consisted of mild to se-
vere 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 natsu-
daidai trees carried a mild strain.

Seedlings of marumera inocu-
lated with buds from the affected
natsudaidai trees and the dwarfed
Kawanonatsukan trees also devel-
oped vein clearing, vein corking,
and stem pitting. Almost all seed-
lings 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 kid-
ney 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 Kawanonatsu-kan trees in Oota Prefecture and of hassaku dwarf. Evidently these 3 diseases are caused by similar strains of tristeza virus.

Literature Cited