ASD Oil Palm Papers (Costa Rica), No. 35: 13-17, 2010

There is no known evidence of a relationship between incidence and severity of spear rot (PC= pudrición del cogollo) in oil palm and the commercial origin of oil palm varieties planted in the past in tropical America

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Introduction

The oil palm (*Elaeis guineensis*) is a species originally from West Africa that was brought at an indeterminate time to America, where other species (*E. oleifera*) evolved independently. Genetically, these two species are closely related, but the second one has several interesting characteristics, such as tolerance to many spear rots, and this trait can be passed on to the inter-specific crosses, known as OxG (*oleifera x guineensis*).

The objective of this note is to present a general view on spear rots (PC) in oil palm and to argument that these disorders have appeared in planting materials coming from all genetic backgrounds and commercial origins in the past. Not until recently has it become clear that tolerance can be found in some new genetic combinations within *guineensis*. The origins of PC are complex, and in addition to susceptibility in all traditional planting materials, there is a strong environmental effect that must be understood in order to better manage the problem and greatly reduce its negative effects on commercial oil palm plantations.

PC and similar disorders in other continents

PC and similar disorders of the oil palm are not present only in tropical America. Even a quick literature review will show that similar symptoms have been described in Colombia, Brazil, Costa Rica, India, Thailand, the Congo, Nigeria and other countries. If we assume that a pathogen is the sole cause of such symptoms, we would have to accept that the same pathogen is present everywhere, or that different opportunistic pathogens would be associated with similar symptoms in each region and country according to particular environmental conditions.

The disease triangle

A basic principle in plant pathology is that a disease is the result of a successful interaction between a pathogen, a susceptible host (the oil palm in this case) and a particular environment. These elements interact in time. The environmental effect is very important indeed and can be used to exclude, avoid or minimize the effects of a particular pathogen: we change the environment and exclude the pathogen or minimize its effects. In the particular case of weak or secondary pathogens, this is a powerful resource, and it may explain why PC is easier to manage

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in some environments than in others. For example, when a disorder similar to PC appeared on some of the oil palm plantations of the central Pacific coast of Costa Rica, there was a great effort involved in changing the agronomic management of the plantations for the better. After several years the result was that the disorder lost its aggressive behavior (both incidence and severity of symptoms were clearly reduced). Now that symptoms are milder (there is even absence of rots in many affected palms) and palms easily recover, we could conclude that the secondary organisms involved in symptom expression are the same but by changing the environment, the negative effects on plants were clearly reduced

Different types of spear rots in oil palm are associated with several factors that affect normal plant development, particularly the root system. In general, any element that negatively affects root formation and longevity could predispose the plant. Some predisposing factors already identified are nutritional imbalances, poor soil aeration and water availability (i.e. water deficit). But there are no recipes and every plantation and production plot needs a serious study of its particular conditions for developing custom-made solutions.

From a nutritional point of view, these disorders tend to be more serious in soils with low potassium and phosphorus contents and where important imbalances between bases occur (Mg, Ca and K). A potentially negative combination could be the use of excessive amounts of nitrogen in a situation where K is deficient (or is unbalanced with Ca or Mg) and a severe water deficit appears in a soil with low water holding capacity. If these conditions are later followed by persistent water-logging, this could destroy the existing root system and impede the formation of new roots. Such conditions will clearly stress the plants and predispose them to many sanitary problems.

Are the OxG hybrids the final solution to spear rots in oil palm?

Some plantations where PC or similar disorders have affected a large number of plants in the past (but ways were found to recover from them), kept planting *E. guineensis* varieties. However, mainly in some areas in South America, planting OxG hybrids is considered essential for staying in business; but expectations on some of these crosses in terms of tolerance to diseases and oil production could have been overestimated. Some plots have not reached the expected yields (bunches and oil) and some showed an unexpected high early incidence of spear rots.

On the other hand, all known OxG hybrids are susceptible to other diseases that also affect *E. guineensis*, such as red ring disease, *Ganoderma* stem rot and chlorotic ring spot, among others. The importance that these diseases will have for large plantations is yet to be seen. Expressing the yield potential of the OxG hybrids will be also an effect of good agronomic practices. Besides this, if oil production potential is constantly increased through breeding, there is the risk of increasing susceptibility to spear rots or any other disease or condition (water deficit for example). It will be very difficult indeed to create a high yielding planting material with resistance to poor management.

Incidence and genetic material

The oil palm industry today is still based on the use of *E. guineensis* progenitors bred in South-east Asia, East Africa, Costa Rica and some local stations in Ecuador, Colombia and Brazil. All these varieties share a relatively narrow genetic pool: Deli *dura* mother palms and a few pollen sources. From these few varieties, the Deli x AVROS has shown great susceptibility to spear rots, independent of the country or experimental station where it was developed; and the same seems to be true for other vigorous varieties such as Deli x Yangambi and Deli x Ekona.

However, there still seems to be plenty of genetic variation even within the popular Deli x AVROS variety, even in traits normally considered in traditional breeding programs. For other characteristics (not considered in traditional breeding), there is still lot of variation waiting to be exploited. Nevertheless, some breeding programs have been developing new varieties, by using mother palms different from Delis, and new pollen sources. These new varieties are outmoding old varieties, thanks to higher yield potential and adaptability to different environments, and different response to PC.

Probably, absolute immunity to PC could not be incorporated into any commercial planting material containing *guineensis* genes; and this could also be true for the OxG hybrids. Tolerance, on the other hand, could be found in both *E. guineensis* and the OxG materials.

There is at least one Deli x La Mé cross and other '*guineensis'* sources which has shown tolerance to PC. However, even more interesting is the fact that stress tolerance and PC tolerance seem to be associated. This situation has been observed in some crosses genetically separated from the traditional planting materials, such as Deli x AVROS. Wild materials collected from highlands in Bamenda and Tanzania have already originated commercial varieties (Bamenda x Ekona and Tanzania x Ekona) with clear tolerance to stress and PC. Other origins such as Malawi and Mobai from dry lands are also very promising and are being tested in sites where PC is prevalent in South America with encouraging results.

The relationship between the commercial origin of the traditional planting materials and PC susceptibility is still not clear and may not exist at all. The history of PC in tropical America is full of examples of severe outbreaks in different countries and regions where all such varieties were similarly affected. One of the first of these outbreaks occurred in Colombia (Coldesa, Urabá, late 1960s). About the same time, another plantation in Panama (Colón) was also severely affected. The distribution of planting materials for this last plantation established between 1960 and 1966 was particularly interesting: DxD from Surinam (70%), DxT from Malaysia (20%), and 10 % was a mixture of DxT, IRHO, DxT, Surinam and DxP, Surinam. In 1976, it was determined that 80% of the plantation was affected by PC and no differences were observed between planting materials. In Coldesa, the composition of planting materials was also unusual: seed from Colombia (Instituto de Fomento Algodonero), DxT, TxD and DxP crosses from Ivory Coast, seeds from Surinam, Malaysia and even DxP crosses produced in Aracataca (*duras* from Patuca and Venezuela with pollen from Venezuela). Did these mixtures favor the sudden existence of a new oil palm pathogen in America? We do not know, but it is not likely.

Other outbreaks of importance occurred in DEMPASA (Para, Brazil, 1985), Ecuador and Surinam (1982). In all these cases, incidence was similar in all varieties planted, including Deli x La Mé (brought from Africa), Deli x AVROS (Harrison & Crossfield) and local varieties (INIAP, Ecuador). During the 1990s, several local varieties were similarly affected during an outbreak of the disorder on the central Pacific coast of Costa Rica. All affected areas in Costa Rica recovered from the disorder and now maintain normal yields expected for the prevalent soil and environmental conditions. Other plantations, particularly in South America, have not been so lucky and were partially or totally abandoned.

From 1988, PC incidence increased in Los Llanos in Colombia and the last devastating outbreak occurred in the Tumaco region, where the disorder eventually affected all planted varieties, but started in areas planted with Deli x La Mé. A particular 1,414 ha plantation planted in 1986-87 offers a good example of the variety composition in this region: Deli x AVROS from Papua (59 % of the plantation), varieties from Costa Rica (39%) and a local variety (2%: possibly Deli x Ekona). In another plantation (3, 680 ha), the varieties planted were: 73 % La Mé (Africa), 16 % Papua, and 11 %, Costa Rica. In yet another plantation (1,220 ha), the varieties planted were from Costa Rica (57%), 37 % Papua (37%) and other local varieties (6%). These are examples of the diversity of commercial origins of palms planted that were equally affected by PC in the Tumaco region.

Is there a pathogen as the 'sole' cause of PC in oil palm?

PC and other similar disorders in oil palm probably do not have a particular pathogen as the sole cause of all symptoms. More than 45 years of field experience and research have yielded no conclusive evidence in favor of a simple cause/effect relationship. Looking for such an elusive pathogen has taken precious time from searching for an agronomic solution to the problem. All attempts to directly attack any suspected pathogens have failed, but the environmental effects on incidence and severity are too obvious to be ignored.

Many plantations were free of these disorders for decades (or incidence remained very low), and then, more or less suddenly, the disorder spread to affect most of the plants in a relatively short period of time. Such a behavior points toward important changes in the environment, but not necessarily to changes in pathogen virulence or pathogenicity. The opposite situation is also true; some plantations that were severely affected (in terms of incidence and severity of symptoms) were able to overcome such periods and recovered, indicating that any pathogen present in disease syndrome was an opportunist.

Epidemiological evidence in favor of the presence of a primary pathogen as the sole cause for PC is also not conclusive, as was recognized by Dr. Sadoks, a well known epidemiologist: “this problem behaves in a different way to any epidemic caused by any known pathogenic agent”. Some data on PC incidence obtained in Surinam were statistically analyzed by two different research groups and opposite conclusions were reached about the presence (or not) of a pathogenic agent.

Even those in favor of a pathogenic agent as the primary cause of PC are careful to point out that there are several other organisms associated with the disorder, whose participation is crucial in

terms of symptom severity. This is the case of the so-called opportunistic or secondary organisms that are associated with rots. Even more important is the omnipresence of the American palm weevil (*Rhynchophorus palmarum*) which is attracted to any injury or rot in the whorl region of PC-affected palms and whose larvae can easily kill a palm. All these organisms associated with the disorder have caused some people to call it "the PC complex". Other organisms can also easily aggravate symptoms. The root miner *Sagalassa valida* (common in Ecuador and other countries) can debilitate the root system to intolerable levels and *Cyparisius daedalus* (*Castnia daedalus*) in Brazil was associated with the final fate of many plants initially affected by PC in Para.

Conclusions

Spear and whorl rots in oil palm are not endemic to tropical America; nor are PC-like symptoms. However, it has been in tropical America where outbreaks of these problems have caused more damage in terms of both economic and social effects.

Searching for a culprit, it has been normal to try to associate the geographical (or commercial) origin of a determinate planting material with the appearance (and severity) of a particular phytosanitary problem in a determinate region or country. Such attempts may also hide a protectionist intention. The presence of PC (in terms of both incidence and severity) has been particularly attractive for such attempts, but no scientific evidence has been presented whatsoever to back such claims. One such example came from Colombia, until the ICA intervened in 2008 to clarify the situation: "there was no evidence to back the possibility of transmission of the agent(s) associated with PC in oil palm." Besides this, it was concluded that: “In Tumaco, the development of the PC occurred with equal intensity in palms originating from seed of local origin or imported from other countries or regions within Colombia."

It is true that most commercial oil palm varieties have a narrow genetic pool, but there is still plenty of genetic variation waiting to be exploited within the species *E. guineensis* (and *E. oleifera*) Sound agronomic management offers the solution to PC and related disorders: incidence, symptom severity and the ability to recover are closely associated with a) environmental factors (present even before actual symptoms developed that are affecting (or negatively affected) growth (particularly the root system), b) agronomic management (during the entire life of the plantation from planting), c) the type and populations of harmful organisms present, and d) the presence of other organisms that aggravate symptoms (such as *Rhynchophorus palmarum*). All these factors have an important effect on the disorder and the fate of the plantation.

The development of commercial varieties with tolerance to PC and related disorders is also an important part of the equation, but it has to be kept in mind that sound agronomic management is a key element for preserving a sustainable system. No variety will express its tolerance potential if agronomical management is poor. Besides this, it is possible that some price in terms of yield potential has to be paid in some highly tolerant varieties: theses varieties will, however, have the potential for better yield that any traditional variety under conditions highly favorable for PC-related disorders (which are certainly associated with stress conditions), given that stress tolerance and PC tolerance seems to be related.

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