Cocoa Protection by Quarantine

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Wherever cocoa is grown farmers are burdened by diseases and pests. However the situation is nowhere as bad as it might one day become, because not one of the major troubles is yet pan-tropical in distribution.

Diseases can however be spread by the movement of planting material and there are obvious needs for such movement either for planting in new areas or for plant breeding purposes. The purpose of this paper is to examine the risks attached to the movement of planting material and the quarantine measures designed to minimise those risks.

Diseases and pests to be restricted

The following notes on major diseases and pests will explain the need to restrict their geographical spread. Witches' broom, Moniliasis and probably Ceratocystis wilt are restricted to the Americas, in or near the centre of origin of cocoa. Other diseases have not reached the Americas. Black pod is described as a special case.

Witches' broom

Crinipellis (Marasmius) perniciosa is endemic on cocoa in the Amazon basin where the tree and fungus presumably evolved in close proximity. Its present distribution is limited to Surinam, Guyana, Peru, Ecuador, Colombia, Venezuela, Trinidad and Tobago, Grenada, and the northern and western parts of Brazil including Rondonia and Belem, but not Bahia. It is unknown in the "Old World" tropics.

Losses from witches' broom are difficult to assess, but up to 70% loss of pods has been reported in areas that are particularly suitable to the fungus, and persistent attacks may cause a farm or an area to go out of cocoa production. Spraying with a protective fungicide is not very effective because of the need continually to protect young tissue.

Basidiospores of *Crinipellis perniciosa* are produced in great quantities from mushroom type sporophores on dead brooms. They are small, delicate, and adapted for infecting young tissue of nearby trees after transport by light winds at night in rain forest. But they are tender and unlikely to survive transport by wind for more than a kilometre or two. The danger of spreading witches' broom to new areas therefore lies in infected budwood, rooted cuttings and infected pods. The possibility that the pathogen may also be seed borne cannot be dismissed (1). Every effort must be made to prevent the witches' broom fungus from reaching the major areas of cocoa production, and well organized quarantine services are essential.

Moniliasis. Monilia pod rot, caused by the little known fungus *Monilia roreri* is confined to the north west corner of South America; Ecuador, Colombia and Venezuela, with some overspill into Peru and Panama. Its spores are robust, long-lived, dry, powdery and apparently well-fitted for dispersal by wind.

Economically it is a serious disease where it occurs, and up to 80% of pods may be lost, – a scale of loss comparable with *Phytophthora palmivora* and *Crinipellis perniciosa* at their worst, and enough to deter farmers in badly affected areas from growing cocoa. In the world context the current annual loss from Monilia is small but potentially the danger is enormous.

Ceratocystis Wilt. One popular name for this disease, "mal de machete", gives a clue to the danger of infection through wounds, initiating what has been described as the *Xyleborus-Ceratocystis* complex because of the close association of the fungus with bark beetles.

The affected tree dies suddenly, the leaves wilt and droop, roll up and turn brown. Sudden death follows invasion by bark beetles (*Xyleborus* spp.) which inoculate the tree with the fungus, *Ceratocystis fimbriata*, although the tree is often first infected through man-made wounds. The disease is a major trouble in the areas infested, but its incidence varies greatly at different times. The areas worst affected are in Central America, the Caribbean, and the northern parts of South America. It is also reported from the Philippines, Sri Lanka and Fiji.

Significantly, the disease is not reported from Africa, and the reason for this is not apparent. The pathogen, *Ceratocystis fimbriata*, is widely distributed through the tropics and sub-tropics on many hosts, including *Hevea* rubber and *Crotalaria juncea* in West Africa. These facts suggest (though there is as yet no experimental proof) that some races of *Ceratocystis fimbriata* are pathogenic to cocoa whereas others are not.

The possibility that races differ in aggressiveness gives added support to the plea for quarantine precautions. The beetle vectors are also more widely distributed than the disease on cocoa.

The disease is difficult to control. Judging from the literature, neither sprays nor sanitation have been useful in controlling the disease which breaks out sporadically. Saunders (6) sums up the position: "Control measures have not been satisfactory and most are economically impractical". He estimates that millions of trees have been killed by the disease. Quarantine measures are essential. Imle (4) recommends that budwood should be taken only from symptomless trees without internal discolouration, and should be surface sterilized. As Scolytid beetles are vectors of the fungus, packages should be fumigated and all packing material destroyed on arrival.

Cocoa swollen shoot and other virus diseases

The viruses of cocoa include: cocoa swollen shoot virus, cocoa yellow mosaic virus, cocoa necrosis virus, Ceylon cocoa virus and cocoa Trinidad virus. Swollen shoot is economically the most important. It is known in the Ivory Coast, Ghana, Nigeria, Sierra Leone and possibly occurs in Sri Lanka. In

Ghana and Nigeria millions of trees have been either killed by the virus or felled during eradication campaigns: in some areas the disease is apparently out of control and other areas have been abandoned.

Symptoms of cocoa swollen shoot virus vary from one isolate to another: some have little effect but most of the milder isolates depress yield, and some severe strains can kill the tree in a couple of years. The swellings on shoots or sometimes roots, which give the name to the disease, may not be present. More characteristic are the leaf symptoms which vary with stage of infection. The virus has a wide host range, especially in the Sterculiaceae and Bombacaceae where it infects *Adansonia, Bombax* and *Ceiba* spp. Tall shade trees are often affected.

Local spread is by mealy bugs, either wind-blown or carried by ants. Evidence is against seed transmission but the virus has been found in the seed testa, therefore seed from an infected area should be peeled. The movement of budwood or seedlings could take the virus into a new area.

Vascular streak dieback

Among various types of dieback, the one caused by a new species of basidiomycete, *Oncobasidium theobromae*, was identified as a distinct disease in Papua-New Guinea as recently as 1971. Later it was found in West Malaysia where a severe dieback had been known since the 1950s. The fungus evidently encountered its new host after cocoa cultivation had spread into the south-east Asia and Pacific areas.

Minute colourless basidiospores are released into the air at night. They are tender and must germinate rapidly to infect leaf surfaces, but symptoms do not appear until some three months later. Seedlings infected below the jorquette are usually killed. Viable inoculum travels only short distances on the wind. Normally, infection will be carried to new areas by human activity. We do not know whether the pathogen can infect other hosts in nature, and the disease deserves continued study and watchfulness.

The disease may possibly occur, still unrecognised, in other areas, but until more is known of its distribution the pathogen will have to be considered when propagating material is moved out of the known affected area.

Black Pod

Unlike other major cocoa diseases, cocoa black pod, caused by a pathogen broadly labelled "*Phytophthora palmivora*", occurs in all countries where the crop is grown. Not all areas are seriously affected: for instance the disease is of small importance in much of the Ivory Coast, Malaysia, and parts of Ecuador and Colombia. By contrast in some areas losses may account to 70–80% if the crop is unprotected. Ten per cent annual loss of the world crop is often quoted but is probably an underestimate. This may be translated as 150,000 tonnes, worth perhaps £300 million annually.

Quarantine against "*Phytophthora palmivora*" might seem superfluous in view of its pan-tropical distribution. However, evidence is growing that this name includes several distinct species and therefore quarantine measures should be taken in order to prevent the movement of a species or strain to a new area.

At the Cocoa Phytophthora Workshop held at Rothamsted Experimental Station in 1976 we learned to distinguish several "morphological forms": M.F.1 is typical of Ghana, much of the Caribbean and Central America. In Nigeria M.F.1 is of little importance but M.F.3 can be devastating. In Bahia both M.F.1 and M.F.4 are important. Further, we already know that these forms or species differ in epidemiology, indicating that control measures will also have to be studied separately in the different cocoa-growing areas.

The existence of these different species may account for some of the discrepancies reported from different countries when certain cocoa cultivars are tested for resistance against local isolates of *Phytophthora*.

Consequently it will not only be necessary to test new cultivars against local isolates of *Phytophthora* in each region, but it is also clearly essential to avoid introducing new forms of the black pod pathogen even into areas where the disease is already established.

Cushion gall diseases

Knowledge of the five kinds of cushion gall as distinguished by Hutchins (see 8) is still far from satisfactory. Green point gall is associated with strains of the fungus *Calonectria rigidiuscula*, but the etiology of other kinds of cushion gall needs more research. Losses through suppression of flowering can be considerable. Because of the danger of transporting gall diseases, Hutchins (3) recommends that propagating material should be taken only from gall-free trees and should be surface sterilised.

Trachysphaera fructigena

Mealy pod is a minor disease which accelerates rotting of pods damaged by vertebrates, and is confined to Africa, where it also causes one form of banana fruit rot. This organism should be watched for in quarantine, both because of its nuisance on cocoa and its potential danger to banana growers.

Insect pests

Because of their size insect pests should be easier to exclude from transported material by visual inspection than are microbes and viruses. However, some first instar crawlers of mealy bug virus vectors are hard to detect by visual inspection, and routine treatment with contact insecticides and fumigants is necessary when introducing propagating material.

Several species of mirids, including *Sahlbergella singularis* and *Distantiella theobroma* are damaging in West Africa but absent from America where they are replaced by species of *Monalonion*. Some mirids exist in more than one race, differing for example in resistance to insecticides. Breeding material should be treated with suitable insecticides and all packing material destroyed on receipt. This procedure would also exclude bark beetles (*Xyleborus*) vectors of *Ceratocystis* wilt, and Lepidopterous pests, including the cocoa moth, *Acrocercops cramerella*, which can limit cocoa yields in the Orient but is absent from Africa and America.

To sum up, of all the pests and diseases mentioned top priority must be given to preventing witches' broom, Monilia pod rot and Ceratocystis wilt from extending their geographical range, and to preventing swollen shoot and vascular streak dieback from reaching the Americas. Some pathogens require the presence of an alternate host to complete their life cycle. But as far as we know *Crinipellis*, *Monilia* and *Oncobasidium* do not require an alternate host, so it must be assumed that none of these pathogens are tied geographically to a part of the world where some particular species of flowering plant grows, and there is therefore nothing to stop these fungi from attacking cocoa anywhere when conditions are suitable – once they arrive. Our strategy must aim at delaying their arrival for as many years as possible. And this demands the provision of safe, easily available and acceptable quarantine procedures to prevent spread.

Winds will carry the main cocoa pathogens over short distances, but the great distances separating the world's major areas of cocoa production seem to form insuperable barriers to unassisted spread. Quarantine arrangements should prevent human negligence from transporting inoculum across these great distances. The traveller must still be responsible for disinfecting his clothing and baggage.

Genetic material and disease transmission

Genetic material of cocoa may be moved in the form of mature pod, beans, budwood or even occasionally pollen. Procedures for transporting such material and ways of propagating it are described by Soria (7). The risks attached to these different forms will be examined. Mature pods are not a safe method of moving seed because they could carry insect pests unless fumigated, or fungal spores; in addition, when viruses occur they can be carried in the pod husk.

Cocoa beans are a relatively safe means of transmitting genetic material but there is evidence that witches' broom may be carried by beans so that beans should not be moved from witches' broom areas unless through a quarantine procedure. There is no evidence that swollen shoot virus is seed borne but beans from virus infected areas should be peeled, a procedure which reduces the risk of transmission of any pathogen from any country.

Budwood is a common means of moving selected planting material, but, even with the greatest care, there is some risk of transmitting a disease. Therefore budwood must be passed through a quarantine station on its way from one cocoa growing area to another.

Rooted cuttings or potted seedlings present much greater risks of moving pests or diseases and these methods should never be used. The movement of pollen from one country to another has been undertaken occasionally because it

is possible to retain its viability for relatively long periods but generally there is little cause to resort to it. It involves some risk of transmitting disease such as Monilia or witches' broom.

Quarantine procedure

The relevant principles for cocoa quarantine are expounded by Hewitt & Chiarappa (2).

Export of cocoa propagating material demands thorough inspection in the country of origin, followed by quarantine at an intermediate quarantine station.

Facilities for this may exist within the tropics reasonably far from growing cocoa, as at Mayaguez in Puerto Rico, but for safety the material should be held at an intermediate station in a temperate country, for instance at Kew, Washington, D.C., Miami or Wageningen.

Essentially the method is that recommended by Thresh (9). Batches of Amelonado plants (still the best known virus indicator plant) are raised from seed in pots in the glasshouse or screenhouse. Selected, surface sterilized budwood sent from the donor country (e.g. Trinidad) is budded to decapitated seedlings. Health of scion and indicator shoots growing from the Amelonado rootstock is checked weekly for virus symptoms. Any iron or manganese deficiency is corrected, and insect or mite infestations are controlled. For further safety the scion should be topworked later with an Amelonado bud. If free from symptoms after three or four leaf flushes, budwood is sent to the recipient country, where it should be re-quarantined in a screenhouse before release.

This procedure should exclude the major virus diseases, fungal pathogens and insect pests, as well as preventing spread of nematodes and minor pathogens. But it has been known to fail with some mild viruses. Legg (5) records how clonal material after years at an intermediate station first developed symptoms of mild virus infection sixteen months after import into Ghana, and that there was circumstantial evidence that the virus was alien. Improved methods of detecting virus infection, and better indicator plants than Amelonado are needed.

Careful inspection by technically qualified workers is necessary at all stages, first during selection of material and its export from the country of origin, again while in intermediate quarantine, and again while under test in local quarantine before release to the field in the receiving country. This may involve training personnel to recognize alien diseases.

Any quarantine system must be readily accessible. If too cumbersome, then safety precautions may be by-passed with consequent international risk. The greatest danger is probably from reckless clandestine transport of materials by persons not understanding the consequences. The two competing requirements of security and gene-flow must be kept in mind.

To prevent the spread of swollen shoot virus, cocoa genetic material should not be exported from West Africa. Further, other plants belonging to the families Sterculiaceae, Bombacaceae and Tiliaceae are potential carriers of swollen shoot virus, and their export should be strictly controlled. Especially is this necessary with *Cola* spp. if this is cultivated as a beverage in America. The possibility of having to protect cocoa from cola infected with swollen shoot virus, and to protect banana plants from cocoa infected with *Trachysphaera fructigena*, points to the need to look beyond the individual species in planning quarantine measures.

Living cocoa material should never be transported back towards the South American centre of origin of *Theobroma*, and in any case such transport seems superfluous. Equally, careful quarantine is needed to ensure that new pathogens are not imported into Africa. It is safer to move germplasm *within* Africa, rather than risk importing it a second time from America. Migration of *Monilia* or witches' broom eastwards or of swollen shoot westwards could be disastrous for the industry. Adding another major disease to a grower's problems would probably turn him against cocoa by making the crop unprofitable and troublesome.

In the future micropropagation techniques may speed up breeding, and also provide pure culture collections of cocoa germplasm in test tubes, compact to store, easily kept free from pathogens, and convenient to transport. These possibilities are being examined in Kew and in the United States.

Meanwhile collections must be maintained as trees in plantations, and their protection by quarantine remains essential.

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