EPPO Datasheet: *Fusarium oxysporum f. sp. albedinis*

Last updated: 2020-04-22

IDENTITY

Preferred name: *Fusarium oxysporum f. sp. albedinis*
Authority: (Killian & Maire) Malençon
Taxonomic position: Fungi: Ascomycota: Pezizomycotina: Sordariomycetes: Hypocreomycetidae: Hypocreales: Nectriaceae
Other scientific names: *Cylindrophora albedinis* Killian & Maire, *Fusarium albedinis* (Killian & Maire) Malençon
Common names: bayoud disease of date palm, fusarium wilt of date palm, tracheomycosis of date palm
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EPPO Categorization: A2 list
view more categorizations online...
EU Categorization: Quarantine pest ((EU) 2019/2072 Annex II A)
EPPO Code: FUSAAL



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HOSTS

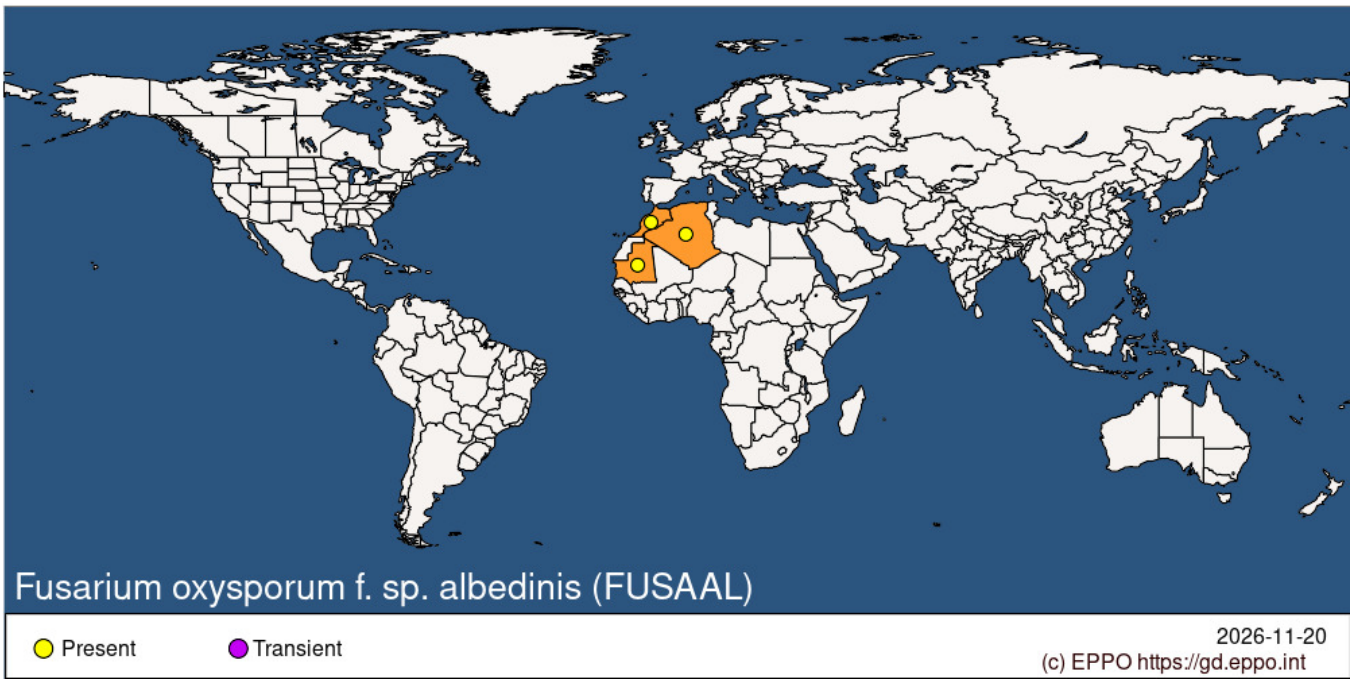
The principal host of *Fusarium oxysporum* f. sp. *albedinis* (bayoud disease) is date palm (*Phoenix dactylifera*); all commercial high-quality North African cultivars are susceptible (e.g. cvs Mejhoul, Deglet Nour, Bou Feggous). The first observations showed that some cultivars show good resistance (cvs Black Bou Sthammi, White Bou Sthammi, Tadment, Iklane, Sair Layalet, Bou Feggous, Moussa in Morocco and Takerboucht in Algeria). However, among these cultivars, only Sair Layalet and Takerboucht have dates of acceptable quality although not equal to Deglet Nour or Mejhoul (Pereau-Leroy, 1954; Toutain & Louvet, 1974; Saaidi, 1979). Recent studies since 1980s on varietal selection have permitted the obtention of the seventh resistant cultivar (Bou Khanni) and of new varieties that combine resistance and good quality dates (Sedra, 1995; 2003a; 2011a,b; 2012; 2015a).

F. oxysporum f. sp. *albedinis* has also been reported on some other species of plants grown in date plantations: *Lawsonia inermis* (henna), a dye plant; *Medicago sativa* (lucerne) and *Trifolium* sp. (Djerbi *et al*., 1985a). These plants are symptomless carriers of the pathogen and are cultivated in North African and Near East countries (Djerbi *et al*., 1986a). The pathogen strains isolated from these plants are less aggressive compared to those isolated from infected palm leaves (Sedra, 2004; 2011b).

The causal agent of the vascular wilt of Canary Islands date palm (*Phoenix canariensis*) differs from *F. oxysporum* f. sp. *albedinis* in its cultural and pathological characteristics as well as by vegetative compatibility, and belongs to a different *forma specialis* of *F. oxysporum* (Djerbi *et al*., 1986b; Sedra & Djerbi, 1986; Djerbi, 1990b). Recent research showed that some strains collected from Canary Islands palm have similar cultural morphology to some *F. oxysporum* f. sp. *albedinis* strains and could react in the same way with the molecular tests used for *F. oxysporum* f. sp. *albedinis* (Sedra and Zhar, 2010; Sedra, 2011b; 2013, 2015a).

Host list: *Lawsonia inermis*, *Medicago sativa*, *Phoenix dactylifera*, *Trifolium*

GEOGRAPHICAL DISTRIBUTION



EPPO Region: Algeria, Morocco
Africa: Algeria, Mauritania, Morocco

BIOLOGY

F. oxysporum f. sp. *albedinis* persists in the form of chlamydospores in dead tissues of diseased palms (roots, rachis, etc.). With subsequent disintegration of such tissues, the chlamydospores may be released into the soil where they remain dormant. The fungus may also survive on symptomless carriers, e.g. *Lawsonia inermis*, *Medicago sativa* (lucerne), *Trifolium*. *F. oxysporum* f. sp. *albedinis* can multiply on decomposed plant debris in soil but its saprophytic development is relatively weak compared to that of other saprophytic microorganisms (Sedra, 1993a; Sedra and Bah, 1993).

The fungus is distributed very unevenly in the soil and has been found at depths of 0-30 cm and sometimes more than 1 m (Tantaoui, 1989). Chlamydospores are rare but can persist in soil for more than 8 years. When spores are stored in fine sand under ambient temperature conditions, they can retain their vitality and their level of pathogenicity for more than 30 years (Sedra, 2003a; 2011b). In contaminated oases, the pathogen is unevenly distributed and is usually found in the rhizosphere (30-60cm deep), and in particular in areas where date palm trees are densely planted and actively growing (Sedra, 1993a, 2003a; 2011b). Even relatively small numbers of clamydospores (some thousands) are sufficient to initiate the disease and infection of only a few roots can result in tree death.

Under suitable conditions, chlamydospores germinate and enter the vascular tissues of roots, from which the mycelium advances to the stem. Microconidia are carried upwards in the vessels; when impeded by a cross-wall, they germinate, the germ tubes penetrate the wall and the microconidia formation is resumed on the other side of the wall. The tree dies when the fungus and its toxins reach the terminal bud. During its upward progression in the xylem, *F. oxysporum* f. sp. *albedinis* colonizes the surrounding parenchyma by inter- and intracellular mycelium. This later gives the reddish-brown colour characteristic of the diseased tree. After the death of the tree, the mycelium continues to develop in the dead tissues and forms numerous chlamydospores in the sclerenchyma cells (Louvet, 1977). Other studies carried out later (Sedra and Lazrek, 2011; Sedra *et al.*, 2008) show that the pathogen secretes specific and non-specific toxins which cause the same symptoms on young plants and can be used to carry out *in vitro* selection for resistance to bayoud. In general, conditions that are favourable to the host also favour disease development. The optimum range for growth of the fungus is 21-27.5°C; growth remains significant at 18 and 32°C, but stops at 7 and 37°C (Bounaga, 1975).

DETECTION AND IDENTIFICATION

Symptoms

External symptoms

Bayoud disease attacks mature and young palm trees alike, as well as their basal offshoots.

The first external symptom of the disease, noticeable to experienced observers, appears on one or more leaves of the middle crown. The affected leaf takes on a leaden or ash-grey colour and then withers in a characteristic way: some pinnae or spines situated on one side of the leaf become white; then, the disease progresses from the base to the apex. After one side has been affected, the withering begins on the other side, progressing this time from the top of the leaf to the base, until the whole leaf dies.

During the whitening and dying of the pinnae, a brown stain appears lengthwise on the dorsal side of the rachis and advances from the base to the tip of the frond, corresponding to the passage of the mycelium in the vascular bundles of the rachis. Afterwards, the leaf appears arched, resembling a wet feather, and hangs down along the trunk. This process may take a few days to several weeks.

The same symptoms then begin to appear on adjacent or opposite leaves. The disease advances to the central cluster and the tree dies when the terminal bud is affected. Finally, offshoots at the base of the palm tree are attacked.

Sometimes, symptoms develop differently. The brown stain appears in the middle of the rachis on its dorsal side, not unilaterally, and progresses upwards until the rachis becomes so narrow that all tissues are affected, leading to the death of the tip. Thereafter, the whitening and dying of pinnae progress downwards until the leaf is killed. Other variations may occur in the early symptoms; a general yellowing may be detected before the appearance of typical symptoms, mainly during autumn and winter. The atypical symptoms of bayoud on date palm are often observed under stress conditions of the plant and sometimes in palm trees affected by other rot diseases of the apical part and during infections of the palms by *Thielaviopsis paradoxa* and/or *Botryodiplodia theobromae*. These have been encountered in contaminated Mauritanian oases (Sedra, 1999, 2003a,b, 2007, 2011b, 2013, 2015a, 2018).

Palm trees may die within 6 months to 2 years after the appearance of the first symptoms, depending on the cultivar, age of trees and planting conditions (Bulit *et al*., 1967; Louvet *et al*., 1970; Djerbi, 1982). On young plants planted in the field (less than two years old) from seedlings or produced by in vitro culture, the signs of the disease are characterized by a slight yellowing of diseased palms. On seedlings grown in the greenhouse or in the nursery, the symptoms are characterized by wilting and curling of the juvenile leaves (Sedra, 1993e; 1994; 2011a, 2013, 2015a, 2018).

Internal symptoms

When an affected tree is uprooted, only a small number of diseased roots, which are reddish in colour, are revealed, and seem limited in proportion to the extent of damage observed above ground. These diseased roots correspond to several groups of vascular bundles found on the stipe (with the sclerenchyma and the parenchyma surrounding them) which have taken on a reddish-brown colour. Towards the stipe base, the coloured areas are large and numerous. Higher up, the coloured vascular bundles separate and their convoluted paths, inside the healthy tissues, can be followed. When cut, palm fronds manifesting external symptoms exhibit a reddish-brown colour with highly coloured vascular bundles.

Symptoms have not been reported in peduncles, flowers or fruits (Koulla & Saaidi, 1985).

Morphology

The pathogen can be isolated on potato dextrose agar from discoloured date palm tissue and from symptomless carriers, or on selective media from soil. Fresh cultures appear salmon-pink, but cultures maintained on synthetic media by mass transfers become peach, pink, purple or violet and whitish when cultures are incubated in the dark. In addition to the shrubby appearance of the wild strain of the pathogen, certain colonies in successive cultures can have several different aspects (or mixtures of these aspects): cottony, flaky, fluffy, flat, spreading (Sedra, 1993b,c,d; 2003a).

Microconidia are spherical to elongate, slightly curved, mostly unicellular, hyaline, 3-15 x 3-5 µm; they are produced by microphialides, swollen at the base and pointed at the tip. Macroconidia are falcate, usually three-septate, 20-35 x 3-5 µm. Chlamydospores are intercalary or terminal, spherical, occurring singly or in groups of two to three. Sclerotia are rare in culture, dark-blue to black, 100-200 µm diameter, either distributed over the mycelium or in groups. See also Brayford (1992).

Detection and inspection methods

To confirm *F. oxysporum* f. sp. *albedinis* among isolates of *F. oxysporum* obtained from date palm, symptomless plants and soil, a pathogenicity test can be carried out. Isolates can be artificially inoculated to the roots of young date plants at the two-leaf stage; *F. oxysporum* f. sp. *albedinis* is recognized by death of the plants after 1-2 months (Dubost & Kada, 1974; Watson, 1974; Saaidi, 1979; Sedra, 1993e; 1994).

The pathogenicity test is valid if the final mortality exceeds 20% for the known pathogenic isolate (positive control) and also for the isolate studied, and if the seedlings inoculated with the non-pathogenic isolate (negative control) do not show any signs of the disease. Date palm is genetically variable due to its dioecious nature, so at least 50 seedlings must be used in the pathogenicity test (EPPO, 2003). In addition, it is possible to use at least 20 genetically compliant plants produced by the tissue culture technique based on organogenesis (Sedra, 1993e, 1995, 2003a).

The pathogen can also be identified by cultural characteristics of single-spore cultures (Chettab *et al*., 1978; Djerbi *et al*., 1985b; Sedra & Djerbi, 1985; Cherrab, 1989; Sedra, 1993c) or by the vegetative compatibility test (Djerbi, 1990a; 1990b; Djerbi *et al*., 1990). These two methods allow relatively rapid and accurate identification of the pathogen without the need for artificial inoculation, but also require considerable experience.

The development of molecular tests has made it possible to rapidly identify *F. oxysporum* f. sp. *albedinis*. Fernández *et al*. (1998) developed a PCR test which produced two amplicons of 400 bp and 200 bp using the pairs of primers TL3-FOA28 (3?-ATCCCCGTAAAGCCCTGAAGC-5?) and BIO-FOA1 (3?-GGTCGTCCGCAGAGTATACCGGC-5?), respectively. This test differentiates the date palm pathogen from other special forms of *F. oxysporum*, as well as from saprophytic strains. Extended studies in a population of *Fusarium oxysporum* including *F. oxysporum* f. sp. *albedinis*, have showed that the use of these primers, especially the primer that is producing the 200 bp band, did not provide reliable results (Sedra, 2011b, 2013, 2015a, Sedra and Zhar, 2010). Other additional molecular markers have also been developed to enable the diagnosis of strains of the pathogen (Sedra, 2006, 2011b, 2013, 2018; Sedra and Zhar, 2010) and others new markers (Sedra, unpublished). Other *F. oxysporum* f. sp. *albedinis* tests have been developed in recent years (Raja *et al*. 2017; Belarbi *et al*., 2018) but performance characteristics remain to be confirmed on a large number of *F. oxysporum* f. sp. *albedinis* strains of different origin. Since these molecular markers were generally developed on strains isolated from infected plants, it is also necessary to optimize performance on the telluric pathogenic strains of *F. oxysporum* f. sp. *albedinis* in the total DNA extracted from soil.

PATHWAYS FOR MOVEMENT

F. oxysporum f. sp. *albedinis* can be spread by infected offshoots, soil, symptomless hosts, infected date tissues (especially infected pieces of rachis) and by irrigation water passing through infested fields, as well as by tools and objects which can transport contaminated soil. It is not carried by date fruits or seeds.

Within a plantation, the disease is spread by contact between diseased and healthy roots; the extent of such spread varies according to cultural conditions (e.g. it is increased by copious irrigation and organic fertilization, or by tillage).

PEST SIGNIFICANCE

Economic impact

Bayoud disease occurs in major epidemics and causes death of trees. In the 20th century, the disease has destroyed

more than two-thirds of the Moroccan palm groves (12 million trees), and it continues to cause the death of 4.5 to 12% of date palms per year (Djerbi, 1983). Morocco, which was formerly an exporter of dates, is now an importer. Currently, the disease occurs in the majority of Moroccan date groves and has spread, in recent years, to areas beyond traditional oases (Sedra 2003a, 2004, 2006, 2011b, 2015a). In Algeria, more than 3 million trees have been destroyed, particularly in Tidikelt, Touat and M'Zab (Brochard & Dubost, 1970a,b; Benzaza *et al.*, 1970; Dubost & Kellou, 1974; Toutain, 1965). Surveys in the Drâa Valley (Morocco) in 1981 revealed 165 574 date palms killed among 2 million trees (Djerbi *et al*., 1986a). In the majority of oases, more than half the commercial cultivars have been destroyed; this has resulted in the progressive disappearance of high-quality cultivars in favour of poor-yielding, seedling trees. Oases that formerly had 300-400 palms per hectare were reduced to 40-50 palms per hectare (Saaidi, 1979; Djerbi *et al*., 1986a). Since the 1980s, farmers have been trying to repopulate the devastated orchards with commercial cultivars, but as these are susceptible to bayoud, this has not solved the problem (Sedra, 2015a). In Morocco, the number of bayoud foci has considerably increased in the last decades. Recently, within the traditional plantations at the Draa valley for example, the distance between the outbreaks of the disease ranges from 50 to 200 m, compared to 300 to 800 m in the past (Sedra, 2018).

The disease has caused not only the loss of a staple food for the Saharan population but also the loss of a major source of income and foreign currency. Damage by bayoud disease has also reduced the annual crops formerly protected by date palms and has accelerated desertification.

Since the best North African and commercial cultivars are highly susceptible, bayoud disease constitutes a phytosanitary crisis for Moroccan and Algerian Saharan agriculture. It reduced the genetic inheritance in the devastated oases and is responsible for the disappearance of several cultivars such as Idrar and Berni in Morocco. Most of the best commercial cultivars of Mauritania and the Gulf countries have also proved to be susceptible to the disease (Sedra, 2011b, 2013, 2018).

The disease was discovered in the North of Mauritania in 1999. The pathogen has been confirmed in Ammaria and Chanker oases, near Atar city in the region of Adrar (Sedra 1999, 2004, 2003a,b, 2006, 2007, 2011b, 2013, 2015b). In this country, the disease has caused damage and losses have been estimated to several thousand palms in some contaminated date palm orchards (Sedra, 2007, 2015b, 2018).

Symptoms resembling those of bayoud disease have been reported in Egypt, Saudi Arabia and Sudan but the strains isolated from diseased roots and leaves remain to be fully confirmed. Based on molecular markers, some of these strains showed a great similarity with the pathogen (Sedra, 2018; Sedra and Zhar 2010). Symptomatic palms presenting an external hemiplegia character were found in Sultanate of Oman and Yemen but no fungus could be isolated from the diseased leaves (Sedra, 2008, 2018). In Saudi Arabia, the same situation was seen (Ammar and El-Naggar, 2011). These symptoms are attributed to a disease called ‘false bayoud’ whose causes are not yet known.

Control

Control of bayoud disease depends on strict internal quarantine measures. Soil disinfection is uneconomic and difficult, except perhaps at a primary focus of infection in a disease-free area; in this case, soil can be treated with metam sodium (Essarioui and Sedra, 2007, 2010, 2017). Soils suppressive to bayoud disease have been identified in Morocco (Sedra, 1993a, 2010; Sedra and Rouxel, 1989; Sedra *et al*. 1994) and Algeria (Amir *et al*., 1985); the mechanisms of suppressiveness of these soils may be biotic or abiotic (Sedra, 1993a, 2011b; Sedra *et al.*, 1990; Amir and Amir, 1988).

Promising results have been obtained in selecting resistant high-quality cultivars among the natural date palm population or in breeding such cultivars (Louvet & Toutain, 1973; Toutain & Louvet, 1974; Djerbi *et al*., 1986a). The first restoration programmes for palm groves damaged by bayoud disease in Morocco were made in 1990 by planting 200 000 plants propagated in vitro. Many new resistant varieties with a good date quality were selected and characterized. Some of these new resistant varieties were multiplied on a large scale and planted in diseased areas in Morocco (Sedra, 2003a, 2011a, 2012, 2013, 2015a). Examples of these selected varieties are: Najda, Al-Amal, Sedrat, Bourihane, Daraouia, Mabrouk, Al-Faida. About 3 million date palm trees produced by tissue culture have been planted in less than 10 years in the framework of the ‘Green Morocco Plan’ program, of which almost 30% of the resistant Najda variety were planted in contaminated oases.

A similar breeding programme for resistance has been operating since 1981 at Adrar, Algeria (Djerbi, 1982). The cv. Takerbouchte is known to be resistant (Bulit *et al.* 1967) and Tirichine (1991) identified another resistant cv. named Akerbouch in the region of Mzab. No cultivar produced outside Morocco and Algeria is known to be resistant to bayoud (Sedra, 2018).

Phytosanitary risk

F. oxysporum f. sp. *albedinis* is listed as an A2 quarantine pest by EPPO (EPPO, 1982) and is also of quarantine significance for Inter-African Phytosanitary Council. In view of its considerable potential for spread, it poses extremely serious human, social and economic risks to other date-producing areas in the EPPO region (eastern Algeria, Tunisia, and other North African countries), and also throughout the Near East.

The related *Phoenix canariensis*, widely grown as an ornamental in many Mediterranean countries, is affected by a *Fusarium* wilt which is not strictly bayoud disease, since cross-infection studies show that different formae speciales of *F. oxysporum* are involved. *Fusarium* wilt of *P. canariensis* is a much less severe disease, and does not deserve quarantine status in its own right. However, a certain ambiguity remains on the status of the two forms and on the possibility that *P. canariensis* might carry bayoud disease. This is in particular the case as certain strains of *F. oxysporum* f. sp. *canariensis* will produce the 400 bp band with the primers used to test for *F. oxysporum* f. sp. *albedinis* (Sedra, 2011b, 2013; Sedra and Zhar, 2010). Sedra (2003a, 2011b, 2013) has suggested that *F. oxysporum* f. sp. *canariensis* could be an ancestor of *F. oxysporum* f. sp. *albedinis* which has evolved on date palm cultivars because the introduction of *Phoenix canariensis* in Morocco coincides with that of the first appearance of bayoud in this country.

PHYTOSANITARY MEASURES

Algeria (1942 and 1949) and Morocco have implemented internal quarantine on all contaminated oases to prevent the movement of offshoots from diseased areas to healthy ones. For the purpose of development in Morocco, this country put in place the law 01/06 in 2007 for the sustainable development of palm groves and the protection of the date palm and Order No. 2027-15 of June 20, 2015 (modified in 2018 by decree 1812-18) fixing the conditions of production, circulation, transfer and planting of date palms in certain zones protected against bayoud disease. Morocco has also demarcated zones for planting disease-free date palms and has adopted phytosanitary measures to be implemented in these zones**.**

Date-producing countries are advised to prohibit the importation of the following from countries where bayoud disease is present: (i) all date-palm material (offshoots, leaves, handicrafts, etc., but not fruits); (ii) soil and plants for planting (with roots, cuttings) accompanied by soil; (iii) plants for planting of *Lawsonia inermis* (except seeds).

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