Pathogenicity of *Fusarium oxysporum* f. *sp. passiflorae* to Banana Poka and Other *Passiflora* spp. in Hawaii

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**ABSTRACT**


*Fusarium oxysporum* f. *sp. passiflorae*, the cause of vascular wilt of passionfruit (*Passiflora edulis* f. *edulis*), also attacked inoculated banana poka (*P. mollissima*) seedlings. Other noncrop *Passiflora* spp. (*P. ligularis* and *P. foetida*) were susceptible, whereas *P. e. f. flavicarpa*, the cultivated passionfruit in Hawaii, and *P. suberosa* were resistant. This work is part of an initial evaluation of possible biocontrol agents for banana poka.

Banana poka, an introduced vine of the *Passifloraceae*, was first reported in Hawaii in 1921 (5). The common name refers to the oblong-shaped fleshy yellow fruit, superficially somewhat resembling a banana. Banana poka has been usually referred to as *Passiflora mollissima* (Kunth) Bailey (6) (subg. *Tasconia*), but some workers consider *P. mixta* L. or *P. tripartita* (Juss.) Poir. the proper placement. Close relatives of banana poka (here referred to as *P. mollissima*) are known from cultivated or wild populations in Colombia, Ecuador, and Peru. However, the Hawaiian form may have resulted from inbreeding among a small introduced population and may no longer have an exact native counterpart (6). Aside from this consideration, Hawaii has no native *Passifloraceae* (10).

Although probably introduced as an ornamental, banana poka has aggressively spread into native forests where it covers hectares of vegetation with draping mats of foliage reminiscent of kudzu in the southeastern United States. Local spread is by birds and feral pigs that are attracted to the succulent fruit and pass the seeds through the digestive tract. Interisland spread is by man. Because of its growth habit and wide distribution, biocontrol may be the only feasible approach. The present study is part of a multiagency research effort to discover and evaluate possible insect and pathogenic agents for banana poka. Only the edible yellow-fruiting passionfruit, *P. edulis* Sims (subg. *Passiflora*) f. *flavicarpa* Deg., of the approximately 30 introduced species and forms of *Passiflora* in Hawaii (10) is commercially produced for human consumption. Wild populations of this form are also an important source of the fruit.

*Fusarium oxysporum* (Schlecht.) emend. Snyder & Hans. f. *sp. passiflorae* Gordon apud Purs was reported in Australia in the 1950s. It caused severe vascular wilt of purple-fruiting passionfruit (*P. e. f. edulis* Sims), the form then produced commercially in Australia (7-9). *F. o. f. sp. passiflorae* is not known to occur in Hawaii. Investigations to discover sources of resistance among other species of *Passiflora* in Australia demonstrated that *P. e. f. flavicarpa* was resistant and offered most promise as a rootstock to which scions of *P. e. f. edulis* could be grafted (3,9). The objectives of the present study, conducted in a laboratory environment, were to determine if *F. o. f. sp. passiflorae* would attack *P. mollissima*, and to provide information on the host range of this pathogen.

**MATERIALS AND METHODS**

An isolate of *F. o. f. sp. passiflorae* was obtained from the Plant Pathology Branch, Department of Primary Industries, Indooroopilly, Queensland, Australia, under Hawaii Department of Agriculture and USDA-APHIS permits. Pure cultures were grown on potato-dextrose agar (PDA) and other standard media. Cultural and morphological characteristics of the fungus were confirmed as typical of *F. oxysporum* (12). PDA cultures sporulated profusely, producing mostly microconidia, and were used throughout the study as an inoculum source. All culture and inoculation procedures were conducted under secure laboratory conditions at the University of Hawaii. Inoculated plants were maintained in a light incubator or in Plexiglas growth chambers, designed to minimize escape of fungal spores at 20–23°C under continuous Gro-Lux fluorescent lighting.

Seeds were germinated in new vermiculite. Seedlings in the cotyledon or first-leaf stages were removed from

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**Table 1. Nonpassifloraceous species root-dip inoculated with *Fusarium oxysporum* f. *sp. passiflorae***

<table>
<thead>
<tr>
<th>Family</th>
<th>Species and common name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apocynaceae</td>
<td><em>Vinca major</em> L., periwinkle</td>
</tr>
<tr>
<td>Bromeliaceae</td>
<td><em>Ananas comosus</em> (L.) Merr., pineapple</td>
</tr>
<tr>
<td>Caricaceae</td>
<td><em>Carica papaya</em> L., papaya</td>
</tr>
<tr>
<td>Chenopodiaceae</td>
<td><em>Beta vulgaris</em> var. <em>esculenta</em> L., Swiss chard</td>
</tr>
<tr>
<td>Compositae</td>
<td><em>Lactuca sativa</em> L., lettuce</td>
</tr>
<tr>
<td>Tagetes sp., marigold</td>
<td></td>
</tr>
<tr>
<td>Zinnia elegans Jacq., zinnia</td>
<td></td>
</tr>
<tr>
<td>Cruciferae</td>
<td><em>Lobularia maritima</em> (L.) Desv., sweet alyssum</td>
</tr>
<tr>
<td>Cucurbitaceae</td>
<td><em>Cucumis sativus</em> L., cucumber</td>
</tr>
<tr>
<td>Gramineae</td>
<td><em>Saccharum officinarum</em> L., sugarcane</td>
</tr>
<tr>
<td>Zea mays L., corn</td>
<td></td>
</tr>
<tr>
<td>Leguminosae</td>
<td><em>Acacia koa</em> Gray, koa</td>
</tr>
<tr>
<td><em>Crotalaria juncea</em> L., sunn hemp</td>
<td></td>
</tr>
<tr>
<td>Glycine max (L.) Merr., soybean</td>
<td></td>
</tr>
<tr>
<td><em>Leucaena leucocephala</em> (Lam.) de Wit, koa haole</td>
<td></td>
</tr>
<tr>
<td><em>Phaseolus vulgaris</em> L., bean</td>
<td></td>
</tr>
<tr>
<td><em>Phaseolus vulgaris</em> L., bean</td>
<td></td>
</tr>
<tr>
<td><em>Psium sativum</em> L., pea</td>
<td></td>
</tr>
<tr>
<td>Liliaceae</td>
<td><em>Allium cepa</em> L., onion</td>
</tr>
<tr>
<td>Sapindaceae</td>
<td><em>Dodonaea viscosa</em> Sm., 'alii'</td>
</tr>
<tr>
<td>Solanaceae</td>
<td><em>Capsicum annuum</em> L., pepper</td>
</tr>
<tr>
<td><em>Lycopersicum esculentum</em> Mill., tomato</td>
<td></td>
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<tr>
<td><em>Solanum melongena</em> L., eggplant</td>
<td></td>
</tr>
<tr>
<td>Umbellifera</td>
<td><em>Daucus carota</em> L., carrot</td>
</tr>
<tr>
<td><em>Petroselinum crispum</em> (Mill.) Nym., parsley</td>
<td></td>
</tr>
</tbody>
</table>

*Rooted ratoons were inoculated.*

*Rooted stem cuttings were inoculated.*

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476 Plant Disease/Vol. 73 No. 6
the growth medium and the roots were immersed and agitated in conidial suspensions (approximately 10⁶/ml) in water. The seedlings were replanted in new vermiculite. Equal numbers of control seedlings were root-dipped in water and replanted. Symptom development was observed and recorded 4-6 wk following inoculation. In other tests, seeds were germinated in commercial potting soil amended with F. o. f. sp. passiliorae cultured on a moist oatmillsand mixture (1:5, v/v). Controls were grown in either unamended soil or soil amended with a sterile oatmillsand medium. Alternately, 3-wk-old postmergent seedlings of P. ligulae Juss. (subf. Taccosia) were treated by pouring an F. o. f. sp. passiliorae PDA culture slurry into the soil.

In addition to P. mollissima, seedlings of P. e. f. edulis, P. e. f. flavicarpa, P. ligulae, P. foetida L. (subf. Passiliora), and P. suberosa L. (subf. Passiliora), all from seed from local wild populations, were similarly inoculated. Seedlings of a variety of nonpassilioraceous crop, ornamental, and native species were root-dip inoculated with F. o. f. sp. passiliorae to confirm specificity of the pathogen to the genus Passiliora (Table 1). At least 10 plants, representing at least two replications of each of the species and an equal number of controls, were tested.

Wilted seedlings were surface-disinfested by shaking in a 10% commercial sodium hypochlorite solution for 30 sec. The stems were then cut into 0.5-cm serial sections and placed on 2% water agar. Fungal growth from cut ends was examined for sporulation and eventual chlamydomospore production. The recovered fungus was recultured on PDA and its characteristics were compared with those of the original cultures.

RESULTS AND DISCUSSION

F. o. f. sp. passiliorae caused significant wilting and death of inoculated P. mollissima seedlings, such that the Hawaiian population of this species may be considered susceptible to Fusarium wilt disease. Recovery of the pathogen from successive stem sections indicated systemic distribution, an important characteristic of vascular wilt diseases, distinct from localized root diseases associated with other pathogens. Mortality among root-dip inoculated younger seedlings (i.e., those in the cotyledon stage, 5 days or less after emergence at inoculation) sometimes exceeded 90% (Fig. 1A). Mortality decreased to below 50% among older plants (i.e., those with 2-3 developing leaves, 10 days or more after emergence at inoculation). Although only one isolate of F. o. f. sp. passiliorae was available for this study, it is possible that more virulent isolates exist or could be selected through host passage manipulation. P. e. f. edulis, P. ligulae, and P. foetida were also attacked by the fungus, whereas P. e. f. flavicarpa and P. suberosa were resistant (Table 2).

Table 2. Mortality of Passiliora spp. seedlings root-dip inoculated with Fusarium oxysporum f. sp. Passiliorae

<table>
<thead>
<tr>
<th>Species</th>
<th>No. of plants</th>
<th>No. diseased</th>
<th>% Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. edulis f. edulis</td>
<td>331/308</td>
<td>111/0</td>
<td>34/0</td>
</tr>
<tr>
<td>P. e. f. flavicarpa</td>
<td>487/424</td>
<td>1/0</td>
<td>0.2/0</td>
</tr>
<tr>
<td>P. foetida</td>
<td>322/292</td>
<td>85/1</td>
<td>26/0.3</td>
</tr>
<tr>
<td>P. ligulae</td>
<td>74/74</td>
<td>32/0</td>
<td>30/0</td>
</tr>
<tr>
<td>P. mollissima</td>
<td>531/489</td>
<td>247/21</td>
<td>47/4</td>
</tr>
<tr>
<td>P. suberosa</td>
<td>224/186</td>
<td>0/0</td>
<td>0/0</td>
</tr>
</tbody>
</table>

*Data were recorded approximately 6 wk after inoculation. 
*An unidentified Fusarium sp. producing predominantly macroconidia was recovered from diseased controls.
families (1). Therefore, pathogenicity of *F. o. f. sp. passiflora* within different subgenera, although perhaps exceptional, is not without precedent. It is possible that the known host ranges of other formae speciales of *F. oxysporum*, although still remaining relatively narrow, could be expanded by inoculation surveys of allied noneconomic species, as was indicated by this study.

Australian studies (8,9) showing *P. e. f. flavicarpa* to be resistant to Fusarium wilt are supported by the resistance reported here of *P. e. f. flavicarpa* from Hawaiian populations. Resistant cultivars (e.g., Redlands Triangular) developed in Australia to replace *P. e. f. edulis* are currently available to the passionfruit industry (4).

Disease expression among susceptible plants grown in both preemergence- and postemergence-infested soil was less uniform than among root-dip inoculated seedlings. Nevertheless, both amendment methods were effective, resulting in 66% mortality among preemergence-inoculated *P. mollissima* plants 10–15 wk following emergence (Fig. 1B). In postemergence tests, 84% mortality among *P. ligularis* plants was obtained 6–15 wk following addition of inoculum to the soil (Fig. 1C).

Whereas the susceptibility of banana poka seedlings and other Hawaiian *Passiflora* spp. to *F. o. f. sp. passiflora* was determined under controlled laboratory conditions, the potential of this pathogen as a biocontrol agent under natural field conditions depends on many additional factors. *F. o. f. sp. passiflora* is capable of dissemination and disease production among mature purple-fruited passionfruit under cultivation in Australia (7,8). However, the pathogenicity and dissemination effectiveness of the fungus in mature banana poka infestations of higher elevation (≥1,210 m) wet forests in Hawaii remains to be determined. Field resistance of the edible passionfruit forms and of families related to *Passifloraceae* (e.g., *Flacourtiaeae*, *Violaceae*), represented in Hawaii by native or introduced species, should also be evaluated.

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**LITERATURE CITED**