Diseases of date palms (*phoenix dactylifera* L.)

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Summary

Date palm (*Phoenix dactylifera* L.) is one of the most important fruit trees growing in the Arabian world and some neighboring countries and represents a good cash crop for many farmers. Palm diseases are among the major factors that affecting the products. Fungi and Phytoplasma are known as the most causal pathogens on date palm trees. The present study is an attempt to provide an update informations on the previously known as well as the recently reported pathogens on date palm trees. The causal pathogens, their associated symptoms, distribution, known epidemiology and possible control strategies are discussed.

Keywords: date palm, palm diseases, fungi, phytoplasma.

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1-Introduction

Date palm(*Phoenix dactylifera* L.) is of economic importance and represents a source of income to many farmers in large parts of Iraq, Iran, Arabian Peninsula and countries in North Africa. In addition date palm groves create a favorable conditions to oases farmers for cultivation other crops in between date palm trees, like alfalfa ,barley and different vegetables. In middle of Iraq, date palm plantations provide good conditions for raising several fruit trees including orange, lemon, figs, grapes and some stone fruits. The date palm disease have been reviewed by several authors, Klotz (1931), Fawcett &Klotz (1932), Calcat (1959), Carpenter&Elmer (1987) and Djerbi(1983).

The most recent comprehensive review was published by Zaid et al.(2002). New accumulating data on date palm diseases have been appeared during the last few years.

This paper is an attempt to provide an update information's on the most important diseases that have been reported on date palm (*Phoenix dactylifera* L.).

2- **Diseases caused by Fusarium species**.

2-1. **Bayoud disease**

The causal pathogen is *Fusarium oxysporum* Schlechtendahl f.sp.*albedinis*

(Killian&Maire)W.L.Gordon.

Origin and importance:

The pathogen *F.oxysporum f.sp.albedinis* (FOa) is a soil-bone fungus . Up to date the disease is only known from the Eastern part of North Africa. The disease was first known in Morocco since more than a century ago(Killian&Maire,1930). The disease then spread to neighboring Algeria(Djerbi,1982). More than twelve million date palm trees in Morocco and three million in Algeria have been killed since the origin of the disease. This castrotraphy imposed negative effects on the farmers in the affected areas by creating social and economical problems due to their leaving their lands and loosing their main source of income. Beside that , the neglected lands were subjected to the phenomenon of desertification .Almost all the Moroccan oases were affected by the disease , while the spread of the disease was restricted to the

western and central oases in Algeria. Unfortunately , the most commercial cultivars in North Africa (Medjool and Deglet Noor) are highly susceptible to bayoud disease. This resulting in dominating the poor quality cultivars on the expense of those of high quality(Djerbi,1982).

Biology and epidemiology of the pathogen

Fusarium oxysporum f.sp.albedinis developed chlamydospores in dead tissues of different organs of the infected plant especially in the roots. Chlamydospores may released to soil after decaying of such tissues where they remain dormant and can survive in soil for longer than eight years (Tantaoui,1989). Under favorable conditions , chlaymydospores germinate

and penetrate the roots of the host plant.The mycelium of the fungus enters the vascular tissue of the infected root and then advanced to the stem. The fungus develops microconidia in the vessels and carried upwards to reach the terminal bud. The fungus colonizes the surrounding parenchyma cells by inter and intracellular mycelium during its upward progression in the xylem vessels .The tree dies when the fungus and its toxins reach the terminal bud. The mycelium continue to develop in the dead tissues and develops numerous chlamydospores in the sclerenchyma cells (Louvet,1977).

The fungus has been found colonizing roots of several other crops and vegetables grown as intercrops in palm groves. These symptomless carriers serve in the persistence and the increase of the pathogen inoculum in date palm nursery (Djerbi *et al*.1983).

The spread of the pathogen from the infected areas to non-infected one can be achieved by planting infecting offshoots or by the transport of dead palm fragments harboring the fungus ,symptomless hosts, manures, infected soil and by irrigation water passes through infected fields.

Colonies of the pathogen on potato dextrose agar appear salmon-pink . Phialides short swollen at the base and pointed at the tip. Microconidia are mostly unicellular ,hyaline spherical to elongated, 3-15 X 3-5 um. Macrocoidia are falcate ,usually 3-septate, 20-35 X 3-5 um. Chlamydospores are spherical, occurring singly or in groups of two to

three, intercalary or teminal. Sclerotia are rare in culture, dark blue to black, 1-2 mm diameter (Bounaga, 1975).

Disease symptoms:

External symptoms: The first external symptom of the disease appears on one or more leaves of the middle crown. The affected leaves showed a leaden hue color and then withens from base to top. Pinnae or spines stunted on one side of the leaf , become white and then the disease progress from the base to the apex. After one side has been affected ,the whitening begins on the other side , progressing this time from the top of the leaf to the base , until the whole leaf dies. Corresponding to the passage of mycelium in the vessels of the rachis , a brown stain appears lengthwise on the dorsal side of the rachis and advances from the base to the tip of the frond. Afterwards , the leaf appears arched , resembling a wet feather and hangs down along the trunk . The whitening and dying process of the pinnae may take a few days to several weeks. Similar symptoms then begin to appear on adjacent leaves . The palm dies when the terminal bud is affected. Death of the palm can take place from 6 weeks to 2 years after the appearance of the first symptoms depending on the cultivar and the planting conditions . Finally offshoots at the base of the palm tree are attacked (Built *et al*.1967, Louvet *et al*.1970, Djerbi,1982).

Internal symptoms: When the affected palm is uprooted , a small number of infected roots showed reddish color. Toward the stipe base, the colored

areas are large and numerous in numbers. Higher up , the colored vascular bundles separate from the healthy tissue. Palm fronds manifesting external symptoms exhibit a reddish brown

color when cut, showing highly colored vascular bundles . Therefore, a continuing of vascular symptoms is existing from roots of the palm to the tips of the fronds (Zaid *et al*.2002).

Diagnosis and detection of the pathogen:

Preliminary diagnosis are verified by isolation and identification of the fungus from infected plant materials , symptomless carriers and soil. Pathogenicity test should be applied by artificially inoculation of fungal isolates to the roots of young date palm seedlings at the two leaf stage. Confirmation of the pathogenicity is recognized by the death of the plants after 1-2 months (Watson,1974). However, applying inoculation test to asses pathogenicity of *F. oxysporum fsp.albedinis* remains difficult mainly because of time consuming. Studies at the molecular level showed that isolates of *F. oxysporum f.sp. albedinis* are genetically closely related and assigned to a single clonal lineage (Tantaoui *et al*.1996). In a recent stydy, Fernandez *et al*.(1998) able to develop a specific oligonucleotides to use as primer in polymerase chain reaction (PCR) assay for rapid identification of the pathogen. It has been well documented now that PCR has identified the presence of many forma speciales of *F. oxysporum* (Plyler *et al.*1999, Fernandez *et al*.1998, Tantaoui *et al*.1997).

Control of Bayoud disease:

Since the pathogen is a soil-borne fungus, control of the disease by using chemical materials is uneconomic, except for a limited site of infection in a disease-free areae. Soil fumigation by methyl bromide has been used as a control measure in Algeria (Frederix &Den Brader,1989). The practical way for controlling the disease is by selecting resistant high quality cultivars. In Morroco, this was achieved by the results obtained in field and laboratory (Djerbi *et al*.1986).

A collaboration between Moroccan and French scientists led to the development of a rapid and efficient selection of bayoud resistant individuals from the large number of date palm trees obtained by natural crosses which display good date quality. The diagnostic tool based on the presence or absence of two plasmids-like DNA (the S and R plasmid) in mitochondria as a reliable molecular marker of resistance or susceptibility to bayoud disease caused by the fungus *F.oxysporum f.sp.albedinis* (Quenzer *et al*.2001). By using in vitro propagation it would be possible to select hundreds of bayoud-resistant genotypes to rehabilate the Moroccan and Algerian palm groves that have been destroyed by bayoud (Zaid *et al*.2002).

Other attempts used as a control measure of the pathogen of bayoud disease were including inducing resistance and using biocontrol agents. Inducing of host resistant in the date palm in response to FOa expressed different

mechanisms such as the induction of phytoalexins biosynthesis , the accumulation of cell wall-bound phenolic, the intensification of liqnification and the increase of accumulation of caffeoylshikimic acid. The induction of these mechanisms is always early and intense in the resistant cultivars , whereas, , it is late and weak in susceptible cultivars (El Modafer & El Bustani,2002). Pretreatment of date palm seedlings with an hypoaggressive isolate of FOa , protected them partially from further infection with FOa , the bayoud disease pathogen. Such protection involved biochemical interaction between the host plant and the Bayoud pathogen. Plants treated with the hypoaggressive isolate accumulated higher amount of phenolic mainly non-constitutive hydroxycinnamic acid derivatives along with constitutive caffeoylshikimic acid.(El Hassne *et al* 2004b). These compounds thought to play a role in date palm defense against FOa as previously showed by Daayf *et al*(.2003) and EL Modafar *et al*.(.2000).

El Hassni *et al*.(2004a) investigated the effect of chitosan on the growth and morphology of FOa and its ability to elicit a defense reaction against the pathogen in date palm roots. Chitosan at 1 mg .ml reduced the growth of FOa on potato dextrose agar medium by an average of 75% and caused morphological changes in the fungal mycelium , while mycelial growth was totally inhibited in a liquid medium. In addition chitosan injected into roots at three concentrations (0.1, 0.5 and 1mg.ml) elicited peroxidase and polyphenol oxidase activity and particularly at the concentration of

1mg.ml, increased the level of phenolic compounds. Chitosan led to the accumulation of non-constitutive hydroxycinnamic acid derivatives known to be of great importance role in date palm resistance to FOa (El Hadrami *et al*.1996).

In a recent study, El Hasseni *et al*.(2007) tested twenty one isolates of microorganisms (Bacteria and Fungi) to determine their effect on the mycelial growth and sporulation of FOa and the potential of these antagonists in the induction of defense reactions in date palm seedlings. Four bacterial isolates viz. *Bacillus pumiius* WI, *Rahnella aquatica* W2, *B.cereus* X16 and undetermined isolate have exhibited a high inhibition toward mycelial growth of FOa (70-77%) or its sporulation (80-95%) of the control. Application of these antagonists to date palm seedlings has led to trigger defense reactions with an accumulation of non-constitutive hydroxycinnamic acid derivatives , known to play a crucial role in resistance of date palm to FOa. The reaction was more clear in resistant cultivars than in susceptible.

An actinomycete strain assigned to the genus *Kitasatosporia* isolated from date palm rhizosphere soil sample collected in Marrakesh showed strong antifungal activity against FOa and appears of high potential interest for the biocontrol of the disease (Oubdouch *et al*.1996).

2-2. Wilt diseases caused by other Fusarium species.

In recent years several reports on the isolation of *Fusarium* species from roots, leaves and trunks of date palm trees showed wilt and decline.

Abdalla *et al*.(2000) during their investigation on the incidence of date palm disease in Saudia Arabia and in particular in Al Qassim and Medina Al Monawara regions, several trees showed symptoms of wilt and dieback very similar to those caused by FOa. Three *Fusarium* species were isolated from the infected leaves and roots of the date palm trees. These identified as *F. proliferatum*, *F. solani* and *F. oxysporum*. Pathogenicity test on the date palm seedlings showed that *F. proliferatum* should be regarded as a potentially dangerous pathogen of date palm in Saudia Arabia , since the species was the most frequently isolated one from palms showing disease symptoms . Although, *F. solani* was highly pathogenic on seedlings of date palm, but it was considered less important than *F. proliferatum* in the regions since it was isolated rarely.In contrast , the *F.oxysporum* strains tested showed low virulence on the date palm seedlings (Abdalla *et al*.2000). More recently, Mansoori and Kord (2006) reported a serious disease of date palm caused by *F. solani* associated with yellowing and death of the fronds. The disease occurred in date palm groves in Kazeron district, west of Fars province in Iran. The causal pathogen was isolated from the crown and xylem rays sampled from the trunk 1.5 m above soil level. Pathogenicity test was performed by planting 1-year old date palm seedlings in artificially infested soil with an isolate from the trunk of

diseased palm tree as well as seedlings planted in naturally infested soil. Similar symptoms were obtained in both procedures, distal portions of the roots and crown were affected.

The pathogen was re-isolated from the crown and leaf bases of the inoculated seedlings. In Iraq, a similar disease symptoms caused by *F. solani* have been reported recently (Al Yaseri *et al*.2006). The wilt symptoms appeared with gradual yellowing that reached the palm tip followed by quick death.

2-3 Fusarium species associated with date palm decline.

Fusarium monliforme and *F. solani* were found associated with declined date palm trees in Egypt (Rashed & El Hafez, 2001). Symptoms appeared on th leaves, fruit stalks and the heart of palm tree. The symptoms on the leaves appeared as yellowish brown streaks on rachis, then turn to brown and eventually became malformed and dried. The symptoms on fruit stalks appeared as brown necrosis and stunting of new fruit stalks. On the heart of palm tree , the new leaves exhibited yellow to brown color. Pathogenicity test proved a relation between the infection by *F. moniliforme* and *F.solani* and the decline of date palm.

Fusarium oxysporum and *F.solani* were the most frequent and most abundant in the roots of date palm trees showing decline in middle of Iraq.(Sarhan,2001).

3- Inflorescence rot of date palm

Origin and importance: Inflorescence rot disease also called Khamedj in North Africa caused by *Mauginiella scaettae* Cav. was reported for the first time by Cavara (1925) in Libya. The disease was reported subsequently in other North African countries (Cabrolin,1938;Muneer,1955;Calcat;1959;Michael&Sabet;1970,Taxana&Larous ,2003) and has also been reported from Arabian Peninsula (Abu Yam & Abu Blam,1971;Djerbi;1982; Al Shridia & Al Shahwan,2003) and from Iraq (Allison,1952;Hussain,1958,Al Ani *et al*.1971,Abdullah *et al*.2006). Recently the disease has been reported in Elx, SE Spain (Abdullah *et al*.2005).

The disease is considered as the second most dangerous pathogen causing losses to date palm, next to FOa, the bayoud pathogen. The disease is considered to be of major economic importance in Iraq and Suadia Arabia . Severe outbreaks occurred in Basrah, Iraq in 1948-1949 and 1977-1978, causing 80% loss of the annual harvest (Al Hassan & Waleed). Losses up to 70% of the crop occurred in 1983 in the Katif province, Suadia Arabia (Zaid *et al*.2002).

Disease symptoms:

Infected spathes first showed rot symptoms when they begin to emerge in early spring . These symptoms were observed on the external surface of unopened spathes as brownish or rusty-colored lesions . The side of the spathe facing the infected flowers showed similar but milder symptoms.

When the infected spathes split, symptoms appeared mostly nearly the top of the spathe and thereafter, a complete destruction of the flowers and strands occurred. (Fig.1:a,c). Severely affected spathes at an early stage remain unopened and became dry (Fig1:b) (Al Ani *et al*.1971;Djerbi,1983;Abdullah *et al*.2005).

Diagnosis and detection of the pathogen:

The major cause of inflorescence rot is considered to be the fungus *Mauginiella scaettae* Cav. (Cavara,1925; Hussain,1985;Al Ani et al.1971;Djerbi,1983;Abdullah *et al*.2005). However, other fungi such as *F.oxysporum* , *F.moniliforme*, *F.solani*, *Trichothecium roseum*, *Botrytis aclada*, *Thielaviopsis paradoxa*, *Acremonium strictum* and *Memmoniella sp*., have also been found associated with date palm rotted inflorescences and considered of minor importance (Brown & Butler,1938; El Behadli *et al*.1977; Rattan & A l Dboon,1980; Al Roubaie *et al*.1987; Al Shraridia & Shahwan,2003; Taxana & Larous,2003; Abdulah *et al*.2005).

Mauginiella scaettae can be easily isolated from rotted inflorescence after surface disinfection of small pieces with 5% sodium hypochlorite solution and plated on suitable culture media such as malt extract agar, potato dextrose agar or potato carrot agar. Isolation can be achieved also after incubation of disinfected pieces in moist chambers and then picking up conidia which developed abundantly and streak them on a suitable medium. Inoculated plates should be incubated at 25 C. The fungus grows as white

colonies with immersed and superficial mycelia. Mycelium is composed of branched hyaline septate hyphae. Colony reverse at first creamy to pale brown, becoming black in some isolates on potato dextrose agar. Sporulation are abundant showing powdery appearance . Immersed hyphae are 2-2.5 um wide ,aerial hyphae measuring 3-4 um wide. Arthroconidia produced by segmentation of the aerial hyphae ,unicellular, or multicellular, hyaline , glistening white in mass, non-septate conidia, 6-8X2.5-4um, septate conidia 6-14 X 3-4um ,2-eptate conidia 16-22 X 3.5-4um, 3-septate condia 12-26 X 3.5-5um 4-septate condia,24-26 X 3.5-4.5um and 6-septate conidia up to 35 um long (Fig.1:d) (Cavara, 1925; Abdullah *et al*.2005).

Pathgenicity test can be performed on detached inflorecence free of disease. Inoculation with spore suspension of the pathogen developed typical symptoms after 4 days.

Biology and Epidemeology:

The ultrastructure of the cell wall and the hyphal septa, together with the diazonium blue B test have shown that *M. scaettae* represents an anamorph of an unknown ascomycete (Walt, Van der and Hopsu-Hava, 1976; Arx, Von *et al*.1982). Recently Abdullah *et al*.(2005) showed that sequncing of the Internal transcribed spacer (ITS) region of this fungus demonstrated that it is closely related to *Phaeosphaeria* I.Miyake clade B and in particular to *P. triglochinicola* which belongs to subclade B4 according to

Camara *et al*.(2002). The majority of species of *Phaeosphaeria* form pseudoparenchymatous ascomata with bitunicate asci which mainly occurred on monocotyledonous plants (Barr,1987; shoemaker & Babcock,1989).

Al Ani *et al*. (1971)demonstrated that the pathogen is mainly preserved as mycelium in infected inflorescence remaining on palms from the previous season or remain within the infected leaf bases. Al Roubaie *et al*.(1987) suggested that the primary infection by *M. scaettae* probably occurred during the early stage of floral bud formation and prior to the envelope development of the spathes and their hardening. The availability of rain prior to the stage of flower bud formation and during the early stage of bud formation is probably responsible for creating favorable conditions for fungal growth ,when hyphae hidden between the leaf bases can grow and infect newly developed inflorescence (Abdullah *et al*.2005).

The disease is more serious in hot and humid regions or in areas with prolonged periods of heavy rains. Hussain and El Baldawy (1977) indicated that up to 52% of palms might be affected in Al Fao town in Basrah province, southern Iraq, where high humidity is prevailed , whereas proportions of the affected trees in the middle Iraq was ranging between 10-20%.

Abdullah *et al*.(2006) demonstrated that conidia of *M.scaettae* germinated best at high % r.h. Maximum percentage of conidial

germination (80.7%) occurred at 95% r.h. and declined sharply (20.8%) at relative humidity below 95% r.h. and no germination occurred below 80% r.h. Moreover, obvious increase in sporulation occurred according to the increase in relative humidity. The highest is being at 100% r.h. and the lowest occurred at 70% r.h(Abdullah *et.al*.2006)

It is generally assumed that conidia of *M. scaettae* are very short lived and do not persist through the winter. Primary infections are thought to arise from mycelium (Al Ani *et al*.1971; Al Hassan & Waleed,1979; Djerbi,1983). However, Abdullah *et al*.(2006) have showed in a recent study that conidia of *M. scaettae* can survive as a saprophyte in infected dead inflorescences for a period of more than twelve months and therefore, these conidia may contribute to the new infection.

Eight isolates were tested for their ability to produce extracellular enzymes on solid media. All isolates showed positive activity with varying degrees for cellulase, lipase, protease, phenol oxidase, polygalacturonase and pectate lyase. In contrast, all isolates gave a negative test for amylase(Al Saadoon *et al*.2004).

Control measure:

The first step in the control of inflorescence rot disease achieved by good management such as leaf pruning and collection and burning of all infected inflorescences. Application of several fungicides including 3%

dichlone spray or 4% thirame spray at the rate of 8 litres per individual palm (Al Hassan *et al*.1977).

4- Diseases caused by *Ceratocystis paradoxa* and *C. radicicola*.

Ceratocystis paradoxa (Dade) C.Moreau (anamorph: *Thielaviopsis paradoxa* (de Seynes) Hohn.), and *C.radicicola* (Bliss) Moreau (anamorph: *T. punctulata* (Hennebert) Paulin, Harrington *et* McNew, are two pathogens commonly found either alone or in combination associated with several disease symptoms on palm trees. These fungi can infect any part of the palm tree, and symptoms are often expressed as black scorched leaves, trunk rot, neck bending or inflorescence blight.(Suleman *et al*.2001; Djerbi,1983, Zaid *et al*.2001; Abbas & Abdulla,2003; Abbas *et al*.1997; El Gariani *et al*.2007) . These disease have been observed in the majority of date growing areas of the world (Abdullah *et al*. 2009). The diseases are more likely to occur on stressed trees especially in areas where drought and salinity are prevailing . In *vivo* studies also showed that both *C. paradoxa* and *C. radicicola* colonized palm tissues under drought stress at -2.3 MPa and had relatively larger necrotic lesions then developed into cankers , death of buds and eventually plant death (Suleman *et al*.2001).

In severe cases, the pathogen attacks the terminal bud and heart leading to the mechanical weakness of the tissues in the uppermost portion of the trunk resulting in the neck bending. Sometimes the crown rotted off , leaving a bare trunk (Abbas & Abdulla,2003). Some palms recover

probably by the development of a lateral bud initiated from the unaffected meristematic tissues of the terminal bud. The palms set normal growth back by several years and that is why it is called in Arabic Medjnoon (fool disease). (Zaid *et al*.2003).

The anamorphs of the two pathogens produced an abundance of endoconidia (Phialoconidia) and Chlamydospores (aleuroconidia) on media such as potato dextrose agar, malt extract agar and potato carrot agar. In *T. paradoxa* anamorph of *C.paradoxa* , the aleuroconidia borne terminally in chains from short hyphal branches and are thick-walled ,pale brown to brownish black, smooth, oval, measuring 10-17 X 5-10um, phialoconidia are hyaline to pale brown, cylindrical formed endogenously in uniseriate chain measuring 7-12 X 3-5 um (Fig.2:a,b).

In *T. punctulata* anamorph of *C. radicicola* , the aleuroconidia are borne singly on a short hyphal branches and are thick-walled, minutely roughened , pale brown to dark brown, oval, measuring 8-22 X 7-14 um. Phialoconidia are hyaline to pale brown, cylindrical, formed endogenously in uniseriate chain measuring 6-12 X 3-5 um (Fig.2:c,d). The thick-walled aleuroconidia are likely to play a role as survival propagules of the two plant pathogens in soil.

Control measure:

The avoidance of wounds on palms grown in the field or nurseries can limit disease incidence (Chase & Broschat,1993). The affected fronds,

leaf bases and inflorescencs should be pruned , collected immediately and burned . The pruning cuts and surrounding tissues should be protected by spraying with any copper-based fungicides (Zaid et al.2003).The use of less saline water for irrigation (Suleman et al.(2001). In laboratory, Suleman *et al*.(2002) assessed the efficacy of the biofungicide Mycostop on *C. radicicola* which causes black scorch on date palm in Kuwait. Mycostop at a rate of 0.35 g /l or greater reduced spore germination , plasmolysed germlings and reduced sporulations . Roots inoculated with *C. radicicola* and then treated with Mycostop were less necrotic than those in untreated soil.

5- Diplodia leaf-base disease:

The disease is caused by *Diplodia phoenicum* (Sacc.)H.Facet & L.J.Klotz. The fungus attacks offshoots while they are still attached to the mother palm or after their detachment and planted out. The disease was originally reported from California by Fawcett & Klotz (1932) and then its distribution covered most of date palm growing regions (Djerbe, 1983; Sarhan ,2001; El Deeb *et al*.2007).

The pathogen may infect the outside leaves of the offshoots while younger leaves and the buds remain unaffected but finally both of them killed. Other types of symptoms, started with the infection of the central young leaves and terminal bud and then gradually infect the outside leaves and finally leading to the death of the whole plant. On the leaves of the

older palms, symptoms appeared as yellowish brown streaks ,15 cm to one meter in length extending along the leaf- base and rachis . The upper part of the leaf remain unaffected and still appear green. The symptoms appeared on the ventral surface of the leaf which facing the palm crown. Pycnidial bodies developed on the dead leaf bases . Pycnispores are at first hyaline ,unicellular becoming dark two-celled with age, measuring 22-24 X 10-12 um. Pycnidia can bee seen after incubation of infected pieces in moist chamber. Since the infection of the palm takes place through the wounds made during pruning or cutting when removing the offshoots from the mother plant, disinfection all tools and cut surface is necessary . In addition to dipping or spraying the removed offshoots with various fungicides such as benomyl , bordeaux mixture, or thiram (Carpenter,1975).

6- Graphiola leaf spot:

The disease is also called false smut on date palm. The causal pathogen is Graphiola phoenicis (Moug.)Poit. Symptoms of the disease appear as subepidermal spots on both sides of the pinnae (leaf flat) and on the rachis with small black sori (fruiting bodies) developing in abundance on old fronds . The sori are 1-3 mm in diameter, more abundant in the apical regions of the pinnae . Sori superficially resemble a scale insect but microscopic examination revealed the presence of powdery yellow spores on whitish filaments . Spores are spherical to ellipsoidal , 3-6 um in diameter, with smooth hyaline wall. The disease is widely spread and

occurs whenever the date palm is cultivated under humid conditions but absent in less humid regions (Abbas & Abdulla,2004; Djerbe,1983; Zaid *et al*.2002; El Deeb *et al*.2007; El Gariani *et al*.2007; CAB international,2003).

Date palm cultivars showed variability in their response to the pathogen. For example, Barhee, Abdal Rahman, Gizaz showed resistane, while cultivars Khistawi, Gozi, are tolerance. In contrast cultivars Khisab, Ashrasi,Maktoom, Zahdi and Bream are very susceptible (Nixon,1957; Sinha *et al*. 1970; zaid *et al*.2002).

Severe infection reduces tree growth and date production through premature death of leaves . To ovoid the incidence of the pathogen, leaf pruning and then burning of the infected leaves should be carried out to prevent new infection. Spraying the palms after pruning with appropriate fungicides such as bordeaux mixture, mancozeb, cupric hydroxide and maneb (Zaid *et al*.2002).

7- Belaat disease:

The causal pathogen is *phytophthora sp*.. The disease is of minor importance and sporadic. It is known from North African countries (Calcat,1959; Toatain,1967). Symptoms appear at the crown of the palm. Young fronds whiten and die ,followed by the infection and death of the terminal bud and then progression of the infection downwards in the trunk

as a conical wet heart rot form, releasing an odour of acetic and butyric fermentation (Zaid *et al*.2002).

To ovoid attacks by this fungus , efficient management of date palm plantation is recommended . To control the disease at its early stage , spraying with maneb or bordeaux mixture at the rate of 8 liters /palm is recommended. Offshoots of the infected palms usually remain free of the disease(Djerbi,1983).

8- Omphalia root rot:

The disease is caused by two species of *Omphalia* (*O. tralucida* Bliss and *O. pigmentata* Bliss). The disease is of minor economic importance to date palm and it is known from USA (California) and in Muritania (Fawcett & Klotz,1932; Bliss,1944).

The disease is characterized by the premature death of fronds followed by the retardation and cessation of the plant growth , and then necrosis and destruction of the roots . Sachs(1967) recommended the use of brestan or dexon fungicides at the rate of one spray every two weeks for eight weeks as a chemical control.

9- Leaf spot diseases:

In general , leaf spot diseases are of minor economic importance . Different fungal species have been isolated from palm leaves showing leaf spot symptoms. Leaf spot diseases are very common on date palm trees in

all date palm growing countries (Carpenter & Elmer,1978; Fayad & Mania,2006; El Deeb *et al*.2007; Livingston *et al*. 2002).

Generally infection is more severe on the lower whorls and old leaves than in upper young leaves, and the infection rate and severity is increased with increasing palm age. Negative correlation between tannin and wax content in the leaves and severity of infection were recorded (Fayad & Mania,2006). Among these diseases , brown leaf spot caused by *Mycosphaerella tassiane* (anamorph: *Cladosporium herbarum*) is the most common. Symptoms of the disease occur on the rachis ,pinnae and spines as dark lesions with well-defined margin on green leaves and on drying leaves, the margin of the lesion remains reddish brown as the centre becomes pale.

Other fungi caused leaf spot symptoms on palm trees include *Alternaria alternate*, *Bipolaris australiensis*, *Drechslera sp*., *Helmnthosporium sp*., *Colletotrichum sp*., *Stemphylium sp*., *Pestalotiopsis palmarum* , *Chaetosphaeria sp*., *Phomopsis sp*., *Phoma spp.*, (Livengston *et al*. 2002; Fayad and Mania,2006; El Deeb *et al*.2007, Carpenter & Elmer,1978; El Gariani *et al* 2007).

Control measures include annual pruning of old infected leaves and their immediate burning is recommended (Zaid *et al*.2002). At early stage of the disease, spraying with mancozeb , mancozeb + copper are effectively control the disease (Livingston *et al*.2002).

10- Disease caused by Phytoplasma.

10.1- Al Wijam

In Arabic Al Wijam means poor fruitful . The disease was observed for the first time by Nixon (1954) in Al Hassa oasis eastern of Saudia Arabia . The main symptoms of the disease are leaf stunting with yellow streaking and a marked reduction in fruit and stalk size. Leaves become choritic and their life span is reduced. Stunting and yellowing increases with age leading to the death of the leaves. Diseased spathes are shorter than healthy one and split open before their complete emergence. Fruits and fruit stalks showed reduction by 36-40% in the size. Al Hudaib *et al*.(2007) reported on the identification and molecular characterization of phytoplasma associated with Al Wijam in Al Hassa (Saudia Arabia). The phytoplasma identified from 28/40 date palm showing typical Al Wijam symptoms clearly placed in the 16SrI group "Ca.P.asteris" which is supported by the sequencing and phylogenetic data. Moreover, phylogenetic analysis showed that the phytoplasma identified in the leafhopper *Cicadulina bipunctata* Melichar was 100% identical to that detected from date palm showing Al Wijam symptoms and accordingly it has been identified as a putative vector of the disease (Alhudaib *et al*.2007).

10-2- Leathal yellowing.

The importance of the disease was first known from USA (Florida) on coconut palms destroying about 1/2 million coconut palms (McCoy,1976). The disease has wide range of hosts including *Phoenix dactylifera* L., *P. canariensis* Hort., and *P. reclinata* Jacq (Thomas,1974). Symptoms on coconut are characterized by early dropping of developing fruits , followed by formation of new inflorescence which rapidly becomes necrotic, a rapid and generalized yellowing and eventually the death of the palm. In Kuwait, Al Awadhi *et al*.(2002) reported their finding on a phytoplasma associated with yellowing disease of date palms. The disease displayed similar symptoms of Al Wijam as expressed on leaves, spathes and bunches of date palm. In Egypt, Ammar *et al*. (2005) detected phytoplasma associated with diseased date palm refereed to it as streaking and yellowing disease. Harrison *et al*.(2002) detected phytoplasma belonging to the 16SrIV group, subgroup D, causing lethal yellowing decline in Canary Island date palm in Texas.

10-3. White tip die-back.

This is newly recognized disease on young date palms (*Phoenix dactylifera* L.). The disease occurs in isolated foci in northern Sudan (Cronje *et al*.2000a). Symptoms appeared on 5-8 years old palm trees which die within 6-12 months of symptoms appearance . Severe chlorosis of the emerging leaf and at the tip of the pinnae of older fronds which change quickly from green to dry white without showing yellowing of the crown..

Using molecular techniques, the causal pathogen has been assigned to Phytoplasma (Cronje *et al*.2000a).

10-4. Slow decline:

The disease is attacking mature date palms along the Nile between Dongola and Mero-karem , North Sudan. Palm death occurs between 1-2 years after appearance of symptoms and causing losses estimated at 6%. The symptoms appeared at first as yellowing of the outermost fronds and progressing towards the young central fronds and newly emerging leaves. Eventually, all fronds dry white to light brown and are then shed leaving few young leaves at the top of the trunk which may break off leaving the trunk alone(Cronje *et.al*.200b).

The sequence of slow decline Phytoplasma 16S/235rDNA intergenic spacer showed a very high (99%) homology with comparable sequencies of Phytoplasma associated with White tip-dieback disease on young date palm (Cronje *et al*.2000b).

11- Brittle leaf disease.

In French the disease is called "Malade des feuilles cassantes". The disease was first known from southern (desert) parts of Tunisia . According to Mehani (1958) palms with symptoms of the disease were found since 1960s in Nefta and Tozeur oases. However, only after twenty years the disease begins to draw attention due to the rapid increase of the effected

trees particularly in the Nefta oasis (Tukrouni *et al*.1988). In Algeria, the presence of the disease was confirmed in 2006 (Al saadi *et al*.2006).

The causal pathogen is not yet determined exactly. The symptoms are assocated with manganese deficiency and the presence of a small double strand RNA. However, the effected trees in the field seem to cluster into foci , suggesting a biotic origin. A possible soil microorganism is responsible for rendering soil manganese insoluble and unavailable to the palm trees (Triki *et al*.2003).

The early symptoms of the disease appeared on the fronds showing chlorosis . Leaflets become brittle, twisted, frizzled and shrivled with a scorched appearance . In severe cases, only frond midribs without leaflets remain. Affected trees have shorter fronds, stop growing and eventually die. Four to six years may elapse between the appearance of the first symptoms and the death of the tree (Tiriki *et al*.2003).

12- Date Bunch Fading Disorder (DBF).

The date palm bunch fading disease was first reported in 1997 in the south of Kerman province (Iran). In the last 5 to 6 years, the DBF has been the most harmful phenomenon on date yields in date palm plantations of southern Iran. The mean amount of damage at different regions and in different years has been estimated between 30-50% of the crop (Karampur,20002).

Symptoms of this disorder occur at first as light yellow lesions on peduncles and gradually developing to longitudinal pale brown strips on the whole peduncle. Date fruits wilt usually from the bottom of the strand up and then the pedicel, peduncle and whole bunch wilt dry.(Karampour,1999).

Many fungal species have been isolated from affected date palm trees showing DBF disorder. These include *Alternaria sp*., *Aspergillus flavus*, *A. niger*, *Penicillium sp*., *Fusarium sp*., *Trichoderma sp*., and *Thielaviopsis paradoxa*. Among the isolated fungi, *T. paradoxa* had the ability to increase incidence of DBF disorder on date tree "Mordaseng" under drought and hot winds stresses in natural climatic conditions of date palm plantations in Hormozgan province exclusively . Karampour and Pejman (2007) concluded that the associated fungal agents had no direct and or primary role in occurrence of BDF disorder

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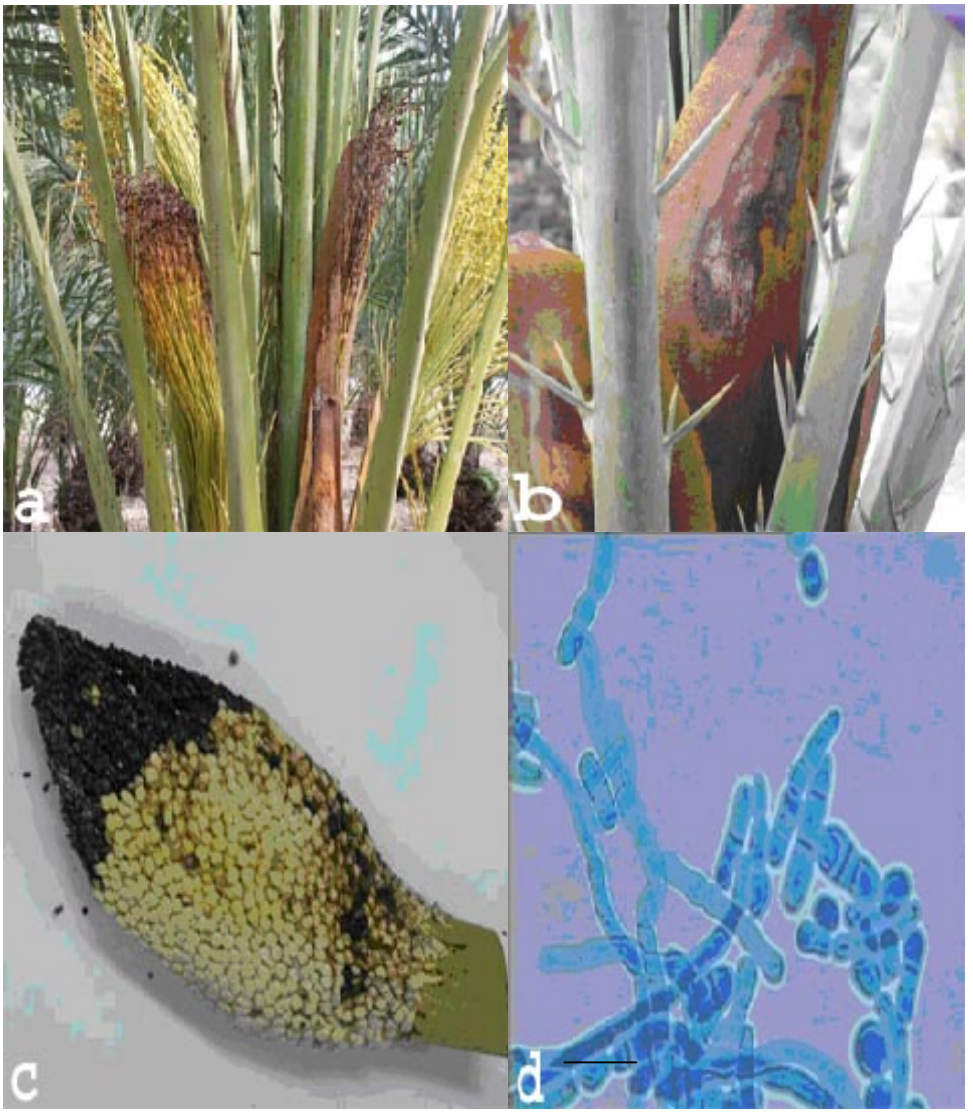

Fig.1 *Mauginiella scaettae* a,rotted female inflorescence, b:unopened male spathe due to severe infection c: opened infected male spathe. d: arthroconidia in chains.

Scale bar =15um

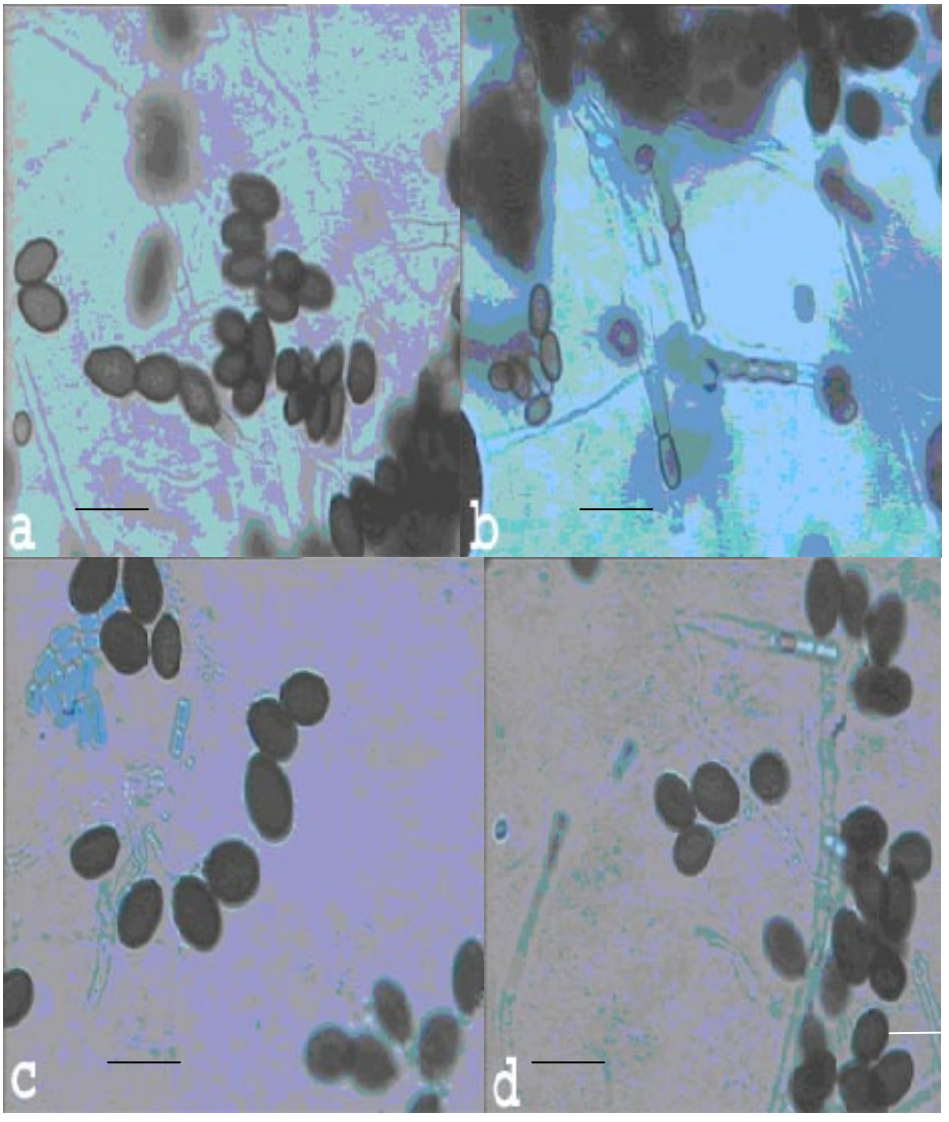

Fig.2. *Ceratocysts paradoxa* (anamorph: Thielaviopsis paradoxa) a,b: aleuroconidia(chlamydospores) and phialoconidia (endoconidia)

Ceratocystis radicicola (anamorph: *Thielaviopsis punctulata*) c,d. aleuroconidia and phialoconidia. Scale bar =20um