Mechanical Transmission of Viruses of Satsuma Dwarf, Citrus Mosaic, Navel Infectious Mottling, and Natsudaidai Dwarf to Herbaceous Plants

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Satsuma dwarf virus (SDV) has been transmitted from citrus to sesame and 16 varieties in nine species of leguminous plants (*5, 9*). The viruses of citrus mosaic (CiMV), navel infectious mottling (NIMV), and Natsudaidai dwarf (NDV) were mechanically transmitted to sesame, Blackeye cowpea, and Satisfaction kidney bean plants (*3, 4, 6, 7, 8*). The latter three viruses are considered by the authors to be related to Satsuma dwarf virus, because all cause the typical boat-shaped, malformed leaves on Satsuma seedlings by graft inoculation, and all produce the same symptoms on sesame seedlings by means of sap inoculation.

This paper describes a host-range study made with these viruses and with some of the psorosis viruses. A secondary goal was to find suitable local lesion and production hosts for bioassay and purification of the causal viruses.

MATERIALS AND METHODS

Inocula. Sources of SDV, CiMV, NIMV, and NDV were infected plants maintained at the Laboratory of Plant Pathology, Akitsu Branch, Fruit Tree Research Station. Citrus-variegation virus (CVV) and citrus crinkly-leaf virus (CCLV) (California strains) came from France, and psorosis virus, presumably the concave gum strain, came from Spain. Soft, young leaves of citrus trees and/or Blackeye cowpea plants singly infected with the above-mentioned viruses were used for inocula. Inoculations were made by grinding soft, young leaves in a mortar with 2- to 5-fold volume of 1/15 M Sörensen phosphate buffer solution (pH 7.0) with 20 per cent sucrose, and rubbing carborundum-dusted leaves (*7*). All experiments were conducted in an insect-proof glasshouse maintained at 21 to 23° C.

Herbaceous plants inoculated. The following plants were used for the transmission experiments made in 1970–1972: *Phaseolus aureus* (Black Matobe, Bundo, Mei-ryokuzu, Oosaka-ryokuzu, Takeazuki); *Physalis floridana; Nicotiana glutinosa, N. clevelandii, N. rustica, N. tabacum* (Bright Yellow, Havana, KY 57, Xanthi); *Chenopodium amaranticolor, C. capitatum, C. murale, C. quinoa; Cucumis sativus* (Chicago Pickling, National Pickling); *Crotalaria spectabilis;* and *Gomphrena globosa.*

Inoculated plants were observed over four to five weeks after inoculation. Infection of plants by SDV, CiMV, NIMV, and NDV was confirmed by transmission to sesame.

RESULTS

Phaseolus aureus. Black Matobe and Bundo seedlings developed mottling and vein necrosis in noninoculated upper leaves when inoculated with SDV and NIMV. These varieties developed large necrotic ringspots or chlorotic ringspots with ring necrosis in inoculated primary leaves when inoculated with CVV or CCLV. Mei-ryokuzu and Oosaka-ryokuzu seedlings inoculated with SDV, CiMV, CVV and CCLV developed similar necrotic spots or ne-

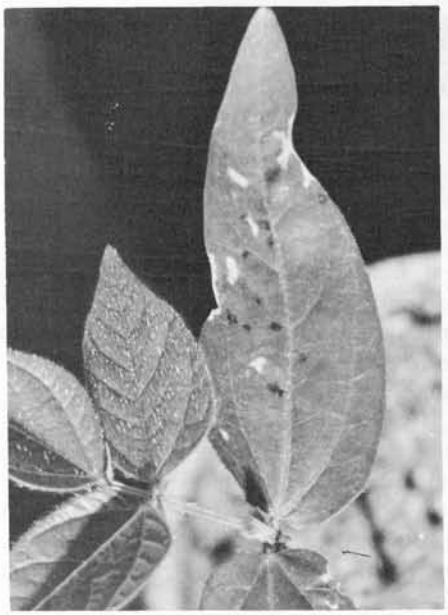

Fig. 1. Small, necrotic ring spots on primary leaves of *Phaseolus aureus* var. Oosaka-ryokuzu inoculated with SDV.

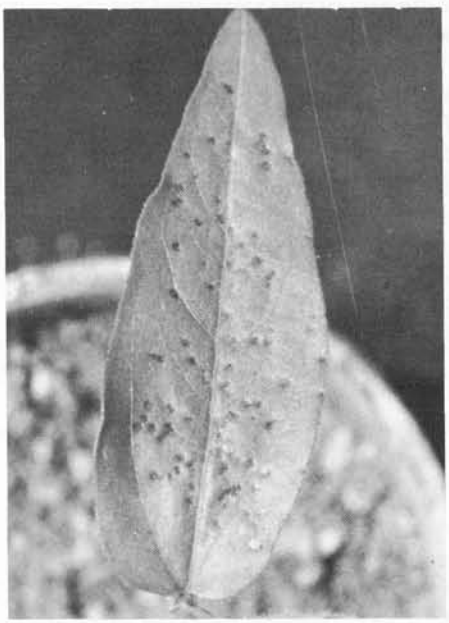

Fig. 2. Small, necrotic spots on primary leaves of *Phaseolus aureus* var. Oosaka-ryokuzu inoculated with CVV.

Fig. 3. Small, necrotic ring spots on primary leaves of *Phaseolus aureus* var. Oosaka-ryokuzu inoculated with CCLV.

crotic ringspots in inoculated primary leaves (figs. 1, 2, and 3). These seedlings inoculated with NIMV developed a different type of large, necrotic ringspot. Inoculation from seedlings of Mei-ryokuzu with SDV, Oosaka-ryokuzu with SDV and CiMV, and Black Matobe and Bundo with NIMV induced symptoms in sesame plants the same as those produced by viruses from the original citrus source trees. Seedlings of Takeazuki did not react to any of the viruses used in the experiments.

Physalis floridana. Seedlings inoculated with SDV, CiMV, and NIMV exhibited large diffused chlorotic spots or mottling in newly developed leaves (fig. 4). Viruses from the seedlings affected with viruses of the three diseases were transmitted to sesame plants.

Nicotiana clevelandii. Seedlings inoculated with SDV exhibited mottling and malformation in developing leaves. Virus from those seedlings was transmitted to sesame plants.

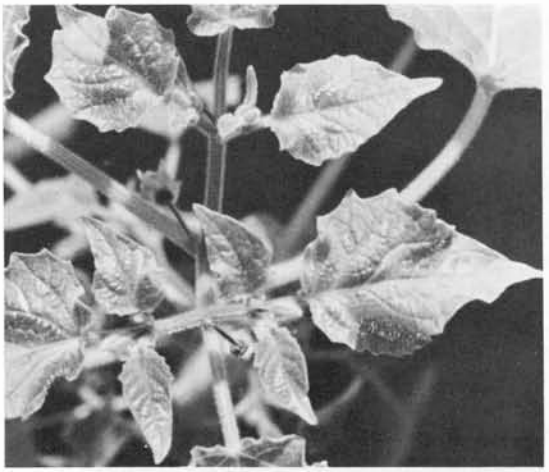

Fig. 4. Mottling on newly developed leaves of *Physalis floridana* inoculated with CiMV.

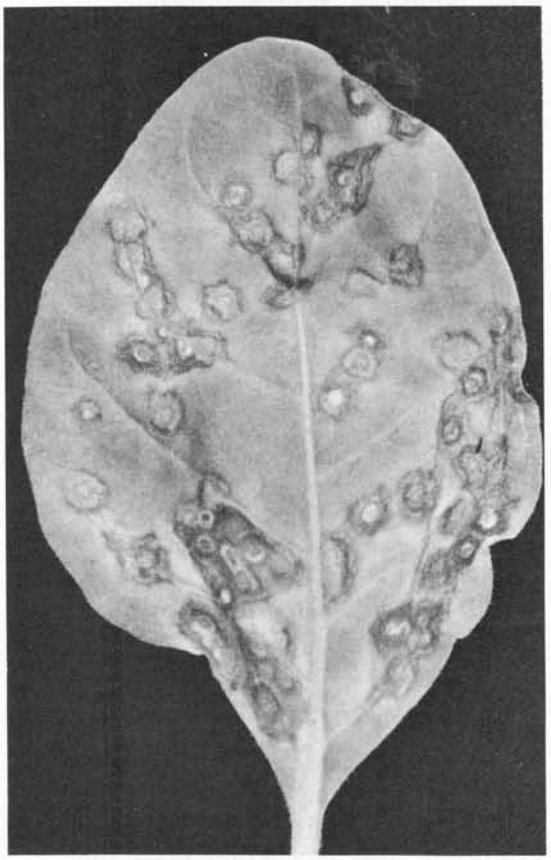

Fig. 5. Large, chlorotic spots with ring necrosis on leaf of *Nicotiana rustica* inoculated with NIMV.

Fig. 6. Large, chlorotic spots with ring necrosis on leaf of *Nicotiana tabacum* var. KY 57 inoculated with SDV.

Nicotiana rustica. Seedlings inoculated with NIMV developed large, chlorotic spots with ring necrosis in inoculated leaves (fig. 5) and developing upper leaves, and necrosis in stems. Virus from those seedlings was transmitted to sesame plants.

Nicotiana tabacum. Seedlings of the cultivar KY 57 inoculated with SDV, CiMV, and NIMV developed large, chlorotic spots with ring necrosis in the inoculated leaves (fig. 6). Those inoculated with SDV also showed clear-cut line-pattern symptoms, diffused along the main veins in newly developed leaves, that resembled an oak leaf pattern (fig. 7). Havana seedlings inoculated with CiMV and Xanthi seedlings inoculated with SDV and CiMV developed chlorotic ringspots in inoculated leaves. Viruses from KY 57 and Xanthi seedlings were transmitted to sesame plants.

Chenopodium capitatum. Seedlings inoculated with SDV, CiMV, and

NIMV developed indistinct, chlorotic spots in the inoculated leaves. Those inoculated with SDV showed crinkling, vein clearing, and mottling in young leaves. However, no symptoms developed on sesame, which suggests that the symptoms in *C. capitatum* may have another cause.

Chenopodium quinoa. Seedlings inoculated with SDV developed small, chlorotic spots in inoculated leaves. Virus was transmitted from these seedlings to sesame plants.

Gomphrena globosa. Some inoculated leaves of seedlings inoculated with SDV, NIMV, NDV, CVV, and CCLV developed faint red spots. Many inoculated leaves remained symptomless. Viruses from the seedlings inoculated with SDV, NIMV, and NDV were transmitted to sesame plants.

Other herbaceous plants. In our experiments, seedlings of *Nicotiana glutinosa, N. tabacum* var. Bright Yellow, *Chenopodium amaranticolor, C. murale, Cucumis sativus,* and *Crotalaria spectabilis* did not react to inoculation with any of the viruses used.

Tanaka and Kishi (*9*) reported that *Crotalaria spectabilis* was susceptible to SDV. Desjardins and Wallace (*1*) and Grant and Corbett (*2*) also reported that CVV could infect *C. spectabilis* and *Cucumis sativus* var. Chicago Pickling. Why these plants did not react to SDV or CVV in the present experiment is not clear.

Fig. 7. Line-pattern type of systemic symptom on upper leaves of *Nicotiana tabacum* var. KY 57 inoculated with SDV.

DISCUSSION AND CONCLUSIONS

Since viruses from the affected herbaceous plants in these experiments were transmitted to, and produced definitive symptoms of Satsuma dwarf in sesame plants, the assumption is that SDV was transmitted to those herbaceous plants and induced symptoms in them.

From the comparison of host ranges and symptoms on plants affected by these viruses, CiMV and NIMV appear to be similar to SDV, but the NDV differs from all three. These four viruses found in Japan are also somewhat different from California strains of CVV and CCLV. Psorosis virus did not induce symptoms on herbaceous plants used in this experiment, which indicates that large differences exist between psorosis virus and these other viruses with respect to mechanical transmissibility.

Phaseolus aureus var. Oosaka-ryokuzu seems to be a good local-lesion host for bioassay of SDV, CVV, and CCLV. *Physalis floridana* is potentially a good production host of SDV, CiMV, and NIMV because the infected seedlings grew well despite severe systemic infection. *Nicotiana clevelandii,* because of stunted growth, and *N. tabacum* var. KY 57, because of erratic, limited symptom expression, may be inferior to *P. floridana* as production hosts of SDV. Further experiments are being made to confirm the merits of these herbaceous plants as local-lesion and production hosts for these viruses.

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