

"Motley Dwarf" Virus Disease Complex of California Carrots

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ABSTRACT

Three morphologically distinct virus types were found in field samples of "motley dwarf"-infected carrots. Host range studies suggest that more than three viruses are involved. At least two aphids are vectors of one or more of these viruses. No evidence of seed transmission was found.

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"Motley dwarf", an economically important virus disease of carrots, appears to have a worldwide distribution. It was first identified in California in 1956 by L. L. Stubbs, who had previously worked extensively on the disease in Australia (5).

Losses attributed to motley dwarf in the heavily infected 1969 spring carrot crop in the Salinas Valley of California were estimated by growers at 50-60%, but there is considerable year-to-year variation due to fluctuations in the aphid populations. There has been a tendency, however, to lump most viruslike diseases of carrots in that production area (except for aster yellows), as motley dwarf. This study demonstrated that more than the two component viruses of motley dwarf (6) were present in many fields. Samples were also taken from diseased fields in the Modesto and San Juan Bautista areas.

TRANSMISSION STUDIES.—The vector of motley dwarf, *Cavariella aegopodii* Scop., was found in infected carrot fields. It was often parasitized, as previously noted by Stubbs (5). Transmission studies indicated that this aphid would transmit both carrot mottle and red leaf viruses, the two components of motley dwarf (6), from infected carrot plants.

In addition, large populations of *Dysaphis apiifolia* Theob. (*Aphis ferrugineastrata* Essig) were found feeding in the crowns of the plants. Aphids taken from diseased plants and placed on carrot seedlings transmitted a virus (or, perhaps, the viruses) which produced yellow mosaic symptoms, although the marginal reddening associated with motley dwarf was lacking.

To test for possible seed transmission, seed was collected from plants of 'Danvers 126' carrots in the Salinas Valley and CVC-12 (an Emperor selection) carrots in the Modesto area which showed typical motley dwarf symptoms (mosaic, marginal reddening, and petiole twisting). The seed was sown in flats and maintained in the greenhouse for observation until the seedlings were approx. 10-cm high. Any plants that appeared to be infected were further checked by mechanical inoculation and attempted aphid

transmission using *C. aegopodii*. Approximately 5,000 seedlings were examined, but no evidence of seed transmission of any viruses was found.

Samples of diseased leaves were ground with small amounts of 0.001 M phosphate buffer, pH 7, in autoclaved mortars and pestles. The sap was rubbed

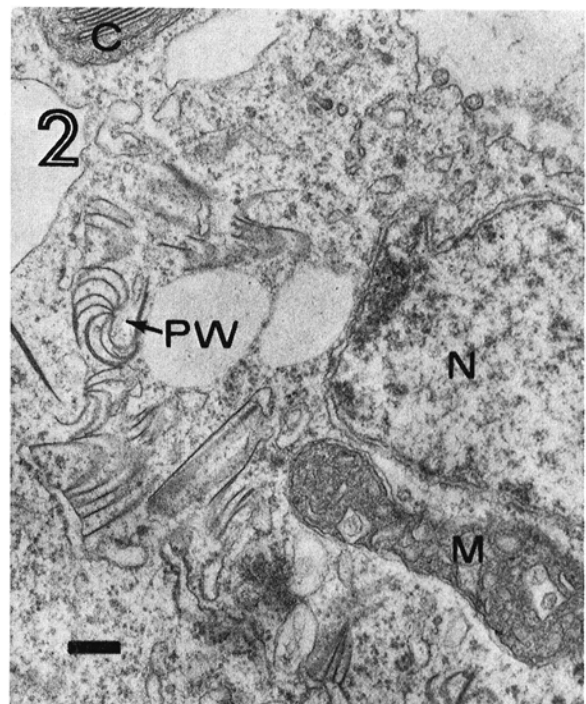
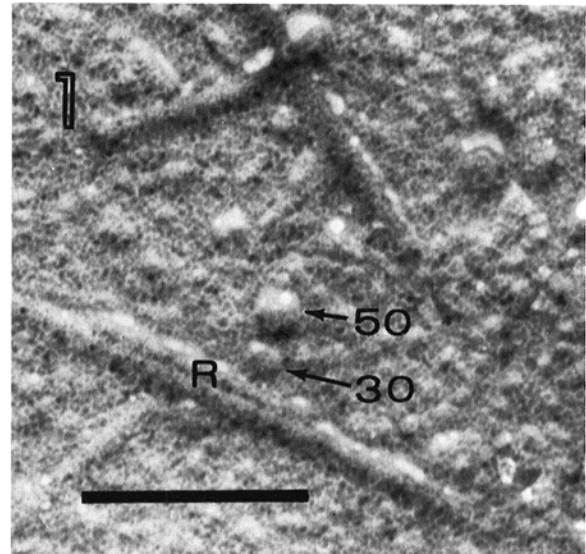


Fig. 1-2. "Motley dwarf" of carrot. Bar = 0.25 μ . 1) Shadowed, partially purified virus preparation. Three virus types are discernible: rods (R), 30-nm diam, and 50-nm diam particles. 2) Typical pinwheel inclusions (PW) in diseased carrot leaf. C = chloroplast, N = nucleus, M = mitochondrion.

onto Carborundum-dusted leaves of *Nicotiana tabacum* L. 'Xanthi' & 'Xanthi-nc', *Nicotiana clevelandii* Gray, *Daucus carota* L. spp. *sativus* (Hoffm.) Thell. 'Danvers 126' & 'Imperator 58', *Coriandrum sativum* L., *Chenopodium amaranticolor* Coste & Reyn., *Chenopodium quinoa* Willd., *Phaseolus vulgaris* L. 'Bountiful', and *Cucumis sativus* L. 'National Pickling'. Local lesions were produced on *N. tabacum*, *C. amaranticolor*, and *C. quinoa*. Systemic infection occurred in *N. clevelandii*, occasionally in *D. carota* and *Coriandrum sativum*, and on two occasions in *P. vulgaris* (Salinas Valley samples). Systemic infections in *N. clevelandii* and *P. vulgaris* were confirmed by serial transfer. No infection was observed in *Cucumis sativus*, indicating the absence of cucumber mosaic virus.

VIRAL MORPHOLOGY.—Partial purification of the viruses was accomplished using a modification of the procedure devised by Murant et al. (3) for carrot mottle virus. One hundred grams of diseased carrot leaves from the Salinas Valley were ground in a Waring Blender in 300 ml of buffer (0.06 M phosphate, 0.01 M Na₂SO₃, 0.001 M EDTA, and 0.001 M NaN₃, pH 7) at 4 C and expressed through cheesecloth. A bentonite suspension (1%, w/v) was added (12 ml/100 ml filtrate) with stirring. The mixture was centrifuged at 8,000 g for 10 min; the supernatant was then centrifuged at 80,000 g for 2 hr. The resulting pellet was resuspended in buffer, an additional low-high-low cycle carried out, and the final virus suspension dialyzed overnight against distilled water to remove buffer salts.

Samples of the preparation were nebulized onto electron microscope grids and shadowed with uranium. Examination of the grids revealed an abundance of 30-nm diam particles, a few 50-nm diam particles, and fragments of long, flexuous rods (Fig. 1).

Samples of diseased leaves were prepared for thin-sectioning by fixation in glutaraldehyde, postfixation in osmium tetroxide, dehydration in ethanol-propylene oxide, and embedment in Epon

812. Blocks were sectioned with a diamond knife, the sections mounted on Formvar-coated grids, stained 5 min in methanolic uranyl acetate, and examined. Typical pinwheel inclusions, diagnostic for approx. 750 nm-long, rod-shaped viruses (2), were found in many cells (Fig. 2). Alfalfa mosaic virus, reported in diseased carrots in the Modesto area (1), was not found in any samples that we examined.

No identification of the virus which produced a systemic infection in *P. vulgaris* was made. The long, flexuous rod was, however, tentatively identified as celery mosaic virus, based on morphology, host range, and vectors. Both aphid species had previously been found by Severin and Freitag (4) to be vectors of celery mosaic virus.

In summary, three morphologically distinct virus types were found: 30-nm diam particles, 50-nm diam particles, and approx. 750 × 15 nm rods. Host range studies indicated, additionally, that at least four distinct viruses were present in some samples, as neither carrot mottle, carrot red leaf, nor celery mosaic viruses has been reported to produce a systemic infection in *P. vulgaris*.

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