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

TOLBERT V. FEATHER, Former Graduate Student, HOWARD D. OHR, Cooperative Extension Specialist, and DONALD E. MUNNECKE, Professor Emeritus, Department of Plant Pathology, University of California, Riverside, 92521, and JOHN B. CARPENTER, USDA Retired Research Plant Pathologist, USDA Date and Citrus Experiment Station, Indio, CA

ABSTRACT

Feather, T. V., Ohr, H. D., Munnecke, D. E., and Carpenter, J. B. 1989. The occurrence of *Fusarium oxysporum* on *Phoenix canariensis*, a potential danger to date production in California. Plant Disease 73:78-80.

Fusarium oxysporum, in association with *Gliocladium vermoeseni*, causes a disease complex called wilt and dieback on *Phoenix canariensis* (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 Schlect., in association with *Gliocladium vermoeseni* (Biourge) Thom. (*Penicillium vermoeseni*), 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 street 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.

Portion of the dissertation submitted by the first author in partial fulfillment of the requirements for the Ph.D. degree.

This research supported in part by the Elvenia J. Slosson Endowment Fund.

Mention in this publication of a commercial company or of a manufactured product does not imply endorsement by the University of California.

Accepted for publication 31 August 1988 (submitted for electronic processing).

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. vermoeseni* 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. vermoeseni* 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. vermoeseni* 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 2.23×10^3 W cm^{-2}.

Preparation of inocula. *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 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. vermoeseni 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.

Pathogenicity tests on 10-mo-old *P. dactylifera*. Seeds of the Deglet Noor variety of *P. dactylifera* were surface-sterilized for 15 min in 0.5% sodium hypochlorite (NaClO), rinsed with tap water, and planted in 12 × 15 × 25 cm plastic seedling bags filled with steamed U.C. soil mix. The U.C. soil was made by mixing 0.5 m^3 of blow sand, 0.5 m^3 of peat moss, 1.5 kg of phosphate, 150 g of potassium nitrate, 150 g of potassium sulfate, and 2.25 kg of dolomite lime per cubic meter of mix (2). The pH of the mix was 6.5. Seedlings were grown 4 mo in a greenhouse, transplanted into 8-L plastic containers, kept under glass for 5 mo, then transferred to a lathhouse 1 mo before inoculation. Two holes, 2 mm in diameter by 20 mm deep, were drilled in the stems of 10-mo-old palms and 2 ml of inoculum were injected into each hole with a hypodermic needle and syringe. The inocula were: 1) *F. oxysporum*, 5×10^5 spores per ml (grown in PDB method 1); 2) *G. vermoeseni*, 5×10^5 spores per ml; 3) a mixture of 5×10^5 spores per ml of each fungus; and 4) sterile distilled water (SDW). After 9 mo in a lathhouse, the plants were examined, harvested, dried for 72 hr at 65 C, and weighed. Treatments were replicated eight times and the data were analyzed statistically. Isolations of fungi from crown tissues were made from four replicates of each treatment.

Infection through roots of *P. dactylifera* seedlings by *F. oxysporum*. Date palm seedlings were grown in seedling bags for 4 mo, as described above. The crown of each plant was exposed by trimming the seed bags and removing the soil from around the stems. Roots were left intact in soil within the base of the seed bag and 100 ml of a suspension containing 1×10^5 spores per milliliter of *F. oxysporum* in water, grown on PDA (method 2), was poured onto the soil surface and seedling roots. After 24 hr, each seedling was transplanted to U.C. mix in 10 × 10 × 13 cm fiber pots. Sterile distilled water was used as a control treatment. Treatments were replicated seven times and plants were grown in a greenhouse for 5 mo. Plants were harvested and processed as described above.

RESULTS

Pathogenicity tests on 10-mo-old *P. dactylifera*. Disease symptoms developed within 2 mo on trees injected with *F. oxysporum*, *G. vermoeseni*, 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. vermoeseni* 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 1. Dry weights of 19-mo-old *Phoenix dactylifera* 'Deglet Noor' inoculated by stem injection with *Fusarium oxysporum*, *Gliocladium vermoeseni*, or with a mixture of both fungi

Inoculum[y]	Average dry weight (g)[z]
Water	104 a
F. oxysporum	60 b
G. vermoeseni	51 b
F. oxysporum + *G. vermoeseni*	60 b

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

[z] Averages of eight replicates per treatment determined 9 mo after inoculations. Values followed by the same letter in each column were not significantly different according to Duncan's multiple range test ($P = 0.01$).

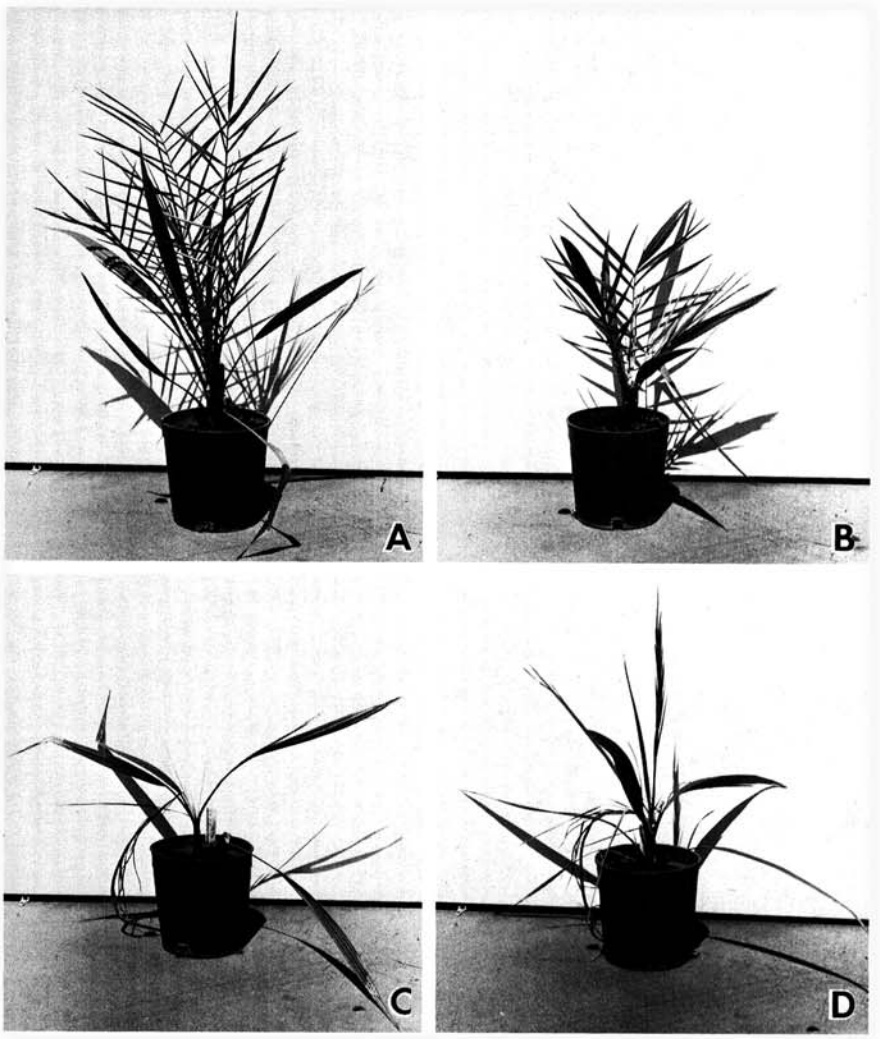

Fig. 1. *Phoenix dactylifera* (date palm) inoculated by stem injection with: **(A)** water, **(B)** *Fusarium oxysporum*, **(C)** *Gliocladium vermoeseni*, **(D)** a mixture of both fungi. Inocula were prepared from fungi isolated from *Phoenix canariensis* with wilt and dieback symptoms. The 19-mo-old 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. vermoeseni* 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 palms inoculated 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. vermoeseni* was a proven pathogen of date palm in California (3). *G. vermoeseni* 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. vermoeseni* 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).

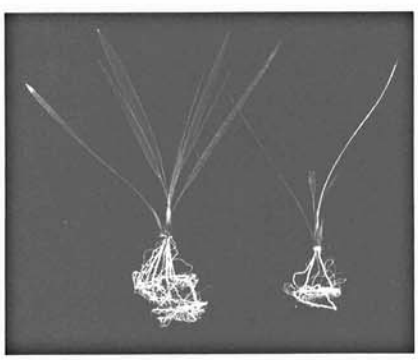

Fig. 2. *Phoenix dactylifera* seedlings (9 mo old) inoculated with *Fusarium oxysporum* isolated from *Phoenix canariensis* showing wilt and dieback symptoms. **(Left)** Sterile distilled water and **(right)** spore suspensions of *F. oxysporum* were poured onto soil around 4-mo-old plants 24 hr before transplanting to larger pots.

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.

ACKNOWLEDGMENT

The authors thank the members of the California Department of Food and Agriculture for their support and cooperation.

LITERATURE CITED

1. Arai, K., and Yamamoto, A. 1977. New Fusarium disease of Canary Island date palm in Japan. Bull. Fac. Agric., Kagoshima Univ. 27:31-37.
2. Baker, K. F., ed. 1957. The U.C. System for Producing Healthy Container-Grown Plants. Calif. Agric. Exp. Stn. Man. 23. 332 pp.
3. Bliss, D. E. 1938. The Penicillium disease of ornamental palms. Proc. Western Shade Tree Conf. 5th. 5:20-27.
4. Bottel, A. E. 1924. Quarantine protection of the date industry. Date Grow. Inst., Rep. 1:15.
5. California Crop and Livestock Reporting Service. 1979. Page 4 in: California Fruit and Nut Statistics 1978–1979. Sacramento, CA.
6. California Department of Food and Agriculture. 1980. Date palm disease interior quarantine. Quarantine regulation 24. 3419. Page 145A in: California Plant Quarantine Manual. Sacramento, CA.
7. Carpenter, J. B. 1971. Notes on bayoud disease of date palms in Algeria. Date Grow. Inst., Rep. 48:14-15.
8. Carpenter, J. B. 1973. Date palm research and culture in Morocco, with special reference to bayoud disease. Date Grow. Inst., Rep. 50:11-12.
9. Carpenter, J. B. 1977. Date palm (*Phoenix dactylifera* L.). Pages 155-163 in: Plant Health and Quarantine in International Transfer of Genetic Resources. W. B. Hewitt and L. Chiarappa, eds. CRC Press, Inc., Cleveland, OH. 346 pp.
10. Carpenter, J. B. 1979. The national date palm germplasm repository. Date Grow. Inst., Rep. 54:29-32.
11. Carpenter, J. B., and Elmer, H. S. 1978. Pests and Diseases of the Date Palm. U.S. Dep. Agric., Agric. Handb. 527. 42 pp.
12. Carpenter, J. B., and Ream, C. L. 1976. Date palm breeding, a review. Date Grow. Inst., Rep. 53:25-33.
13. Corte, A. 1973. La tracheomicosi da *Fusarium oxysporum* f. sp. *albedinis* della *Phoenix canariensis*. Not. Mal. Piante (Genoa) 88/89:107-117.
14. Feather, T. V. 1982. Occurrence, Etiology and Control of Wilt and Dieback of *Phoenix canariensis* in California. Ph.D. dissertation. University of California, Riverside. 119 pp.
15. Feather, T. V., Munnecke, D. E., and Ohr, H. D. 1979. Occurrence of *Fusarium oxysporum* and *Gliocladium vermoeseni* on *Phoenix canariensis* in California, and their effects on seedlings of *Phoenix* species. Date Grow. Inst., Rep. 54:17-18.
16. Feather, T. V., Ohr, H. D., and Munnecke, D. E. 1979. Wilt and dieback of Canary Island palm in California. Calif. Agric. 33(7/8):19-20.
17. Louvet, J., Bulit, J., Toutain, G., and Rieuf, P. 1970. Le bayoud, fusariose vasculaire du palmier dattier-symptomes et nature de la maladie-moyens de lutte. Al Awamia 35:161-181.
18. Louvet, J., and Toutain, G. 1973. Recherches sur les fusarioses. III. Nouvelles observations sur la fusariose du palmier dattier et precisions concernant la lutte. Ann. Phytopathol. 5:35-52.
19. Louvet, J., and Toutain, G. 1981. Bayoud, Fusarium wilt of date palm. Pages 13-20 in: *Fusarium*: Diseases, Biology, and Taxonomy. P. E. Nelson, T. A. Toussoun, and J. R. Cook, eds. Pennsylvania State University Press, University Park. 457 pp.
20. Mercier, S., and Louvet, J. 1973. Recherches sur les fusarioses. X. Une fusariose vasculaire (*Fusarium oxysporum*) du palmier des Canaries (*Phoenix canariensis*). Ann. Phytopathol. 5:203-211.
21. Pereau-Leroy, P. 1954. Recherches sur la fusariose du palmier-dattier. Ann. Inst. Fruits et Agrumes Coloniaux, Paris. 8. 27 pp.
22. Pereau-Leroy, P. 1958. Les parasites du palmier dattier. Pages 39-88 in: Le Palmier Dattier au Maroc. Min. Agric. Maroc, Serv. Rech. Agron. et Inst. Francais Rech. Fruit. Outre-mer. Rabat. 142 pp.
23. Priest, M. J., and Letham, D. B. 1984. Fusarium wilt of Canary Island date palm. Pages 24-25 in: Plant Disease Survey 1982–1983. Biological Branch, Biological and Chemical Research Inst., NSW Dep. Agric., Rydalmere NSW, Australia. 62 pp.
24. U.S. Department of Agriculture. 1962. Quarantine: Nursery Stock, Plants and Seeds. Title 7, Agric., Chapter III, Agric. Res. Serv., Dep. Agric., Part 319. Page 19 in: Foreign Quarantine Notices, Sect. 319.37, Washington, D.C.