The Occurrence of Fusarium oxysporum on Phoenix canariensis, a Potential Danger to Date Production in California

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ABSTRACT


Fusarium oxysporum, in association with Gliocladium verticilloides (Canary Island palm) in California. Both fungi were pathogenic, by stem injection, singly and in combination to P. dactylifera (date palm). F. oxysporum also infected date palm seedlings through roots. The symptoms of wilt and dieback are similar to those of bayoud of P. dactylifera, an important disease found in North Africa, and caused by F. oxysporum f. sp. albedinis. Our work showed that the pathogens, especially F. oxysporum, were potential pathogens of P. dactylifera, and consequently the California Department of Food and Agriculture established a quarantine in an effort to prevent their being introduced into date-growing areas in California.

Fusarium oxysporum Schlcht., in association with Gliocladium verticilloides (Biourge) Thom. (Penicillium verticilloides), causes wilt and dieback of Phoenix canariensis Hort. ex Chab. (Canary Island palm), a disease complex recently discovered in California (16). This disease complex is responsible for the recent decline of Canary Island palms planted in city streets and park landscapes in California. Symptoms of wilt and dieback are reduced canopy, death of pinnae on one side of the rachis, vascular browning, and black-brown dry rot in bud and rachis tissue. Distribution, symptoms, epidemiology, and control of wilt and dieback will be discussed elsewhere.

Diseases with symptoms similar to the wilt and dieback disease caused by F. oxysporum in California have been reported on Canary Island palms in France (20), Italy (13), Japan (1), and Australia (23). In Japan and France, F. oxysporum isolated from Canary Island palm was pathogenic to seedlings of date palm (P. dactylifera) (1,20). Wilt and dieback of Canary Island palm is similar to bayoud disease, which has devastated date palm plantings in Morocco and parts of western Algeria (14). Bayoud is caused by F. oxysporum f. sp. albedinis (Kill. & Maire) Gordon, and its history, distribution, symptoms, epidemiology, and control have been studied thoroughly (11,17,19,21,22).

Wilt and dieback was first found in 1976 on 30- to 50-yr-old Canary Island palms planted in cities along the coast of southern California. F. oxysporum and G. verticilloides isolated from diseased Canary Island palms were pathogenic either alone or in combination on seedlings of date palms (15). F. oxysporum was found in 1978 on diseased 5- to 7-yr-old Canary Island palms at a nursery in Borrego Springs, CA (unpublished). This finding demonstrated the ability of F. oxysporum to cause disease on P. canariensis in a hot desert environment. F. oxysporum has never been found as a pathogen of date palms in California. However, our observations and tests suggest that F. oxysporum from Canary Island palm could infect date palms if introduced to desert areas where they are grown.

This work reports the pathogenicity, on date palm, of F. oxysporum and G. verticilloides isolated from Canary Island palm both alone and in combination, discusses the possible threat of F. oxysporum from that species to date palm, and notes the current interior quarantine that has been extended to protect date palms in California.

MATERIALS AND METHODS

Isolation of fungi. F. oxysporum and G. verticilloides were isolated from Canary Island palm with wilt and dieback symptoms. Isolations were made from leaf rachis tissues. Tissue was cut into 5-mm cubes, soaked 3–5 min in 0.5% sodium hypochlorite (NaClO), rinsed in sterile deionized water (SDW), and placed on potato-dextrose agar (PDA) (250 g of potato, 20 g of dextrose, 20 g of agar in 1 L of deionized water). Plates were incubated 1 wk at 24–30°C under continuous illumination by cool-white 20 W fluorescent lamps with a total intensity of 2.23 × 10⁴ W cm⁻².

Preparation of inoculum. F. oxysporum inoculum was a mixture of five single-spore isolates from five different palms (San Diego, Orange, San Bernardino, and Los Angeles counties). In method 1, isolates were grown for 1 wk on PDA under continuous light, and a loop of spores from each isolate was transferred to 25 ml of potato-dextrose broth (PDB, same as PDA but without agar) in 150-ml flasks. After 1 wk at 24–30°C on a rotary shaker, the spores were washed three times with SDW.
times with 10 ml of SDW resuspended in 10 ml of SDW, and spore concentrations were determined with a hemacytometer. In method 2, isolates were grown for 1 wk at 24–30°C on PDA under continuous light. The agar surface was flooded with 10 ml of SDW and scraped with a spatula. The resulting spore suspension was filtered through four layers of cheesecloth and the macroconidia concentration was determined with a hemacytometer.

*G. vermoesenii* inoculum was a mixture of four single-spore isolates from four diseased trees (San Diego, Orange, San Bernardino, and Los Angeles counties). The fungus was grown on PDA in petri plates at 24–30°C for 7–14 days. Spores were harvested by flooding the plates with 10 ml of SDW, scraping the agar surface with a spatula, and filtering the suspension through four layers of cheesecloth. The concentration of conidia was determined with a hemacytometer.

**RESULTS**

Pathogenicity tests on 10-mo-old *P. dactylifera*. Disease symptoms developed within 2 mo on trees injected with *F. oxysporum, G. vermoesenii*, or a mixture of the two fungi. Compared with plants injected with water, trees inoculated with fungi were stunted (Table 1) and leaves were dead or dying (Fig. 1). Crowns of plants inoculated with *G. vermoesenii* had a brown dry rot, three plants died, and the pathogen was reisolated from diseased plants. None of the plants inoculated with *F. oxysporum* died, but vascular discoloration was observed in the crowns and petioles and the pathogen was reisolated from the plants. Date palms inoculated with a mixture of both fungi had a brown rot and vascular discoloration in the crowns, three plants died, and both fungi were reisolated from diseased plants.

**Infection through roots of *P. dactylifera* seedlings by *F. oxysporum*.** The average dry weight of inoculated plants (7 g) and uninoculated plants (12 g) were significantly different according to an *F* test.

<table>
<thead>
<tr>
<th>Inoculum</th>
<th>Average dry weight (g)</th>
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<tbody>
<tr>
<td>Water</td>
<td>104 a</td>
</tr>
<tr>
<td><em>F. oxysporum</em></td>
<td>60 b</td>
</tr>
<tr>
<td><em>G. vermoesenii</em></td>
<td>51 b</td>
</tr>
<tr>
<td><em>F. oxysporum + G. vermoesenii</em></td>
<td>60 b</td>
</tr>
</tbody>
</table>

Fungi were isolated from *P. canariensis* with wilt and dieback symptoms.

Fig. 1. *Phoenix dactylifera* (date palm) inoculated by stem injection with: (A) water, (B) *Fusarium oxysporum*, (C) *Gliocladium vermoesenii*, (D) a mixture of both fungi. Inocula were prepared from fungi isolated from *Phoenix canariensis* with wilt and dieback symptoms. The 19-mo-old trees were photographed 9 mo after inoculation.
(P = 0.01). None of the seedlings died, but the plants were stunted and leaves were dead (Fig. 2). Roots died and extensive vascular discoloration occurred in the crowns and roots of inoculated plants. *F. oxysporum* was reisolated from shoots and roots of inoculated and infected plants, but not from control plants.

Similar results were found when cultures of *F. oxysporum* isolated from diseased Canary Island palms from Borrego Springs, CA, were used to inoculate roots of date palm seedlings. The five inoculated seedlings wilted after 5 mo; noninoculated plants were healthy.

**DISCUSSION**

*F. oxysporum* and *G. velutinosa* were isolated from Canary Island palms with wilt and dieback symptoms. The two fungi also were pathogenic to date palm seedlings, producing the same disease symptoms as those observed on inoculated Canary Island palms. *F. oxysporum* was pathogenic to date palm seedlings through either stems or roots. The symptoms concur with those reported in France (20) and Japan (1) where *F. oxysporum* isolated from Canary Island palm also was pathogenic to date palm seedlings.

Before our pathogenicity tests, *G. velutinosa* was a proven pathogen of date palm in California (3). *G. velutinosa* has been prevalent on several species of ornamental palms in southern coastal cities for at least 40-50 yr (3). Although there was speculation about the possibility of a severe outbreak of *G. velutinosa* on date palms in California (4), the fungus has never caused any problems on date palms grown in the southeastern deserts. The current concern is that *F. oxysporum* from Canary Island palms could cause a severe disease among date palms in the United States.

Bayoud disease, caused by *F. oxysporum* f. sp. *albedinis*, is an economically important disease of date palm in North Africa. Bayoud was first observed about 1890 in Morocco (11), and by 1950, 10 million palms had been killed by the disease. Areas with 300-400 palms per hectare were reduced to 5-10 palms per hectare (22). The disease also has severely affected date palm gardens in Algeria (7,18). Development of resistant varieties is believed to provide the only method for control of bayoud (8,12,18,19). Quarantine measures to prevent further worldwide spread of bayoud disease have been established in North Africa (9,11).

Compared with North Africa and the Middle East, California has a modest, but productive, date industry. In 1979, California had 3,000-4,000 bearing acres of date palms, providing a total crop value of $11 million (5). Of equal importance to both national and international date production is the National Date Palm Germplasm Repository (10), now located at the Irrigated Desert Research Station, Brawley, CA. The date industry in California is aware of bayoud disease, and international quarantines regulate the movement of date palms and date palm products (24).

Our work demonstrates that *F. oxysporum* from Canary Island palms in California with wilt and dieback is pathogenic on date palm seedlings. When *F. oxysporum* was discovered in the desert on Canary Island palms at a nursery in Borrego Springs, the California Department of Food and Agriculture took regulatory action. A quarantine was established within California to restrict movement of plants, seeds, and plant parts of *Phoenix* spp., as well as the tools used for pruning *Phoenix* spp., into three counties where date palms are grown (6). It is hoped that the quarantine will reduce the probability of the pathogen being introduced into California’s date industry. Because *F. oxysporum* can be transmitted to *P. canariensis* by pruning (unpublished), requirements for tool sterilization were also included in the quarantine even though it is not known if the pathogen can be transmitted to *P. dactylifera* by leaf pruning.

*F. oxysporum* has not been found on date palms in California. However, its severity on Canary Island palm, its pathogenicity to date palm seedlings, and the similarity of wilt and dieback symptoms of Canary Island palm to bayoud of date palm all are reasons for concern in the California date industry.

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**LITERATURE CITED**