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Symptomatology of *Phytophthora* canker of cacao following river flooding

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Abstract

Cocoa plantations on the banks of the River Doce and River São Mateus in the State of Espírito Santo and River Jequitinhonha in south Bahia were flooded for many weeks after abnormally heavy rains in the hinterland of southeast Brazil between late 1978 and early 1979. Immediate loss of trees was attributed to physiological effects of inundation and physical damage by uprooting.

However in late May 1979, as the rivers were subsiding, investigation into reports of tree mortality showed a severe outbreak of canker on the affected trees caused by Phytophthora palmivora. Certain symptoms of the disease hitherto not reported, are now documented.

Key words: Theobroma cacao, Phytophthora palmivora, canker.

Sintomatologia do cancro de *Phytophthora* do cacau após inundação fluvial

Resumo

As plantações de cacau nas margens do Rio Doce e Rio São Mateus no Estado do Espírito Santo e do Rio Jequitinhonha no Sul da Bahia ficaram muitas semanas inundadas, após uma anormal queda de chuvas na região sudeste do Brasil no período compreendido entre fins de 1978 e início de 1979. De início as perdas de árvores foram atribuídas a efeitos fisiológicos da inundação e danos físicos por tombamento.

Entretanto, em maio de 1979, quando os rios desceram de nível, as investigações relativas à mortalidade das árvores mostraram uma severa incidência de cancro sobre as árvores, causado por *Phytophthora palmivora.* Alguns sintomas da doença, que até o momento não tinham ainda sido registrados, estão agora documentados.

Palavras-chave: Theobroma cacao, Phytophthora palmivora, cancro.

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Introduction

Canker of the cocoa tree caused by *Phytophthora palmivora* was recorded by Porter as early as in 1833 (15), who described that "trees in bearing had lesions, indicated by black spots or blotches on the bark". Between 1892 and 1907, Rorer (17, 18) and Nowell (11) noted the occurrence of cocoa canker in many parts of the world, displaying itself in various degrees of severity. Though Thorold (19) implied that canker has not been the cause of much concern in West Africa and Brazil, Dade (6, 7) described cushion infection and occasional canker involving large areas of bark in Ghana and Bondar (2), Lellis (10) and more recently Rocha and Ram (16) described isolated incidences of cocoa canker in Brazil. The disease has been well reviewed by Firman (8).

As a causal agent of black pod, *P. palmivora* is known to be abundant in cocoa plantations, but its penetration into bark tissue leading to canker has been subject to discussion. Zaiger and Zentmyer (21) refer to mechanical transmission of the pathogen through wounds produced by pruning knives, while others implied wet weather conditions favouring penetration. Pombo in 1810 (12) mentions an incidence of flooding that caused the loss of plantations in the river basin of Magdalena in Colombia. A hurricane in 1965 was suspected to be responsible for a canker outbreak in Fiji (1) and Rocha and Ram (16) associated the disease in 1970 to abnormally heavy rains. Drought, inadequate shade and poor soil fertility have also been suggested as predisposing the plant to the disease in Fiji (9).

A severe and extensive outbreak of canker occurred in Brazil, mainly on Forastero "Comum" cocoa, at Linhares in the State of Espírito Santo, and at Belmonte in the State of Bahia, from April 1979. Earlier in the year abnormally heavy rains in the hinterland of southeast Brazil caused a swell in water levels of River Doce and River São Mateus (Espírito Santo) and River Jequitinhonha (Bahia), esceeding the hydrometer level markers by two meters. Cocoa plantations were inundated for a prolonged period, in some places as much as 3 m deep. Many trees were uprooted or partially buried in silt.

A detailed survey of the incidence and its severity was made, with a view to estimating losses, to recommend control measures and replanting. Results of the survey suggest that this outbreak was the severest and most extensive outbreak of canker ever recorded, with approximately 3,000,000 trees dead or dying and 5,000,000 trees requiring treatment (14).

The present paper is a study of the causes of this outbreak and symptoms of the disease.

Symptoms of canker

External symptoms. The external symptoms of cocoa canker that appeared on the main stem were very similar to the typical or classical dark coloration on the outer bark described by Rorer in 1910 (17) as claret coloured. The more or less circular to oblong blotches, present singly or in groups with diffused edges, were also purplish to black in

varying intensities with a relatively dry appearance (Figure 1). In the early stages of infection the disease was difficult to detect, as it blended with the natural background of bark mottling and epiphytic growth. However, where a profuse growth of green moss existed the infection killed the moss, demarcating itself as a "scorched" area in clear contrast. The number of such discoloured patches varied from one to more than 50 scattered on the main stem, with many more in the branches or joquettes.

Figure 1 – Typical external symptoms of canker on the trunk.

At a slightly more advanced stage of the infection a reddish fluid was seen exuding from the bark, drying to a reddish brown deposit. The liquid was oozing through bark cracks that led to canker inside. The bark around the cracks was depressed into lens-like areas, about four times their breadth.

An additional symptom that may be best described as "button bulge" was manifested as water soaked, spongy protuberances up to one centimeter above the surface of the trunk (Figure 2). Thumb pressure on them also yielded the above reddish brown exudate.

Figure 2 – "Button Bulge" symptoms on the bark.

Another symptom that invariably led to an extensive canker inside was vertical bark cracks on the lower portion of the trunk up to about 50 centimeter in length, often over the trunk's entire circumference and appearing as a dark coloured girdle (Figure 3). These cracks were normally within about 1 m from ground level just below the water mark left by flood water.

Figure 3 – Bark cracks resulting from flood-water providing infection sites.

Figure 4 – Fruit bodies of the saprophytic *Kretzchmaria* sp. growing on canker.

Large quantities of vegetative debris brought by movement of water were accumulated around the collar region. Advanced stages of large cankers were invariably concealed below this debris. Peeling and decaying bark of brown to black colour, with infection often extending below ground level, was the most severe stage of cankers observed (Fig. 4). Vivid black fruiting bodies of the saprophyte *Kretzschmaria* sp. were always associated with such cankers (Figure 5).

Figure 5 – A large canker on the collar extending below ground.

Infection of branches and jorquettes was abundant. While external symptoms on the main trunk may not coincide with dieback until advanced stages, infected branches or jorquettes were quickly girdled due to their relatively small diameters, resulting in early dieback.

Internal symptoms. The internal symptoms were invariably displayed over a much larger area than suggested by the external symptoms. The size of cankers on the trunk varied from a centimeter in diameter to complete

ringing ot the stem even up to 3 m above ground. This is in agreement with Briton-Jones (4) observations that *P. palmivora* spreads more rapidly in the inner cortical tissues and the cambium than in the outer bark. Removal of the outer bark around infected areas revealed uninfected pink inner bark with a dark line separating healthy tissue from the violet infected tissue (Figure 6). Slices progressively cut inwards from bark to wood occasionally revealed infected outer bark, phloem, cambium, sapwood and heartwood, but the infection usually stopped short of heartwood.

Figure 6 – Exposed lesion after removal of bark.

Removal of normal bark without visible external symptoms sometimes showed cortical tissue to be infected, which did not originate from a flower cushion, and indeed flower cushions were not always a source of infection. However, the peduncle was found to be the origin of infection in some cases. Here two distinct types of infection were recognised. In one, colonization was through the bark of the peduncle, infecting a roughly circular area just facing the peduncle of an infected or mummified pod (Figure 7). The medullary rays were clean in contrast to the surrounding infected tissue. In the second type, infection entered through the medullary rays of the peduncle, penetrating deep into the xylem (Figure 8). These descriptions agree with those of Rorer (17) and Dade (7). The medullary ray infection appeared to be less destructive than infection through the bark of the peduncle.

In the hundreds of cankers that were examined, a truly active early stage

Figure 7 – Infection through the bark of the peduncle.

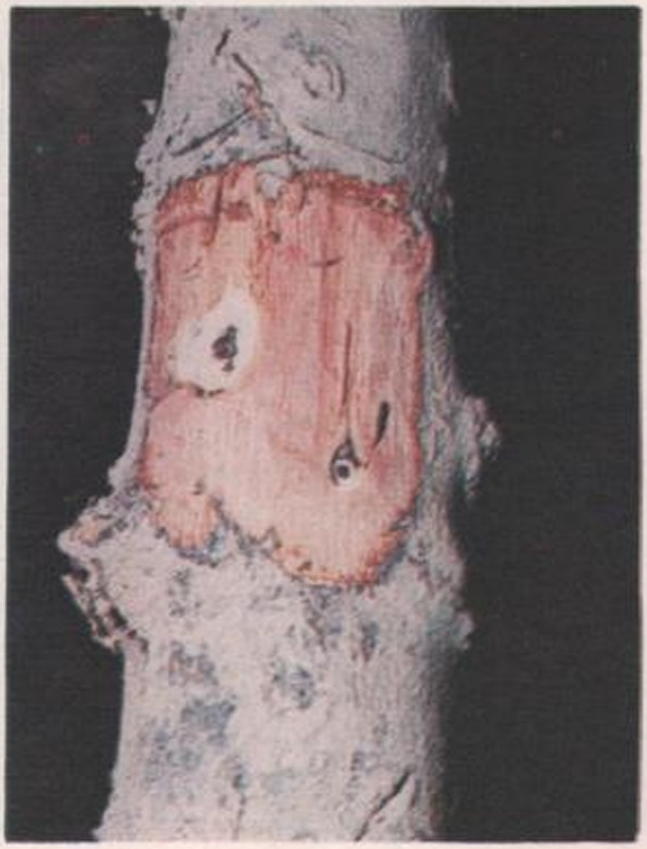

Figure 8 – Infection through the medullary rays of the peduncle.

appeared to be one that had a large volume of liquid (up to 30 ml) entrapped between the periderm and probably the cambium or sapwood, occupying the areas of the degraded phloem (Brooks and Guard (5) considered that the cambium was difficult to identify). On removal of the periderm the liquid squirted out at high pressure. It was of a clear yellowish colour unlike the ooze previously mentioned. The wall of the pocket was lined inside by a layer of suberized cells (Figure 9).

Cankers with bark peeling away in the collar region, as well as those with vertical cracks on the bark over the entire circumference of the trunk, were subsequently completely ring-barked up to about 2 m from ground level. In the latter case, extensive areas of blackish infected tissue were invariably seen below the bark.

Figure 9 – Entrapped fluid squirting out on the bark.

Discussion

Phytophthora diseases of cocoa in Brazil have been atributed to *P. palmivora*. However recent work on three isolates obtained from areas in Espírito Santo and Bahia have shown that one of them may be a different species, while the others are morphotypes (MF_1 and MF_4) of *P. palmivora* (Anna Maria F.L. Campêlo pers. comm.). No attempt was made to obtain specific identification of *Phytophthora* as proposed by Brasier and Griffin (3), and *P. palmivora* is used in this text.

The outbreak of canker coincided with the period, of higher black pod

disease incidence in the areas and the pathogen was also present in cocoa husks piled up in the fields. Water-logged conditions, movement of flood water and water splash are among the factors that contribute to dissemination of pathogens over the bark surfaces or the infection court (13). A diseased pod no doubt provides both inoculum and entry point into branches via the peduncle for the pathogen. Although some cankers were observed immediately facing the peduncle supporting a mummified pod, this was not the commonest symptom observed. Floral cushion are another entry point to be expected (20). In fact, previous workers placed emphasis on infected floral cushions being an important source of inoculum. The "button bulge" symptom described here did not originate on floral cushions, nor did the protuberances limit themselves to the periderm. It was repeatedly felt that cankers on the main stem were indiscriminately located, and certainly not niche-specific. This was attributed to exceptionally ideal environmental conditions, combined with an over-abundance of inoculum.

The severity of the disease and the various symptoms observed in this outbreak are directly related to flood water movement and prolonged water-logged conditions. The collar canker extending to below the ground level, with leaves, cocoa husks and general vegetative debris accumulated at the base, and the long vertical cracks girdling the main stem, were the most severe manifestations of the disease, directly related to a water-logged situation. They accounted for most of the casualities.

The significance of a pocket of fluid trapped under pressure between the periderm and sapwood was not fully understood. Possibly the high water table that favoured high pathogen activity brought rapid degeneration of the phloem and occupation of the resulting space by vascular fluids. In contrast, trees situated on high ground and therefore exposed only for a limited period to flood water, followed by quick soil drying, had much less canker and the disease was invariably moribund. Indeed, the popular remedy adopted by the farmers in their own expression is "operate and bleed", impliyng cutting away all diseased tissue by surgery and allowing the wounds to dry. This treatment alone may have been adequate to save many trees, without any additional application of fungicide. However, the farmers were recommended to paint opened and cleared wounds with a 2.5% a.i. copper fungicide suspension as a safeguard against recurrence of the outbreak and to eradicate residual infection.

Older trees were observed to be more severely attacked by canker as compared to younger fruiting trees. While lacking supporting evidence, the following observations were made. New plantations probably had lower levels of inoculum normally derived from an accumulation of infected cocoa husks. Also, younger trees had smoother bark with less epiphitic growth and less physical damage resulting from successive harvesting. All these factors

probably contributed to lower infection levels in younger trees.

Cocoa canker has been known for many years in most parts of the world where the crop is cultivated. However this incidence is probably the severest and most extensive recorded anywhere. As expressions of the extreme environmental conditions to which these trees were subjected, some unique symptoms of the disease have come to light. These symptoms are now documented.

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