Loss of a Legacy – *Fusarium oxysporum* and Ornamental *Phoenix canariensis*

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1. One-sided die back of a frond of *Phoenix canariensis* infected with *Fusarium oxysporum*.

In temperate regions of the world, *Phoenix canariensis* (Canary Island Date Palm) is an important street and park tree. With increasing incidence of the vascular wilt, *Fusarium oxysporum*, comes the loss of significant numbers of historic specimens, some nearly a century old.

This article is intended to be a resource in identifying the pathogen *F. oxysporum*, understanding how the pathogen affects *P. canariensis* palms and in describing the treatment of an abnormality that makes *P. canariensis* more susceptible to this devastating pathogen.

Tomlinson's "The Structural Biology of Palms" (1990) described palms as "structurally overbuilt." While palms are anatomically resilient, they are monocotyledons, and as such, lack the ability to regenerate or isolate damaged tissue. They are particularly susceptible to vascular wilt diseases.

Fusarium oxysporum is a fungus that, in its pathogenic form, can infect the vessels and cause blockage of the water transport system. As an increasing number of xylem bundles become clogged, the plant is unable to transport a sufficient volume of moisture equal to its demands for transpiration, and it wilts. *Fusarium* comprises a broad range of saprophytes that include both pathogenic and non-pathogenic members, generally found in abundance in the soil microflora. The genus *Fusarium* consists of many species, and each species is further broken down into *forma specialis* (f.sp) based on their host specificity. However, many forms of *F. oxysporum* are non-pathogenic. *Fusarium oxysporum* f.sp. *canariensis* has been identified as the fatal vascular wilt of *P. canariensis* (Mercier & Louvet 1973).

Inoculation

How does *P. canariensis* become inoculated with this fatal vascular wilt? Early work (Feather et al. 1989) led the horticultural community to perceive that the pathogen was being spread from palm to palm during pruning using infected tools. Is the epidemic spread of *Fusarium* simply the result of using chainsaws and using unsterilized pruning tools between specimens? Most likely not. Infection may also arise in the crown, in dead inflorescences. However, there is no evidence of inflorescence infection. Excessive winter soil moisture and/or high soil soluble salt levels can result in inflorescence abortions in *Phoenix* palms (Carpenter & Elmer 1978), a condition known as 'Khamedj' in the date-growing regions of the world. The rotting inflorescences affect leaves in the crown through their vascular connections. Carpenter and Elmer (1978) suggested that these infections may persist for several years. The laboratory work from Khamedj-infected specimens often comes back listing a complex of diseases including *Fusarium*, *Ceratocystis*, *Mauginiella*, *Gliocladium*, etc.

I believe that Khamedj infections may not only cause subsequent *Fusarium* infections that are suspected to begin in the crown but also most likely initiate the catastrophic stem failure of *P. canariensis* termed "Sudden Crown Drop" by Californians.

Khamedj infections in the crown are probably not the way in which most *Fusarium* infections begin in *Phoenix canariensis*.

However, there is no evidence that Khamedj is caused by *Fusarium oxysporum* f. sp. *canariensis*. If some *Fusarium* infections occur, they may not be due to the true wilt pathogen, but to other *Fusarium* species.

I suspect that most inoculations of *Fusarium* occur at the root zone. The first two of the four root orders in *Phoenix* palms are aerenchymatous. Aerenchymatous roots can best be described as those having air channels. Jost (1887) who described their role in gaseous exchange (aeration), referred to these roots as pneumatodes. These roots are commonly referred to as "air roots" by the trade, and can be seen along the lower stem portion of *Phoenix* palms. Many growers may be unaware that these roots also exist in the upper portion of the root zone proper.

The work of Belarbi-Halli and Mangenot (1986) described the susceptibility of *Phoenix* pneumatode roots to invasion by *F. oxysporum*. Apparently, the pathogen is free to run unchecked in the aerenchymatous channels of pneumatode roots. Since the second order roots branch from first order roots, which are also aerenchymatous, the pathogen is free to enter the stem at every juncture via the infected first order roots. When inoculation occurs in the roots, the stem can become massively infected.

Failure to *Fusarium oxysporum*: decline symptomology

There are two (2) distinct decline symptomologies when a *P. canariensis* fails to *F. oxysporum*. One seems to linger, taking as long as two years or more, before killing the crown. The other seems to come on overnight, affecting the entire crown below the inflorescence, with the newest part of the crown seemingly unaffected for a period. The two different symptoms offer clues as to how the palm may have been infected, which in turn, may suggest ways in which infection can be avoided.

Decline symptomology I: The lingering death

Phoenix canariensis specimens affected in this manner generally begin their decline in showing a single symptomatic leaf at mid-crown near the inflorescence. This leaf will show the classic one-sided dieback (Fig. 1) of the leaflets, separated by the rachis. As time progresses, additional leaves show symptoms (Fig. 2). Ultimately, the palm is lost as the entire crown becomes infected, with the rate of crown loss accelerating with passing time. This pattern of decline is that of an inoculation occurring at the crown, and thus by pruning-derived infection. Belarbi-Halli and Mangenot (1987) found that if inoculation takes place near the crown of the plant, the spread is slower, suggesting a slight hampering effect of the plant crown. When inoculation at the crown occurs, the hyphae of the pathogen invade the vascular bundles of the petiole. As their development towards the stem progresses, the hyphae are confronted with the "bottleneck" at the petiole insertion to the stem (Zimmerman & Sperry 1983). In the unlikely event their progress passes the "bottleneck," they enter progressively larger vascular bundles. This is a difficult proposition, since the pathogen is working against the transpiration stream of the large stem axial bundles.

Decline symptomology II: quick and painless

Decline symptomology II seems to come on suddenly, with the grower commenting, "it looked fine two weeks ago." The entire crown below the current season's inflorescences declines, with the portion above appearing generally unaffected for some time (Front Cover). The surviving portion of the crown is ultimately lost as well, again over a relatively short period.

Turning again to the vascular hydraulics work of Zimmerman and Sperry (1983), we find clues that tell us this type of decline is due to a massively infected stem. In summary, this work tells us that juvenile fronds present a greater hydraulic resistance to water passing through the system than do mature fronds. This is due to the smaller physical size of their xylem bundles and the late development of the xylem bundles that join the main stem axial bundles (metaxylem). Hilgeman (1951) described vascular maturation in the crown at the first row below the developing inflorescence. Therefore, as the stem becomes massively infected, the mature fronds are lost suddenly. The line of demarcation is the inflorescence. As the xylem in these fronds develops from protoxylem to metaxylem, they mature to make their association with the infected stem axial bundles. At this point, they are lost.

Decline symptomology II can be associated with mass infection of the stem vascular bundles, which occurs due to infection of the pneumatode roots. The pathogen is free to develop in the aerenchymatous channels of the roots and enter the stem at will (Fig. 3). If one were to perform pathogen cultures on stem tissue taken from a palm that had failed via the symptoms described, one would expect that the axial bundles at the central base portion of the stem would be massively infected.

Making palms less susceptible

We know that we cannot cure palms of *F. oxysporum*, nor can we alter the genetic susceptibility or resistance of an existing palm. What we can do is look at our cultural program and make modifications as necessary to avoid conditions that favor the development and/or spread of pathogen.

Pruning: Become familiar with the logistics and issues involved in pruning palms (Pfalzgraf 2000). To summarize:

Prune fronds only after they have dried completely or if they present a hazard to passersby.

Do not use chainsaws to prune; it is impossible to sterilize a chainsaw.

Remove particles trapped in the teeth of your handsaws with a brush, sterilize your pruning saws or date hooks by immersion in a half-strength solution of bleach and water (1:1 dilution) for no less than five minutes between specimens.

Remove inflorescence after they have elongated from the prophyll.

Irrigation: Probe the soil on a regular basis to check moisture levels in the root zones of your palms. If your population is serviced by an automatic irrigation system, use tensiometers to monitor moisture levels in the root zone. There are large air spaces (macro pores) and small air spaces (micro pores) in the soil. Immediately after fully irrigating a soil, all of the air spaces are filled with water. The water that drains away freely down through the soil profile is called gravitational water. After gravitational water has drained away, the macro pores are filled with air; the micro pores are filled with water. This condition is known as field capacity. The majority of the water left in the micro pores is available for plant use. The air in the macro pores allows the root system to respire. Plants prefer this moisture level. The goal is to keep your soil moisture level at field capacity.

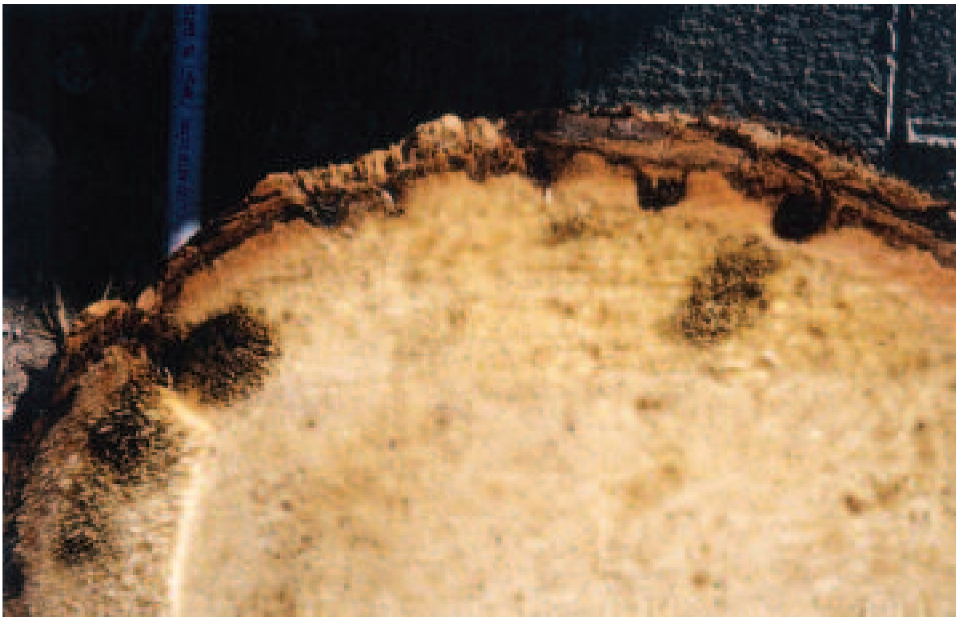
Be aware that excessive root zone moisture promotes the development of pneumatode roots and favors the development of pathogens. Pneumatode roots have a specific susceptibility to *F. oxysporum*. Excessive winter soil moisture favors the development of inflorescence rot pathogens in *Phoenix* palms. Inflorescence rots may be implicated as the cause of class I *F. oxysporum*

2. *Phoenix canariensis* displaying Class I *Fusarium oxysporum* symptomology.

infections and in the catastrophic structural failure of the stem (i.e. "Sudden Crown Drop") in *P. canariensis*. Provide stability in the manner you irrigate your palms. Avoid fluctuation and excess. Palms require consistency.

Fertilization: Take a proactive approach toward the nutrition of your palms. Submit soil and tissue samples for analysis. If this is done on a consistent basis, you can develop a trend in how efficient your palms are at taking up nutrients, by comparing changes in the soil and tissue levels against your fertilizer application history. Do not expect overnight results. Any imbalance that developed over a long period will be slow in its correction.

After your base nutritional problems are addressed, use one of the products that are formulated specifically to address the nutritional requirements



3. Section of the base of a stem of *Phoenix canariensis* infected with *Fusarium oxysporum* f. sp. *canariensis*.

of palms. Be consistent in your fertilization program.

Dense pneumatode mat: Become familiar with the pneumatode roots of your *P. canariensis* palms. As you observe the soil surface radiating from the trunk of your palms, you will notice roots that have a vertical orientation and that rise to just above the soil surface. These are pneumatode roots. How often do we see people chopping away at pneumatode roots in order to install flowers around the base of a palm? Wounding pneumatode roots is an invitation for entry by a pathogen. What if one digs in the root zone of a *P. canariensis* with pneumatode roots are infected with *F. oxysporum*? Would one not entertain the distinct possibility of infecting the next palm one works on with the infected tools? Develop an understanding of the function of pneumatode roots and their susceptibility to pathogen infection. Do not wound them. Practice the same sterilization procedures for tools used in the root zone as one uses for tools used in the crown.

Summary

Fusarium oxysporum poses a substantial threat to the stability of ornamental populations of *P. canariensis* palms worldwide. We should understand that the vast majority of *F. oxysporum* infections begin with imbalances at the root zone. The only option we have is to attempt to defeat the pathogen by removing the conditions favorable for infection. Protect your existing population with proper culture. Do not allow the use of chainsaws for pruning. Insist on a diligent pruning method that considers the importance of proper pruning tool choice and sterilization. In understanding a bit about the physiology of our palms, being sanitary in our treatments and providing our palms with stable culture, we can avoid circumstances that favor the development of this pathogen.

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