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Spiroviruses: A New Group of Serologically Diverse Plant Viruses Associated with Citrus Psorosis and Ringspot*

K. S. Derrick, R. F. Lee, B. G. Hewitt, and G. A. Barthe

ABSTRACT. The very flexible, filamentous virus particles associated with citrus ringspot and citrus psorosis appear to represent a new group of plant viruses. Since the particles appear as spirals when viewed with an electron microscope, we have tentatively named this virus group spiroviruses. Based on serology, electron microscopy and the presence of a 48-kd capsid protein, spiroviruses have been associated with citrus ringspot and citrus psorosis in Florida, Spain, Argentina and Israel. Spiroviruses have an extensive experimental herbaceous host range, but known natural infections are restricted to citrus. There is considerable variation in the symptoms induced by different virus isolates, and serological studies using polyclonal and monoclonal antibodies indicate serological diversity among isolates.

Prior to the development of budwood certification programs, psorosis was one of the most important diseases of citrus in the world. In Argentina, Uruguay and the state of Bahia in Brazil, where psorosis appears to be spread by an unknown vector, it remains a major problem. Indexing of citrus budwood for psorosis is still done by graft inoculation of citrus indicator plants. Bioindexing for psorosis is expensive and time consuming and fails for any isolates that do not induce leaf symptoms. There is an obvious need for serological or other nonbiological indexes for psorosis.

Very flexible, filamentous virus particles were initially associated with citrus ringspot virus (CRSV-4) (3,4). These particles have not been described before and appear to represent a new group of plant viruses. Since the particles appear as spirals when viewed with an electron microscope, we have tentatively named this virus group spiroviruses (SV).

There is evidence for serological diversity among SV. Using CRSV-4 as inject antigen, clones of monoclonal antibodies were obtained that react with CRSV-4 in immunospot, western blot and SSEM assays. No clones were

recovered that react with CRSV-6, which is biologically distinct from CRSV-4 (6). Previously, a polyclonal antiserum was produced that reacts with several isolates of ringspot and psorosis (1,2,5,8) by western blots and/or SSEM. This antiserum reacts weakly with Florida CRSV-6 in SSEM. The virus concentration of CRSV-4 and 6 in young citrus leaves is approximately equal, based on partial purification and analysis of 48-kd protein by SDS-PAGE.

Based on serology, electron microscopy and/or the presence of a 48-kd capsid protein, SV have been associated with citrus ringspot and citrus psorosis isolates from Florida (1,3), Spain (1,8), Argentina (5) and Israel (2). A carla-type virus has been associated with psorosis in California (7). Is psorosis a virus complex or a complex of viruses? It appears more likely to be a complex of individual viruses that cause diseases with similar symptoms and not a disease caused by a complex (mixture) of viruses.

The variation in the symptoms induced by different SV isolates suggest the existence of a variety of virus strains. The finding of serological diversity of SV provides additional evidence for virus strains. Known natural infections of SV are restricted to citrus. But since SV have an extensive experimental herbaceous host range (10), it would

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not be surprising to find natural infections of SV in noncitrus hosts.

In a review of psorosis in this volume, Roistacher states the evidence for natural spread of psorosis is convincing and vector involvement is highly probable. The possible movement of vectors of psorosis responsible for the rapid movement of the disease in Argentina, Uruguay and Brazil into other citrus growing areas should be cause for considerable concern. In view

of the recent rapid spread of the brown citrus aphid *Toxoptera citricidus* (9), tests to determine possible transmission of psorosis by this aphid should be done.

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