Pest risk assessment of the International Coconut Genebank for Africa and Indian Ocean, and Latin America and the Caribbean

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Introduction

The International Coconut Genetic Resources Network (COGENT) of the International Plant Genetic Resources Institute (IPGRI) has been assisting the establishment of a multi-site International Coconut Genebank (ICG), with sites in five countries, each representing one of the main coconut ranges. They are Indonesia for Southeast Asia, India for South Asia, Papua New Guinea for the South Pacific, Côte d'Ivoire for Africa and the Indian Ocean, and Brazil for Latin America and the Caribbean region.

The pest pressure exerted on coconut throughout its major producing regions, and the consequent phytosanitary risks to which it is exposed, are a threat to its sustainability and sometimes lead to it being dropped from a production system. The risks are rarely the same worldwide, and are therefore important to assess them in order to promote germplasm dissemination and exchange under optimum conditions.

Generally, it is the overall phytosanitary constraint that needs to be documented in a given zone, not only to avoid the transfer of pests and diseases but also to guarantee a satisfactory phytosanitary situation in the collections planted at a given site. That means also taking into account fungal diseases and the main coconut pests in the entomofauna that are likely to jeopardise the establishment of a germplasm collection.

In order to determine this constraint, a pest risk assessment was conducted in two ICG host countries, Côte d'Ivoire and Brazil. This paper attempts to document the main pests and diseases in the study zones, analyse the corresponding phytosanitary risk, determine their potential as quarantine organisms and identify the phytosanitary risks involved for collecting and exchanging germplasm.

Material and methods

Documentation

This study is based on all the information gathered by conventional bibliographical research, the author's knowledge of coconut diseases, or

oil palm diseases in some cases that could impact on coconut, consultations and discussions with members of the scientific community, supplemented by information gathered from some particularly useful internet sites.

Visits to ICG host countries: Côte d'Ivoire and Brazil

The visit to Côte d'Ivoire took place in April 1999, in liaison with the Marc Delorme Research Station (Centre National de Recherche Agronomique, CNRA). Sites visited included the station itself, at Port-Bouët, near Abidjan, with its current collection; the lagoon strip between Assinie and the Ghanaian border, to examine the condition of the coconut groves; and the Grand-Drewin Experimental and Production Station (CNRA, Gagnoa regional management), a potential site for a future collection. This station is located at Sassandra, around 240 km from Port-Bouët, and around 330 km from the Ivorian-Ghanaian coastal border. Port-Bouët is around 95 km from the same border (all the distance are direct, as the crow flies). The Ghanaian border at Elubo is around 170 km by road, via Aboisso, from Port-Bouët and 460 km from Sassandra.

These details are important, due to the existence of lethal yellowing disease (LYD) in the neighbouring Ghana. Arrangements will have to be made to duplicate all or part of the Marc Delorme Station collection at the Grand-Drewin Station if the disease gets any closer to the Ivorian border.

The visit to Brazil took place also in April 1999, in liaison with the EMBRAPA research station at Aracaju, in Sergipe State (Centro de Pesquisa Agropecuária dos Tabuleiros Costeiros - Empresa Brasileira de Pesquisa Agropecuária). The sites visited that are candidates for receiving the future ICG material were Itaporanga, west of Aracaju, the Neopolis plateau, northeast of Aracaju, and Betume, located between Neopolis and Ilha das Flores.

Pest risk assessment

Pest risk assessment is a step towards a pest risk analysis (PRA), following the process laid down by FAO (1996a, b). Its purpose is to identify pests and diseases necessitating plant quarantine. It is carried out in a potentially or known pest risk area, usually a country. Ikin (1997) applied these directives to coconut germplasm exchanges for cadang-cadang and cadang-cadang viroid-like sequences. His study led to the revision of the directives governing germplasm movement and the quarantine measures applied to it.

PRA could be broken down into three stages:

1. *Identification of pests or pathways* for which PRA is necessary. Here, the pathway is defined by the form in which germplasm is

transported: seedlings, seeds, pollen or embryo culture. A pest may or may not be defined as being a quarantine organism depending on the germplasm form;

2. *Risk assessment* serves to determine whether the identified organism, as such or combined with the pathway, is a quarantine organism, depending on its likelihood of entering the PRA zone, the capability of establishing itself and spreading, and its economic importance (Diekmann 1997).
3. *Risk management* comprises the development, assessment, comparison and choice of options intended to reduce that risk.

PRA can be carried out by considering either the pathway or the pest (i.e., the form in which germplasm should be exchanged to significantly reduce the risks of introducing a given pest). It is primarily the second approach that will be taken, given the inventory of pests existing in the study areas.

Results

Coconut diseases and pests

Almost 30 diseases affect coconut worldwide (Frison *et al*. 1993; Ikin 1997; Mariau 1999). Most are found on the Asian continent and little is known about most of them. In the study areas, neither identified diseases of viral nor viroid origin have been inventoried. On the other hand, LYD shows a strong presence in Africa, Central America and the Caribbean.

The insects listed during the study do not figure in the germplasm transfer pathways, given their nature and their biology, although special attention must be given to the recent outbreaks of white flies (*Aleurotrachelus atratus* and *Paraleyrodes bondari*) in Comoros Islands (Baudoin and Ollivier 2003, personal communications). However, it is possible that the insect pests do pose a threat for the installation and development of collections in Côte d'Ivoire and Brazil. Mites, especially *Eriophyes guerreronis*, can be harboured by nuts, primarily beneath the floral parts, and are therefore, a risk that has to be considered if germplasm is moved as seednuts. However, as they cannot withstand a vacuum (JF Julia 1999, personal communication), there is little risk of them contaminating pollen. Likewise, it should be possible to detect any contamination of embryo cultures very rapidly.

For the record, vertebrate pests, birds or mammals do not figure in the germplasm exchange pathways, but the risks they represent to collections, especially on young plants, need to be taken very seriously. In general, cultural practices or special arrangements (ditches, fences) help to reduce their impact.

Situation in Africa/Indian Ocean

The following seven diseases were found in Africa and the Indian Ocean:

Phytoplasma diseases

Blast is the main nursery disease on oil palm in Africa, and is also found on coconut (Quillec *et al.* 1978). It is attributed to a phytoplasma due to the preventive role played by tetracycline (Dollet 1980; Dollet 1985). Blast is carried by a leafhopper, *Recilia mica* Kramer (Desmier de Chenon 1979). The insect only seems to be infectious at certain times of the year and incubation lasts a few days (de Franqueville *et al.* 1991). Blast has never been reported on bearing palms, although it has been observed during the first year after planting. Therefore, it is not a major threat to germplasm movement.

LYD first occurred in Africa around 1930 (Bachy and Hoestra 1958), in Togo and was called Kaincopé disease (Dollet and Giannotti 1976), then in Southeast Ghana as Cape St Paul wilt (Dabek *et al*. 1976), in Cameroon as Kribi disease (Dollet *et al*. 1977) and in Nigeria asAkwa disease (Ekpo and Ojomo 1990). In East Africa, LYD causes serious damage in Tanzania (Schuiling and Mpunami 1990), Kenya and Mozambique (Mpunami *et al*. 1996). Analyses by restricted fragment length polymorphism (RFLP) and polymerase chain reaction (PCR) suggest a degree of difference between West African and East African phytoplasmas (Tymon *et al*. 1997, 1998). The disease vector has not been formally identified, but a plant hopper, *Myndus adiopodoumeensis* is strongly suspected in Ghana (Dery *et al*. 1996). Phytoplasma diseases are considered to have little chance of being carried by seeds, pollen, or embryos (Dollet 1995). Phytoplasmas seem to have been detected in embryos, but there is no evidence that these embryos would normally germinate.

LYD is not widespread throughout the African and Indian Ocean region; it has not been reported in Côte d'Ivoire, Benin or the Seychelles.

Fungal diseases

Phytophthora katsurae Ko and Chang causes immature nut fall and lethal bud rots (Quillec and Renard 1984). *P. katsurae,* which was initially identified as *P. heveae*, a very closely related species, seems to be the only fungal species, found damaging in Côte d'Ivoire (Blaha *et al*. 1994). Its incidence is effectively controlled by fungicide injection into the stem (de Franqueville and Renard 1989). *Phytophthora* rot diseases are not documented in the other African countries, but are suspected in Ghana.

Marasmiellus cocophilus Pegler is associated with the so-called lethal bole rot, on seedlings or young palms in Kenya and Tanzania (Bock *et al.*

1970). The fungus can act as a saprophyte, colonizing plant matter, either from coconut palms or from other crops.

Phomopsis cocoina (Cooke) Punith. causes leaf spots and husk rot. It is reported in Kenya, the Seychelles (quoted by Frison *et al*. 1993). It can be borne by nuts.

Bipolaris incurvata causes leaf blight in the Seychelles. This symptom is similar to the *Helminthosporium* leaf spot found in Côte d'Ivoire (Quillec and Renard 1975), caused by *Helminthosporium halodes* (Dresch.), whose limited economic importance has never warranted any intensive intervention.

Diseases of unknown origin

Dry bud rot, which is documented in Côte d'Ivoire (Renard *et al*. 1975), also found on oil palm, is transmitted by two similar species of *Delphacidae*, namely *Sogatella kolophon* Kirkaldy and *S. cubana* Crowford (Julia and Mariau 1982). It is a disease of young palms and primarily occurs in the nursery; damage to adult palms has not been observed. There is no information available on its incidence in the other countries of West Africa.

Pest risk assessment in Côte d'Ivoire

Ivorian coconut plantings are subject to four of the seven diseases documented in Africa and the Indian Ocean. Two are diseases found in the nursery or on young palms - blast and dry bud rot. The other two are fungal diseases, namely: *Helminthosporium* leaf spot and *Phytophthora*.

LYD, in neighbouring Ghana, is spreading and threatening the eastern part of Côte d'Ivoire, but it is difficult to establish the speed with which the disease is spreading. In the Western Region, it first occurred in 1964 at Cape Three Points. It was not until 1992 that it reached Axim, around thirty kilometres to the West, after affecting Cape Coast in 1984, 100 km to the East. The situation has been described by Philippe (1997): a large focus developed around 15 km west of Axim, i.e. around 74 km from the Ivorian border. A smaller focus was detected 13 km to the West (61 km from Côte d'Ivoire) and two diseased palms were detected 34 km from the border. Those two palms were immediately eliminated. By 1999, the situation had barely changed (R. Philippe 1999, personal communication). The larger focus, near Axim, has spread at a rate of one to two km per year, the smaller focus at a rate of around a hundred metres in two years, and the situation has remained unchanged at the site where the two diseased palms were eliminated.

Visits to the lagoon strip, on the Ivorian side, did not reveal any lethal yellowing infection. There were some yellowing palms, in poor condition,

with few or no bunches but there were no signs of any developments in either symptom intensity or dispersion of the symptoms. They are old coconut palms, which have never received any fertilizer or phytosanitary treatment and have always be subjected to attacks from *Oryctes* and scale insects (*Aspidiotus destructor* Signoret), which should not be confused, as emphasized by Dollet (1995) with cases of lethal yellowing.

The Grand-Drewin station is one of the sites selected for establishing a coconut germplasm collection. It also has a large population of oil palm. There is no *Phytophthora* disease.

Given its location in a low rainfall zone, the risks run by the collection are linked to drought unless an irrigation system is installed. Diseases affecting young palms may also occur (blast and dry bud rot), which can be effectively controlled by chemical treatments against the vectors, and by cultural practices. A close watch will have to be kept on *Oryctes* sp. outbreaks in the early years after planting, especially if old oil palm plantings have been felled in the vicinity. During production periods, Aceria (*Eriophyes guerreronis*) damage is to be feared. Damage caused by the Coreid bug *Pseudotheraptus* sp. is slight, probably due to the good establishment of *Oecophylla* ants, which limit its development.

Lastly, it is reasonable to assume that if LYD were to spread into Côte d'Ivoire, it would probably only occur on a scale of at least one generation of coconut palms.

Situation in Latin America and the Caribbean

At least the following ten diseases are documented in Latin America and the Caribbean (LAC):

Phytoplasma disease

LYD was reported for the first time in the Cayman Islands around 1830, has spread throughout the Caribbean, to Haiti, the Dominican Republic, Cuba, Jamaica and then Florida. It reached the Yucatan peninsula in Mexico in the 1980s (Cardeña *et al*. 1991) and was reported in Honduras in 1996 by Ashburner *et al.* Its spread in LAC has been much faster than in West Africa and it is carried by a leafhopper, *Myndus crudus* Van Duzee (*Cixiidae*). Molecular techniques (RFLP, PCR) have shown greater similarity between the phytoplasmas in LAC and East Africa than with those in West Africa (Jones *et al*. 1995; Tymon *et al*. 1998). LYD occurs in most of the countries in the zone in the COGENT network, but not in Costa Rica, Guiana, Trinidad and Tobago, and Brazil. It also doest not exist in Nicaragua or Venezuela.

It should be noted that phytoplasmas are reported to have been detected in the embryos of nuts from diseased palms in Mexico. It has

not been confirmed, but needs to be checked as soon as possible, using all the appropriate techniques (electron microscopy, PCR), along with their viability.

Fungal diseases

Phytophthora palmivora and *Phytophthora katsurae* live side by side in Jamaica (Steer and Coates-Beckford 1990), but *P. palmivora* is usually the only species found in the zone. It causes bud rot leading to the death of coconut palm. Its incidence can be devastating in some parts of the Caribbean, notably the Dominican Republic. It is known to exist in Cuba and Central America, but there is no precise information. *Phytophthora* rot diseases are not documented in Brazil. Bud rot symptoms have been observed in the Fortaleza region of Ceara state and have been assimilated in their advanced stage to those caused by this fungus. However, neither the development of the disease, nor the isolations carried out, has confirmed this hypothesis (de Franqueville 1996).

Bipolaris incurvata occurs in Central and South America. In particular, it was reported in Brazil by Warwick (1997) where it causes *Helminthosporium* leafspot, or 'mancha-foliar', particularly in the nursery.

Lixa pequena, caused by *Phyllachora torendiella* (Bat.) nov.comb., is a widespread leaf disease in Brazil of varying intensity (Subileau *et al*. 1993). It is also found in French Guiana. It can cause up to 50% loss of leaf area, immature nut fall, and consequent yield loss of 20 to 40% (Renard 1999). Lixa grande is another leaf disease associated with the previous one but caused by *Sphaerodothis acrocomiae* (Montagne) von Arx & Muller. Queima das folhas is also a leaf disease of Brazil, caused by *Botryosphaeria cocogena* Subileau. Lixas generally promote the development of this fungus, for which they represent access routes. This constitutes a perfect parasitic complex (Subileau 1993, 1994; Warwick *et al*. 1994).

Phytomonas disease

Hartrot is endemic in northern South America, from Peru or Bahia state in Brazil, to Costa Rica (Renard 1999). It is moving up to Honduras, where infected oil palm marchitez is already found. It has also been identified in Trinidad, under the name of *Cedros wilt*, where 15 000 coconut palms have been killed in three years. It causes sporadic damage in Colombia, Venezuela, Surinam, Brazil and French Guiana. Smallholdings, which do not have access to regular insecticide treatments, can disappear within five years (M. Dollet 1999, personal communication). The presence of *Phytomonas* (Trypanosomatids) is associated with any Hartrot syndrome (Dollet *et al.* 1977a; Dollet and Lopez 1978). Hartrot is carried by bugs of the *Lincus* genus (Louise *et al*. 1986) or *Ochlerus* genus (Mariau 1985).

Nematode diseases

Red ring disease is caused by *Bursaphelenchus cocophilus* (Cobb) Baujard, a nematode carried by an insect, *Rhynchophorus palmarum* (*Curculionidae*). It is endemic in Central America, South America and the Caribbean (Warwick *et al*. 1995). This disease also affects oil palm. Its incidence varies depending on the region. In Venezuela, some oil palm plantations have suffered 70% losses in 15 years. Red ring control consists of limiting the vector populations, notably by using aggregation pheromones.

Diseases of unknown origin

A dry bud rot occurs in Brazil (Renard 1990). It is not known whether it is linked to the one found in West Africa and/or with the so-called oil palm ring spot disease, which is rife in Latin America, although symptoms are similar to those of oil palm dry bud rot in West Africa. As knowledge stands at the moment, it is classified as a juvenile disease in Brazil (Warwick 1998).

Porroca is a disease of unknown origin that seems primarily to affect poorly maintained coconut plantings. Currently, its incidence seems to be limited to Colombia and Panama, countries which are not in the COGENT network. Porroca is not reported in Costa Rica for the time being, but it is worth monitoring closely in Central American countries. Similar symptoms (short leaves) exist in French Guiana.

Pest risk assessment in Brazil

Seven of the 10 diseases listed above are found in Brazil, but the two most serious diseases have not been detected in the country, i.e. lethal yellowing and *Phytophthora*. Several thousand kilometres separate Brazil from the most active lethal yellowing foci, whether in the Caribbean zone or in Central America. The Andes, in Colombia and Venezuela, also form a natural barrier between Brazil and the Central American foci. It is therefore unlikely that lethal yellowing will occur in epidemic proportions in Brazil.

Brazil may be a favourable zone for *Phytophthora palmivora* development, as shown by attacks on cocoa plantings in Bahia state (Ortiz Garcia 1996).

The Aracaju region in Sergipe is characterized by a substantial water deficit and by extended periods of severe drought. The predominant diseases in the region are leaf blights (lixas and queima das folhas), which occur in varying degrees in each of the plantations visited. Hartrot only seems to occur sporadically in the region (DRN Warwick 1999, personal communication).

Wherever the collection is planted, it will run the risk of dry bud rot, which can cause major damage in young plants (Warwick 1998), and

Helminthosporium leaf spot. However, attacks can be limited by preventive treatments.

The list of coconut pests in Brazil is long (Ferreira *et al*. 1998; Morin 1986). The pests that are likely to be a threat to the collection are primarily *Brassolis sophorae* L., *Hyalopsila ptychis* Dyar, *Coraliomela brunnea* Thumberg, *Homalinotus coriaceus*, *Aspidiotus destructor* Signoret and the mite, *Eriophyes guerreronis* Keifer.

Generally speaking, a close watch will have to be kept on the germplasm collection to prevent the risks associated with these different pests. If free of any lethal diseases, drought will remain the main limiting growth factor of the germplasm collections in Brazil.

Risks linked to germplasm exchange in the study zones

From African/Indian Ocean countries to Côte d'Ivoire

Lethal yellowing is a threat to Côte d'Ivoire. The causal agent is capable of surviving in this country, spreading and causing major economic damage. It is therefore a potential quarantine organism.

As far as fungal diseases are concerned, the risk of introducing *Marasmiellus cocophilus*, which has yet to be reported in Côte d'Ivoire, exists from Kenya to Tanzania. *Phomopsis cocoina* is reported in Kenya and the Seychelles and can be borne by nuts. *Bipolaris incurvata* is also reported in the Seychelles, but causes only minor damage, except in the nursery. *Helminthosporium* leaf spot occurs in Côte d'Ivoire. These fungi are not a major threat for coconut cultivation in Côte d'Ivoire and their economic importance does not warrant their being considered as quarantine organisms. *Phytophthora palmivora*, a species not found on coconut in Côte d'Ivoire, has not been reported in the countries of the zone.

From Côte d'Ivoire to African/Indian Ocean countries

Phytophthora katsurae may be a threat for the other countries in the zone involved, but only causes immature nut fall at the Marc Delorme Station. Hence, nuts do not germinate. The Grand Drewin Station is free of it. Moreover, it can be effectively controlled by appropriate fungicide treatments.

For the other fungal diseases, only *Helminthosporium* leaf spot could be a threat, but methods of control and prevention exist for this disease. It only significantly affects certain ecotypes and is of no economic importance.

Dry bud rot and blast are juvenile diseases that only occur at certain times of the year with virtually non existent risk of transmission.

From Latin American/Caribbean countries to Brazil

There is nothing to indicate that the causal agent of lethal yellowing is not capable of settling, developing and causing serious economic damage in Brazil, even in the marginal zone of Aracaju. *Myndus crudus*, the disease vector in Florida and Mexico, has also been seen on oil palm plantations in Para state (Julia 1990). In any event, the Brazilian government has stepped up its quarantine and surveillance measures for palms to prevent the introduction of lethal yellowing in the country.

Phytophthora palmivora probably exists in all the countries in the zone. The recurrent drought in Sergipe and the Aracaju region should hinder the establishment of this pathogen and limit its possible economic impact.

From Brazil to the other countries of Latin America/Caribbean

The economic importance of leaf fungi, *Lixas* and *Queima,* in Brazil means that considerable attention needs to be paid to the movement of the parasites involved. They exist in Sergipe, but also in other much more humid zones, such as Para state, where disease incidence is relatively contained by hyperparasitic fungi, *Septofusidium elegantulum* or *Acremonium alternatum* (Warwick *et al.* 1998). There is nothing to indicate that they are present in the other countries in the zone. Possible transmission of this fungus by pollen has been suggested, although not proven. In any event, based on the available information and given the lack of any effective control method, they have to be considered as quarantine organisms, be it via pollen or seeds.

Hartrot disease occurs sporadically in Sergipe. With the exception of Trinidad and Tobago, it has not been reported in the Caribbean zone and therefore could be a threat from Brazil to Cuba, Haiti and Jamaica. Because of its causal agent, which also exists in Grenada on Alpinia, and the economic damage it causes, it should be considered as a potential quarantine organism for those countries and for Mexico. However, its intraphloemic nature ought to limit the risk of transmission by pollen or embryos. Red ring disease, which is endemic throughout Latin America and part of the Caribbean, should not be a major threat provided precautions are taken to eliminate the vector. Dry bud rot, as knowledge stands at the moment, is a juvenile disease with virtually non existent risk of transmission.

Recommendations

The technical directives drawn up by the FAO impose a few basic measures that govern coconut germplasm movements. Among the measures worth noting in particular, is that such movement must be by embryo cultures or pollen, using the techniques described in the recommendations of the FAO.

It is common sense that germplasm should only be collected from healthy palms (not from the ground) at sites free of serious diseases. In that way, movement of partially dehusked and carefully decontaminated nuts, as recommended by the FAO for most fungal diseases, should not involve any major risks of spreading lethal diseases. It is all the more important in view of the fact that very few countries in the COGENT network have embryo culture facilities as yet.

The two ICG host countries, Côte d'Ivoire and Brazil, are countries free from LYD, unlike most countries in the zone they represent.

Any germplasm movement to these two countries must be by pollen or embryo cultures, seeing that LYD propagation is not possible by those pathways. Occasionally, seednuts could also be used provided they are collected from zones free of LYD or Hartrot, as certified by the exporting countries through a phytosanitary certificate after the evaluation of the collection site. If movement is by seednut, particular care must be paid to mites, with fumigation where necessary.

It cannot be ruled out that *Phytophthora* may have an airborne phase during its cycle and contaminate pollen. This hypothesis is difficult to confirm or refute. Pollen preparation does not eliminate the fungi, but the measures recommended by the FAO (inspection and search for fungi on leaving the exporting country and on entering the importing country) should enable checks to be made notably by using specific *Phytophthora* culture media.

Germplasm movements from Brazil to the other countries in the LAC zone must take into account the risks of propagating leaf diseases that are widespread in Brazil. As knowledge stands at the moment, it is not possible to say that the causal agents are not conveyed by seednuts or pollen. Moreover, they are difficult to isolate and culture, which does not argue in favour of the phytosanitary inspection recommended for *Phytophthora*. Embryo culture is therefore recommended for germplasm exported from Brazil.

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