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Fusarium Wilt (*Fusarium oxysporum* f. sp. *elaeidis*) In Oil Palm: A Rather Weak Pathogen?

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Introduction

Fusarium wilt in oil palm (*Fusarium oxysporum* f. sp. *elaedis*) was initially described by Wardlaw in Zaire (Wardlaw 1946). The pathogen has been associated with important losses in some orchards (15-25 %) in Central and West Africa, but average incidence for the whole continent may be well below 1% (G.Blaak, former FAO official, personal communication), despite the poor agronomic management frequently found on African plantations. In America, the pathogen has been reported from Para (Brazil) and Quinindé (Ecuador) (Turner 1970; Van de Lande 1985; Renard and Franqueville 1989; Franqueville and Renard 1990, Mariau et al. 1992; Franqueville and Diabaté 2004).

Apart from the initial reports of the presence of the disease in some plots of a few plantations in the above-mentioned two countries in America, no further information has been published on any important economic impact on oil palm plantations where the pathogen was found. It even looks as though there was little spread beyond the original spots where the first infected plants were found, indicating the very low aggressiveness of this pathogen, at least in the American tropics. It is normally assumed that the fungus reached America from Africa via infected seeds or in contaminated leguminous seeds used as cover crops in most oil palm plantations (Franqueville and Diabaté 2004).

Symptoms

There is great variation in incidence and symptom expression depending on the tolerance of the planting material, its age and particularly on environmental conditions and agronomic management (Wardlaw 1950; Renard 1979; Renard and Franqueville 1989).

When symptoms are severe (acute) in adult palms, these may die within a few months: older leaves dry out and their rachises break approximately one third from the base and remain hanging beside the stem. The youngest leaves turn yellow and are shorter than normal. Characteristic of the pathogen's presence is the brown color assumed by the vascular fibers. These darker fibers are more conspicuous at the base of the stem where the color may be accentuated in some areas toward the periphery. The radical system looks severely deteriorated, particularly the finest roots that show an internal browning.

Nevertheless, symptoms may also become chronic and infected palms may even show clear signs of recovery. This response may be interpreted as the planting material's tolerance or particular environmental conditions (water availability, soil characteristics, plant nutrition etc.) that impede the pathogen from continuing on an aggressive path of infection. Some palms suffering chronic symptoms for a long time may show a stem tapering with age.

Symptoms normally vary in young palms: initially, a particular leaf located in the middle of the crown turns lemon-yellow, followed by other middle-aged neighbor leaves soon after. Older leaves eventually show symptoms consisting of yellowing that turns brown starting

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with the leaflets' tips. Such symptoms tend to be more conspicuous toward the end of rainy periods indicating the strong enviromental effect on symptom expression. Due to the distribution of the infected vascular bundles of the palms, symptoms are normally only seen on one side of the plant (Wardlaw 1950) (Fig. 1).

In a cross section of the stem, vascular fibers in particular sections appear discolored (first orange, then reddish-brown and finally black) (Fig. 2). The petiole of an affected leaf also shows discolored vascular bundles. Palms so affected may die or enter the chronic phase of the disease (with the fungus remaining latent in the vascular tissue), where new leaves produced are shorter and palm growth is normally retarded.

Infection may take place at the nursery stage, causing retarded growth, short and somewhat deformed leaves (flat-top appearance) and an abnormally swollen bulb (Fig. 3). Roots are few and affected (particularly fine roots), all showing a clear infection that progresses toward the bulb where vascular bundles show an orange coloration that changes to black (Prendergast 1957, 1973; Locke and Colhoun 1974; Aderumgboye 1980, Chinchilla, 1986).

External and internal symptoms are caused by a blocking of the xylem vessels by tyloses and gum deposits that interrupt normal water flow. Filaments and other fungal structures (microconidia and chlamydospores) may also be found in the vessels (Aderumboye 1982; Kobachich 1984).

Epidemiology or, how effective a pathogen is it?

F. oxysporum f. sp. *elaeidis* may survive in the soil as a saprophyte or in contact with the roots of several weeds, 'waiting' for an occasion to gain access to an oil palm root and initiate an infection. Any factor causing root death (and quite possible any limitation for normal root development) may offer an opportunity for the fungus to enter the palm (Aderungboye 1982; Lockey and Colhoun 1974). Root penetration may also take place through the pneumatodes, which are more numerous when soil is wet (possibly too wet); this may explain the increase in incidence toward the end of the rainy season (when root death also increases due to poor soil aeration). An increase in incidence during the start of the rainy season may also be explained by root death during the preceding dry season (water deficit).

Pathogenic strains of the fungus have been found in areas where oil palm had never been planted before (Aderungboye 1982). On the other hand, Hoo and Varghese (1987) compared several Malaysian native isolates of *F. oxysporum* with virulent strains of *F. oxysporum* f.sp. *elaeidis* obtained from Africa and found that growth in culture media, morphology, conidiogenesis, and the effect of temperature and relative moisture on growth were identical for the two origins. More interesting is the fact that some strains of *Fusarium oxysporum*, considered non-pathogenic and native from soils in Malaysia were able to cause wilting and growth retardation in nursery plants (Hoo and Varghese 1986; Flood et al. 1989). These observations could be interpreted as a latent danger of many strains of *Fusarium* becoming pathogenic to oil palm, or as casting important doubts on the real pathogenic potential of these particular strains of *Fusarium*, including those associated with *Fusarium* wilt in Africa.

Germination of chlamydospores (fungal soil survival structures) is stimulated in the neighborhood (rhyzosphere) of roots of both susceptible and non-susceptible plants (such as corn). This was interpreted as if tolerance to the pathogen was posterior to germination (Oritsejafor 1990), but there could be other causes for that. The phenomenon of cross protection has also been observed: a previous infection by a mild strain prevents infection by a more aggressive one (IRHO, 1992).

There is evidence that the fungus can be carried in the oil palm seeds and can even accompany pollen (Locke and Colhoun 1973; Flood et al. 1990). Once established in the soil, the fungus may remain there for years associated with roots of several asymptomatic weed species such as *Amaranthus spinosus*, *Eupatorium* *odoratum*, *Mariscus alternifolius* and *Imperata cylindrica* (Oritsejafor 1986). All these plants can be common in some oil palm plantations.

Eradication of diseased palms was not initially considered a valid control measure option (Prendergast 1957), but this was not always clear since there was a high correlation between the percentage of diseased palms left standing and disease incidence after replanting (Renard and Franqueville 1991).

Diseased palms may occur isolated or in groups within the orchard. The closer a palm is planted to a site where another palm showed symptoms, the higher the chance that the new plant will become diseased: a mere two meter distance from a place where a palm died from the disease may reduce the probability that the new palm would become infected by 50% (Renard and Franqueville 1991).

Since the disease progression over time (1-2% per year, Renard 1979) is rather low even in very susceptible materials (and quite probably, poorly managed plantations); yield effect on the whole orchard is also low, particularly when affected palms are eradicated early, allowing healthy neighbor palms to compensate yield (no yield effect was noted below 20% incidence). Good agronomic management will no doubt more than compensate any missing palms. It can easily be concluded that yield effect will be minimized by using proper agronomic practices, and no doubt, stress tolerant varieties (Franqueville and Renard 1990). A strong environmental effect (climate, nutrition, soils, etc.) on disease incidence and severity has been documented (Aderungboye 1982; Ollagnier and Renard 1976; Prendergast 1957; Renard and Quillec 1983; Oritsejafor 1986; Renard and Franqueville 1991). Some examples are:

- Incidence increases after prolonged dry periods. Disease becomes more prevalent in places with such prolonged dry spells in West Africa. The negative effects of water deficit are enhanced when temperatures are abnormally high, potassium is deficient and the soil has a low water holding capacity. All these effects will cause massive death of the root system which is very superficial in oil palm.
- Poor soil aeration (which also causes root death) is associated with higher incidence. Poor soil aeration can be caused by lack of a proper drainage system, soil compaction, very fine textures, etc.
- Incidence (and probably symptom expression) increases in palms receiving no fertilizer or an unbalanced formula; particularly excesses of nitrogen in the absence of proper amounts of potassium. Inadequate nutrition of oil palm (amount, frequency, and balanced) in a large proportion of West Africa oil palm orchards is certainly a common denominator. This situation is aggravated in soils that are naturally low in fertility.
- Incidence tends to be higher where soil texture is light (high sand content), pH is low and organic matter content is also low.

Genetic Tolerance

There was an ample response in terms of tolerance between planting materials (Ollagnier and Renard 1976, Franqueville and Renard 1990). It has to be kept in mind that many orchards in Africa used native *dura* materials with no formal breeding. Some newer planting materials are recognized by their tolerance to abiotic stress which no doubt is related to tolerance to diseases like *Fusarium* wilt that are closely associated with stress conditions such as water deficit, water logging and inadequate nutrition. It is fascinating that some *oleifera* palms evaluated also showed tolerance to *Fusarium* wilt: stress tolerant materials and *oleifera* and its hybrids with *guineensis* tend to be also tolerant to spear rots.

Breeding for tolerance is rather easy considering that tolerance at the nursery stage seems to be related to field tolerance. Inoculation methods have been developed which permit selection of the most promising crosses in the nursery stage (Franqueville 1984; Prendergast 1963; Renard et al. 1980; Renard et al. 1972; Chinchilla 1987; Franqueville and Renard 1990). Nevertheless, disease susceptibility seems to be associated with many genes (some associated with stress tolerance?), which precludes the possibility of obtaining completely resistant progenies (Prendergast 1963).

Conclusions

Consulting the available literature, talking to people who are familiar with the disease, and knowing that there are poor agronomic management conditions on a large percentage of oil palm plantations in Africa (many are just wild *dura* materials), makes it difficult to avoid concluding that *Fusarium oxysporum* f. sp. *elaeidis* is a rather weak and opportunistic pathogen in oil palm.

Considering the many weaknesses of this pathogen documented in the literature and summarized above, is also safe to conclude that choosing planting sites with no clear limitations for oil palm growing and giving a fair agronomic management will prevent the disease from gaining any economic importance. Some obvious practices that must be followed in sites where there is some risk of *Fusarium* wilt causing problems are intended to reduce water deficit (dry season) and excesses (particularly during the last months of the rainy season). Examples of these practices are:

1 Using the best nursery plants.
2 Planting early in the rainy season, starting in soils with lower water holding capacity.
3 Adding an organic mulch like empty fruit bunches before the onset of the dry season and establishing a leguminous cover crop.
4 Maintaining a balanced nutrition: avoiding the use of high levels of nitrogen, particularly toward the end of the rainy season and keeping recommended levels of potassium both in the soil and on the leaves according to plant age.
5 Keeping the soil well aerated by reducing compaction and maintaining a proper drainage system to lower the water table and eliminating standing surface water. These measures can be complemented by using varieties with tolerance to stress, particularly water deficit.

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Fig. 1. *Fusarium* wilt in adult oil palms (*Marchitez por **Fusarium** en palmas adultas)*

Fig. 2. Nursery palms showing symptoms of *Fusarium* wilt. Note short leaves and thickened and discolored bulb

*Síntomas en palmitas de vivero de la infección por **Fusarium oxysporum** f.sp. elaeidis, Note las hojas pequeñas y arrepolladas de las plantas a la izquierda*

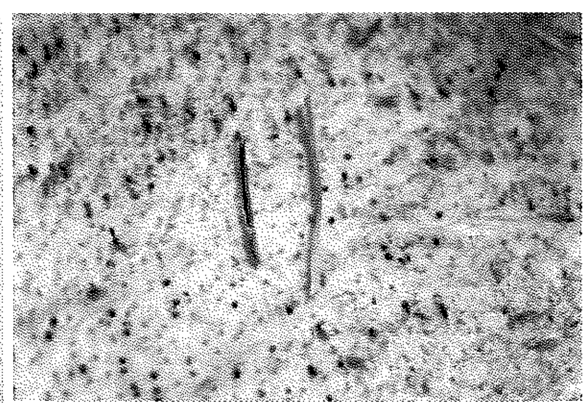

Fig. 3. Discolored fibers in the stem of a *Fusarium* wilt infected palm

*Fibras descoloridas en el tronco de una palma con la marchitez por **Fusarium***