Viruses and Virus-like Diseases of Sweet Potato

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The renewed interest of the international agricultural community in the sweet potato *Ipomoea batatas* (Lam.) L. has resulted in a dramatic rise in the need to exchange primitive and improved sweet potato germplasm. Sound horticultural practices and national quarantine regulations require that sweet potato germplasm intended for international distribution be free of known viruses. Sweet potato germplasm free of known viruses is also needed for commercial production and research purposes. Unfortunately, our ability to certify plants free of viruses and of agents responsible for recognized diseases of unknown etiology has not kept pace with this burgeoning need.

Field observations and assays have revealed virus symptoms and the presence of one or more viruses in virtually all sweet potato grown from materials that have not been virus-tested. In many instances the endemic nature of these viruses has facilitated the natural incorporation of high levels of tolerance to local viruses, via selection and propagation of asymptomatic plants. Although tolerance to viruses has improved production of sweet potato, it has made diagnosis difficult and, in some areas, has resulted in a general complacency about the importance of virus diseases in sweet potatoes. There is, however, justified concern that a virus isolate which is mild or latent in one location on one group of cultivars, may have considerably greater effects, either by itself or in combination with other viruses, when introduced into a new geographic location where local cultivars have a different genetic background. Thus, the necessary precautions must be taken to prevent the inadvertent distribution of viruses with germplasm.

A concerted effort is being made in several laboratories to discover the etiology of those diseases with symptoms frequently associated with virus infections. Recently a group of sweet potato virologists developed a list of 14 different viruses or virus-like agents that infect sweet potato (Table 1). A summary of the best characterized viruses is given below.

Status of Known Viruses and Virus Diseases

Sweet Potato Feathery Mottle Virus

There are many strains of sweet potato feathery mottle virus (SPFMV), which are found nearly everywhere sweet potato is grown. Some of the synonyms used for SPFMV isolates include

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Table 1. A list of recognized viruses known to infect sweet potato.

Virus	Vector	Distribution	Assay hosts[a]
CIP-Isolation (2-C6)	?	unknown	*I. setosa*
Cucumber mosaic virus (CMV)	aphid	widespread Cucumis sativus	*N. glutinosa*
Reo-like	?	Asia	*I. setosa*
Sweet potato caulimo-like virus (SPCLV)	?	widespread *N. megalosiphon*	*I. setosa*
Sweet potato feathery mottle virus (SPFMV)	aphid	worldwide	*I. setosa*[b]
Sweet potato latent virus (SPLV)	unknown	Asia	*I. setosa*
Sweet potato leaf curl virus (SPLCV)	Bemisia tabaci	Taiwan, Japan, Nigeria	*I. setosa*
Sweet potato mild mottle virus (SPMMV)	Bemisia tabaci	East Africa *N. tabacum* *N. glutinosa* *N. benthamiana*	*I. setosa*
Sweet potato mosaic virus (SPMV)		Taiwan	*I. setosa*
Sweet potato ring-spot virus (SPRSV)	unknown	Papua New Guinea	*I. setosa*
Sweet potato vein mosaic virus (SPVMV)	aphid	Argentina	*I. setosa*
Sweet potato yellow dwarf virus (SPYDV)	Bemisia tabaci	Taiwan	*I. setosa*
Unknown virus	?	Puerto Rico	*I. setosa*
Whitefly-transmitted component of sweet potato virus disease (SPVD)	Bemisia tabaci	Africa, Taiwan	TIB 8 sweet potato infected with SPFMV I. setosa[c]

Source: This is a list originally prepared by FAO/BPGR that has been modified with newly available information.

[a]From FAO/IBPGR technical guidelines for the Safe Movement of Sweet Potato Germplasm.

[b]*Ipomoea setosa* is frequently difficult to inoculate by mechanical transmission; graft transmission from sweet potato is the most reliable means of transmission.

[c]Symptom expression is highly variable in *I. setosa*. This host should only be used after its reliability has been established in environment where test is conducted.

russet crack virus, sweet potato virus A, sweet potato ringspot virus, sweet potato leafspot virus, and probably internal cork virus (Cadena-Hinojosa and Campbell, 1981; Cali and Moyer, 1981; Campbell et al., 1974; Loebenstein and Harpaz, 1960; Moyer and Cali, 1985; Sheffield, 1957; Yang, 1972). Co-infection by SPFMV with an unknown virus is frequently a problem in determining the etiology of disease complexes.

The range of symptom types associated with SPFMV infection are as much a function of the host genotype and environment as they are of the virus strain or isolate (Alconero, 1972; Cali and Moyer, 1981; Campbell et al., 1974; Moyer, 1986; Moyer and Cali, 1985; Moyer and Kennedy, 1978). Symptoms on sweet potato leaves may consist of the classic irregular chlorotic patterns (feathering) associated with the leaf midrib, as well as faint or distinct chlorotic spots which in some genotypes have purple pigmented borders. These symptoms are observed predominantly on the older leaves. Veinclearing, veinbanding and chlorotic spots are the predominant symptoms observed in the indicator host *Ipomoea setosa* (Kerr). However, symptoms may be mild, and leaves produced after the initial flush may be symptomless. Some strains of SPFMV cause necrotic lesions on the exterior of the roots (russet crack disease) while other strains induce symptoms on the interior of the root (internal cork disease).

SPFMV is the most thoroughly characterized (Campbell et al., 1974; Moyer, 1986; Moyer and Kennedy, 1978) sweet potato virus and serological procedures have been developed to detect it (Cadena-Hinojosa and Campbell, 1981; Esbenshade, and Moyer, 1982). SPFMV has many biological characteristics and cytopathic effects that support its classification as a potyvirus (Cali and Moyer, 1981; Campbell et. al., 1974), even though its biochemical properties such as capsid protein CMr 38,000 dalton, RNA C 3.65 X 106 daltons (Moyer and Kennedy, 1978) and virion length (850 nm) (Cali and Moyer 1981; Nome, et al., 1974) make it an atypically large potyvirus.

Sweet Potato Vein Mosaic Virus

Sweet potato vein mosaic virus (SPVMV) has been reported only in Argentina (Nome, 1973). Direct comparison of the particle morphologies of SPFMV and SPVMV indicated that SPVMV has a modal length of 761 nm, significantly shorter than SPFMV. Sweet potato plants infected with this virus are severely stunted and produce fewer new roots. SPVMV is also transmitted occasionally by aphids (Nome et al., 1974). Antiserum is not yet available to compare this virus to other known potyviruses or to assay sweet potatoes from other countries.

Sweet Potato Latent Virus

Sweet potato latent virus (SPLV), formerly designated Sweet Potato Virus N, has only been reported in Taiwan (Chung et al., 1986). As the name suggests, infection of many sweet potato cultivars by SPLV does not result in obvious foliar symptoms. The host range of SPLV includes many *Convolvulus* species, *Chenopodium* species and some *Nicotiana* species such as *N. benthamiana* (Domin). Although it induces mild symptoms in *I. setosa*, it can be easily detected in this host by serological procedures.

SPLV also has many characteristics of a potyvirus including production of characteristic cytoplasmic inclusions. However, all attempts at aphid and white-fly transmission have been unsuccessful. Thus, definitive classification of this virus awaits further characterization.

Sweet Potato Mild Mottle Virus

Sweet potato mild mottle virus (SPMMV) was isolated in East Africa from sweet potatoes exhibiting leaf mottling, veinal chlorosis, dwarfing and poor growth (Hollings et. al., 1976). SPMMV-infected *I. setosa* exhibit a bright yellow veinal chlorosis on as many as four leaves following inoculation. Subsequent leaves are symptomless. This virus was referred to as SPV-T in preliminary reports and may be the same as virus B (Sheffield, 1957). Virus B was also isolated from sweet potatoes in East Africa (Sheffield, 1957).

Although the morphology of SPMMV and its cytoplasmic inclusions are similar to that of other potyviruses, its biological characteristics differ greatly from the type member. Most notable among the divergent characteristics is the host range of SPMMV, which includes 45 species in 14 plant families (Hollings et. al., 1976). Additionally, SPMMV is vectored by the whitefly, *Bemisia tabaci* (Genn), and its virions are relatively unstable using purification procedures for other potyviruses (Moyer, 1986; J. W. Moyer, unpublished). Further it does not react to the universal monoclonal antibody for potyviruses (J. Hammond, unpublished data).

Sweet Potato Yellow Dwarf Virus

Sweet potato yellow dwarf virus (SPYDV), which frequently occurs with SPFMV, was described recently in Taiwan (Chung et al., 1986). The virion morphology and vector of SPYDV are similar to those of SPMMV. Neither virus is adequately characterized and a direct comparison has not yet been made to determine the extent of biochemical relationships, but sufficient differences have been reported to justify continuing the designation of SPYDV as a separate virus.

A Caulimo-like Virus

A virus with some properties similar to the caulimoviruses was isolated from sweet potato by grafting and has been provisionally designated as sweet potato caulimo-like virus (SPCLV). It was first isolated in Puerto Rico and has since been isolated from sweet potatoes grown in Madeira, New Zealand, Papua-New Guinea, and the Solomon Islands (Atkey and Brunt, 1987).

Early symptoms on *I. setosa* include chlorotic flecks along the minor veins with interveinal chlorotic spots. These symptoms may develop into a general chlorosis resulting in wilting and premature death of the leaves. Virions associated with SPCLV were typical of caulimoviruses, but some of the inclusions were similar to the fibrillar ring inclusions induced by geminiviruses.

Other Whitefly-Transmitted Agents

Other whitefly-transmitted agents isolated from sweet potato in Nigeria, Israel, Taiwan, and the United States (Chung et al., 1985; Girardeau, 1958; Hildebrand, 1958; Loebenstein and Harpaz,

1960; Schaefers and Terry, 1976) are also considered as separate agents, but a comparison of these agents has not yet been made nor have they been definitively characterized. They have properties different from SPMMV in that they are not mechanically transmitted, they have a narrow host range, and no virions have been identified for these agents. The sweet potato virus disease (SPVD) described in Nigeria is one of the most thoroughly investigated (Hahn, 1979; Hahn et al., 1981; Schaerfers and Terry, 1976). This disease is due to the synergistic interaction of a strain of SPFMV and a whitefly transmitted agent. Diseases similar to SPVD, designated as Georgia mosaic and yellow dwarf, have been reported in the United States (Girardeau, 1958; Hildebrand, 1958). The sweet potato veinclearing virus reported in Israel also induces symptoms similar to SPVD (Loebestein and Harpaz, 1960). Sweet potato leaf curl disease (SPLC) is another disease whose causal agent has been reported as being transmitted by *B. tabaci* (Chung et al., 1985; Yamashita et al., 1984).

Guidelines for Virus-testing of Sweet Potato

It is recommended that all sweet potato clones be placed in in vitro culture by meristem-tip culture accompanied by heat or chemotherapy as necessary for obtaining plantlets free of pests as determined by subsequent pathogen testing. All clones should, whenever possible, be stored in in vitro culture for multiplication and distribution to minimize opportunities for reinfection during maintenance. Each in vitro plantlet should be subcultured for pathogen testing. The youngest portion of the plantlet (apical 2 or 3 nodes) should be used to propagate plantlets as in vitro reference cultures; the remaining stem and roots can be used to propagate the plant in a screened greenhouse for pathogen testing. This strategy favors propagating for maintenance that portion of the plant having the least probability of containing viruses (the youngest), and propagating for virus-testing that portion of the plant that has the most probability of containing viruses.

Plantlets may be assayed at the time of subculturing by biochemical assays as a preliminary step in virus testing. It must be recognized, however, that a virus may only be detected in clones supporting high virus titers and that virus may not be detectable in all tissues. It is recommended that plants for virus testing should be grown in the greenhouse to produce stems with at least 10 to 15 nodes. These plants should then be assayed by making grafts to two separate *I. setosa* plants and to the sweet potato clone TIB 8, which is infected with a mild strain of SPFMV. The TIB 8 clone is used to detect the whitefly component of the SPVD complex. Nearly all known viruses infecting sweet potato also infect *I. setosa*. Although *I. setosa* is susceptible to many viruses that infect sweet potato and although it is a good assay host, the symptoms are not of diagnostic value. However, some viruses such as CMV and TSV, may not be reliably detected by these methods. Thus, mechanical assays directly from sweet potato to other virus indicators such as *N. benthamiana*, *N. clevelandii* Gray, and *Chenopodium quinoa* Wild are strongly suggested. In addition, as for other vegetatively propagated crops, it is recommended that each sweet potato plant be tested several times.

Acknowledgments

The authors are grateful for the discussions and information provided by P. Beetham, A. A. Brunt, C. A. Clark, J. Dodds, S. Green, and H. Roessel. Some of the research by the authors referred to here was supported by USDA Southern Regional Cooperative Agreement No. 5-46764, the International Potato Center, and the North Carolina State University Agricultural Research Service. Portions of this article are from a Feature Article in Plant Disease 73:451-455 (Viruses and Virus-like diseases of sweet potato by J. W. Moyer and L. F. Salazar).

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