Sweet Potato Witches' Broom and Legume Little-Leaf Diseases in the Solomon Islands

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ABSTRACT

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Sweet potato witches' broom disease occurred in *Ipomoea batatas, I. indica, I. triloba,* and *Merremia pacifica* in the Solomon Islands. The disease agent, a mycoplasmalike organism (MLO) found in phloem cells of infected *I. batatas* plants, was transmitted by the sweet potato black-spotted leafhopper, *Orosius lotophagorum ryukyuensis*. Disease incidence was much higher on the Guadalcanal Plains than elsewhere in the Solomon Islands. The high incidence there was correlated with high populations of *O. lotophagorum ryukyuensis*. All 192 accessions of *I. batatas* from the Solomon Islands were susceptible to this MLO when graft-inoculated with infected scions or when infected naturally. Legume little-leaf, another MLO, was manifested as a witches' broom symptom in *Emilia sonchifolia* and *Vernonia cineria*. On Guadalcanal, the legume little-leaf disease was also found in plants of *Crotalaria* sp., *Desmodium heterophyllum, D. triflorum, Polygala paniculata,* and *Vigna sesquipedalis*. This is the first report of the legume little-leaf disease in the Solomon Islands, and *Orosius argentatus* was shown to be a vector. The legume little-leaf agent was not shown to infect *Ipomoea* spp., and the sweet potato witches' broom agent was not shown to infect any of the hosts of the legume little-leaf MLO.

Witches' broom (WB) disease of sweet potatoes (*Ipomoea batatas*) on Guadalcanal, Solomon Islands, was first described by Johnston (11). Presumably the same disease from the northern coast of Guadalcanal (Guadalcanal Plains) was reported later to be caused by a mycoplasmalike agent; this disease was named "witches" broom chlorotic little-leaf" (5,7). A similar but unnamed WB disease of a "weed variant" of *I. batatas* was also described from the adjacent island of Malaita (6) but it was considered possibly distinct because *I. batatas* 'Gina' plants growing nearby were not infected (7) and because symptoms were produced only when shoots of the diseased weed were graft-inoculated to sweet potato but not in the reciprocal test (5). None of the earlier studies involved transmission experiments with leafhoppers.

This paper reports additional studies on the WB disease of *I. batatas* of Guadalcanal and provides evidence that it is synonymous with 1) the WB disease from Malaita and 2) the sweet potato witches' broom disease of Japan (13,15), Taiwan (18), Korea (14), Papua New Guinea (17), and Tonga (12). Also, this is the first report from the Solomon Islands of a second mycoplasmalike organism (MLO)-induced disease: legume little-leaf, which apparently does not infect convolvulaceous plants.

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MATERIALS AND METHODS

Plant and insect identifications. The three wild members of the Convolvulaceae from the Solomon Islands described in this report were identified at the Royal Botanic Gardens, Kew, England, as *I. indica* (=*I. accuminata* and *I. congesta*), *I. triloba,* and *Merremia pacifica*. *I. indica* was the "weed variant" referred to by Dabek and Gollifer (6). Seeds of the following ornamental *Ipomoea* spp. were supplied by J. W. Moyer (Department of Plant Pathology, North Carolina State University, Raleigh 27607): *I. setosa, I. purpurea, I. ericolor,* and *I. nil*. Seeds of the pasture legumes *Desmodium uncinatum, Macroptilium atropurpureum* 'Siratro,' *Stylosanthes guinanensis* 'Schofield,' *Lotonosis bainesii* 'Miles,' *Centrosema pubescens* 'Common,' *Glycine wrightii* 'Tinaroo,' and *Pueraria phaseoloides* were supplied by D. C. MacFarlane (Department of Agriculture, University of Queensland, Australia). Seeds of *Crotalaria* sp., *Arachis hypogaea* 'Red Spanish,' and *Vigna sesquipedalis* were obtained locally.

Common weeds *Emilia sonchifolia, Vernonia cineria,* and *Polygala paniculata* in sweet potato fields on the Guadalcanal Plains and *Desmodium* spp. were identified by R. Steel (Department of Agriculture, University of Queensland, Australia). Leafhoppers *Orosius lotophagorum ryukyuensis* and *O. argentatus* were identified by M. S. K. Ghauri (Department of Entomology, British Museum of Natural History, London, England).

Surveys. Sweet potato plantings on Guadalcanal and other provinces of the Solomon Islands (Central, Isabel, Makira, Malaita, Temotu, and Western) were visited at least once a year since 1976 by the first author. At that time, sweet potato plants and adjacent weeds were examined for WB symptoms and for *Orosius* leafhoppers.

Graft transmissions. The top portions of test plants (*Ipomoea* spp.) were removed 8 wk after sowing in pots to leave a 15-cm-high rootstock onto which individual WB-infected sweet potato shoots (6–8 cm) from Guadalcanal were wedge-grafted and sealed with Parafilm. Twenty days later, infected shoots were removed. Ornamental and wild *Ipomoea* spp. used as test plants were maintained in insect-proof cages after inoculation for symptom development, whereas test plants of sweet potato cultivars were transferred to field plots and monitored for up to 140 days. The Taiwanese sweet potato cultivar PI 344129, reported immune to WB disease (1), and seedlings derived from open-pollinated plants were also inoculated in this manner. In tests where sweet potato seedlings derived from *I. batatas* 'Gina' were graft-inoculated with WB-infected scions of *I. indica* collected from Guadalcanal or Malaita, test plants were maintained in isolation in a screenhouse at the Dodo Creek Research Station for the entire 300-day test.

Insect transmissions. Specimens of *O. lotophagorum ryukyuensis* used in transmission experiments with the sweet potato WB pathogen were derived from eggs deposited on WB-infected sweet potato plants. Shoots bearing eggs were collected from fields, treated with malathion (0.1% liquid formulation) to kill emergent leafhoppers, placed into insect-proof cages, and allowed to develop roots by placing the stems in water. The leafhoppers that emerged from the eggs were transferred to sweet potato seedlings, where they were reared until used in transmission trials. Specimens of *O. argentatus* used in transmission tests with the agent of legume little-leaf were reared on healthy plants of *E. sonchifolia* derived from seed and maintained in insect-proof cages.

For both leafhopper species, acquisition-access periods were at least 28 days. Insects were then transferred in groups of five or six to each seedling test plant and allowed to feed for a maximum of 10 days before being killed with malathion.

In all transmission experiments, uninoculated seedlings were included as controls. None of these plants ever developed WB symptoms during this investigation. All transmission trials were conducted exclusively in the Solomon Islands.

Electron microscopy. Leaf and stem tissues were prepared for thin sectioning by fixing in 8% glutaraldehyde. This material was then forwarded to Florida, where it was postfixed in 4% OsO_4 and embedded in Epon Araldite. Sections were made with a diamond knife and stained with uranyl acetate and lead citrate. Measurements were made by comparisons with a 2,160-line-per-millimeter diffraction grating.

RESULTS

Surveys. In surveys by the first author since 1976, WB symptoms were common on sweet potatoes on the Guadalcanal Plains and occasionally present in isolated plantings on the island of Choiseul (Western Province), Nggela and Russell Islands (Central Province), Santa Ana (Makira Province), Reef Islands, and Utupua (Temotu Province). Symptoms of WB were also found on *I. indica* in Malaita and Guadalcanal, on *M. pacifica* in Choiseul, and on *I. triloba* on the Guadalcanal Plains. The propagating material of the WB-diseased sweet potato plantings on Choiseul, Nggela, and the Russell Islands originated from tuberous roots collected at markets on the Guadalcanal Plains. The origin of the planting stock used on Santa Ana, Reef Islands, and Utupua could not be ascertained, however.

Special efforts were made to find specimens of *O. lotophagorum ryukyuensis* during these surveys. High populations of this leafhopper were evident on sweet potatoes grown on the Guadalcanal Plains, especially during the dry seasons of 1979 and 1980. This leafhopper, however, was not detected at any of the other locations visited.

During the surveys, nonconvolvulaceous plants were found with symptoms of a WB disease, apparently different, from the sweet potato WB disease. Of greatest interest was the discovery that large numbers of the weeds *E. sonchifolia* and *Vernonia cineria* within the diseased plantings of sweet potatoes on the Guadalcanal Plains had severe symptoms. Less commonly and only on the Guadalcanal Plains, *Vigna sesquipedalis* growing in and around sweet potato fields were affected, and two diseased plants of the common weed *P. paniculata* were also found. Diseased plants of *E. sonchifolia* were also seen occasionally on Malaita and, together with plants of *Vernonia cineria*, they occurred within the healthy sweet potato plantings on the island of Nendö (Temotu Province). In addition, leguminous plants *D. heterophyllum* and *D. triflorum* on the Guadalcanal Plains and *D. triflorum* and *Crotalaria* sp. on the southern coast of that island were found with symptoms of witches' broom disease but not in sweet potato plantings. Leafhopper *O. argentatus* was often present on both diseased and healthy plants of *E. sonchifolia* and *Vernonia cineria* on the Guadalcanal Plains. It was not detected elsewhere in the Solomon Islands, however.

Graft transmissions. All the following graft-inoculated *Ipomoea* spp. tested became infected (the numbers are plants infected of 10 inoculated): *I. setosa*, 3; *I. purpurea*, 3; *I. ericolor*, 6; *I. nil*, 3; *I. triloba*, 9; *I. indica*, 9; *I. batatas* 'Gina,' 7. Incubation periods ranged from 35–49 days for *I. ericolor* to 140–196 days for *I. indica*. In a second trial, WB-infected shoots from *I. batatas* 'Gina' were grafted to *I. indica*, resulting in seven of 13 infected plants. In this trial, the incubation period ranged from 210 to 283 days. In a third trial, three of six *I. batatas* 'Gina' seedlings developed WB symptoms 70–117 days after inoculation with WB-diseased shoots of *I. indica* from Guadalcanal. In a subsequent trial using WB-infected *I. indica* from Malaita, four of 24 *I. batatas* 'Gina' seedlings developed WB symptoms 50–186 days after inoculation.

For all *Ipomoea* spp., initial symptoms were veinclearing. Except for *I. ericolor*, leaves produced subsequently were smaller than normal and chlorotic. Infected shoots were abnormally erect and multibranched because of the proliferation of axillary shoots. Plants of *I. ericolor* died shortly after development of veinclearing symptoms. Symptoms on graft-inoculated plants of *I. indica*, *I. triloba*, and *I. batatas* 'Gina' were identical to those naturally infected.

The sweet potato WB agent was successfully graft-transmitted to all 173 indigenous accessions of sweet potato tested from the Solomon Islands. There were slight differences in symptom expression but none appeared to have sufficient resistance or tolerance to effectively control the disease. Nineteen additional accessions developed the disease at Dodo Creek Research Station on the Guadalcanal Plains from natural infections before plants were large enough for cuttings to be taken for graft inoculations. The cultivars, 'Ben Kevu' (= 'Benkefu') and 'Three-months,' previously reported resistant (7), developed WB symptoms during this study.

All 89 seedlings derived from sweet potato accession PI 344129 became infected either when planted in rows adjacent to WB-infected local cultivars or when graft-inoculated. In addition, six of 12 plants of the parent cultivar PI 344129 developed symptoms, the earliest at 46 days after inoculation.

Insect transmissions. *O. lotophagorum ryukyuensis* proved to be a vector of the sweet potato WB agent. In transmission experiments, nine of 18 *I. batatas* 'Gina' seedlings exposed to infective leafhoppers became infected, but no symptoms were seen on any of the uninoculated control plants. Likewise, none of the five seedlings each of *Vernonia cineria*, *D. uncinatum*, or *P. phaseoloides* or the eight *E. sonchifolia* seedlings exposed to these leafhoppers became infected. The agent of sweet potato WB was thus

infective in sweet potato but not in the four nonconvolvulaceous plants tested.

Plants of *E. sonchifolia* and *Vernonia cineria* developed witches' broom symptoms when inoculated by *O. argentatus* that had been allowed acquisition-access periods on infected *E. sonchifolia* plants. Several additional leguminous species and sweet potato seedlings were tested by this insect with the following results (ratios are the number of plants developing symptoms of total inoculated): *E. sonchifolia*, 6/6; *Vernonia cineria*, 2/3; *D. uncinatum*, 2/3; *M. atropurpureum*, 0/6; *S. guinanensis*, 3/6; *L. bainesii*, 5/6; *C. pubescens*, 0/6; *G. wrightii*, 1/3; *P. phaseoloides*, 0/6; *Crotalaria* sp., 2/3; *A. hypogaea*, 1/5; *Vigna sesquipedalis*, 3/3; and *I. batatas* 'Gina,' 0/12. All infected plants had conspicuous witches' broom symptoms.

Electron microscopic examinations. Pleomorphic mycoplasmalike bodies, never seen in healthy plants (*I. batatas, E. sonchifolia, P. paniculata, Vernonia cineria,* and *Vigna sesquipedalis*), were seen in phloem cells of the following species with witches' broom symptoms: *I. batatas* (Fig. 1A), *E. sonchifolia* (Fig. 1B), *G. wrightii, L. bainesii, D. uncinatum, P. paniculata, S. guinanensis, Vernonia cineria,* and *Vigna sesquipedalis* (Fig. 1C). Although an MLO was associated with each disease, results of electron microscope examinations did not distinguish between them.

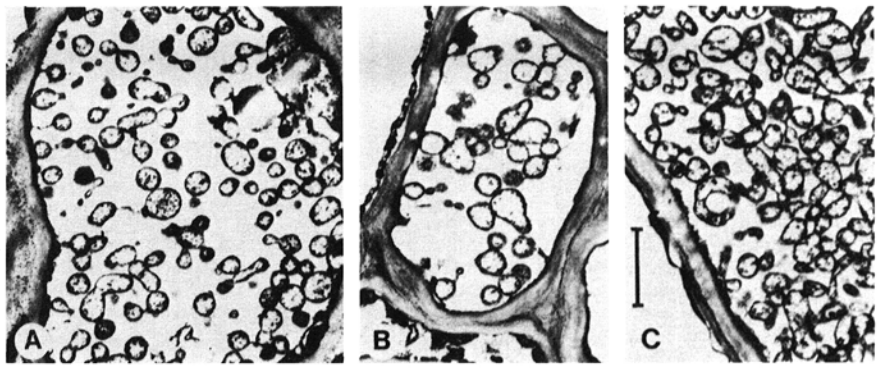

Fig. 1. Electron micrographs of phloem cells containing mycoplasmalike bodies from plants showing witches' broom symptoms. **(A)** *Ipomoea batatas*, **(B)** *Emilia sonchifolia*, and **(C)** *Vigna sesquipedalis*. Scale bar = 1 μm.

DISCUSSION

Sweet potato WB disease in the Solomon Islands, previously referred to as witches' broom chlorotic little-leaf (7), is similar if not identical to the sweet potato witches' broom disease described elsewhere in Southeast Asia and Oceania. This conclusion is based on: 1) typical symptoms induced in various *Ipomoea* spp. (17,19), 2) transmissibility by *O. lotophagorum ryukyuensis* (4,13,21), and 3) detection of mycoplasmalike bodies in phloem cells of WB-infected plants (3,12,14,16).

There is little justification for considering the WB disease of *I. batatas* on the Guadalcanal Plains distinct from that of *I. indica* in Malaita (5,7), of *I. indica* and *I. triloba* in Guadalcanal, or from that infecting *M. pacifica* in Choiseul. Symptoms noted in *I. indica* from Malaita were identical to those observed in Guadalacanal, and when diseased *I. indica* from either source was graft-transmitted to seedlings of *I. batatas*, typical WB symptoms developed. Also, typical WB symptoms developed in seedlings of *I. indica* graft-inoculated with diseased sweet potato from Guadalcanal. The long incubation periods noted (up to 283 days) may have been responsible for the apparent failure of previously reported tests (5). There has been a long tradition in the Solomon Islands of interisland exchange of sweet potato planting stock, and it is likely that diseased plants from the Guadalcanal Plains have been introduced repeatedly to other islands in the past.

The exceptionally high incidence of WB-infected sweet potato plants on the Guadalcanal Plains can readily be attributed to its having a disproportionately high vector population. The Guadalcanal Plains is unique in the Solomon Islands in having a relatively low total rainfall and a marked dry season (8). Populations of *O. lotophagorum ryukyuensis* were especially high during the dry seasons. They are not common in other places in the Solomon Islands with higher rainfall, however. Therefore, even though diseased plants are occasionally introduced to such areas and despite perennial populations of WB-infected *I. indica*, secondary transmission would be very limited. Moreover, because symptoms of WB are so conspicuous in sweet potato, growers would normally avoid using such material as planting stock. When WB-infected sweet potatoes were found on Nggela in 1978 and Choiseul and the Russell Islands in 1980, they were rogued, and no other infected plants were found during subsequent visits.

No sweet potato cultivars resistant to WB were found. All 192 accessions of indigenous sweet potato cultivars were also susceptible to WB. Thus, prospects for control using resistant local cultivars appears remote. Likewise, the exotic cultivar PI 344129 from Taiwan and seedlings derived from it also proved susceptible. Even if that cultivar was resistant, however, it would be considered agronomically unacceptable for the Solomon Islands because of its susceptibility to the sweet potato scab fungus (*Elsinoë batatas*).

The disease of *E. sonchifolia, Vernonia cineria*, and other nonconvolvulaceous plants was identified as legume little-leaf, based on 1) susceptibility of various leguminous plants to this disease, 2) presence of mycoplasmalike bodies in infected plants, and 3) transmissibility of the agent by *O. argentatus* (2,9,10,20).

This is the first report of this disease in the Solomon Islands, and although infected plants are commonly seen in sweet potato fields of the Guadalcanal Plains, there appears to be no relationship between this disease and that causing WB in sweet potato as noted previously (13). Legume little-leaf appears unlikely to pose a significant threat to any of the important cultivated crops currently grown in the Solomon Islands. *Pueraria phaseoloides* and *C. pubescens* are two of the most important pasture and groundcover legumes and neither appears susceptible, as shown by this and other studies (9).

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