



VARIABILITY IN FIELD SYMPTOMS OF BLACK POD DISEASE OF COCOA

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Cocoa (*Theobroma cacao* L.) is cultivated in shady conditions produced by over-storey shade trees such as rain forest trees left standing after partial clearing, coconut (*Cocos nucifera* L.), legumes (*Leucaena* sp. and *Glyricidia* sp.), arecanut (*Areca catechu* L.) and oil palm (*Elaeis guineensis* L.). In India, it is mainly cultivated as a mixed crop in existing coconut and arecanut gardens in the four southern states of India viz., Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. It is also cultivated in the shady condition of oil palm plantations in very few localities in Andhra Pradesh. The area expansion of cocoa cultivation is progressing fast. Recent (2016 - 17) reports (<http://dccd.gov.in>) revealed that in the four southern states of India, cocoa occupies an area of 82940 ha with an annual production of 18920 metric tonnes. Among the four states, the largest area under cocoa cultivation is in Tamil Nadu (29205 ha) closely followed by Andhra Pradesh (24156 ha).

The shady conditions in mixed cropping and high density multi-species cropping systems in coconut and arecanut gardens and the dense canopy of cocoa plants coupled with congenial climatic conditions such as heavy rainfall, high humidity and low temperature provide favourable conditions for diseases caused by the straminipile genus *Phytophthora*, the plant destroyer. *Phytophthora palmivora* (Butl.) Butl. is the most destructive pathogen of cocoa in India.. Most *Phytophthora*-related losses can be attributed to black pod disease (BPD) followed by stem canker disease. The severity of this pod rot disease is

increasing vis-à-vis increase in area under cultivation and age of plantation leading to direct loss in production.

In India, BPD is noticed as a serious problem during south-west monsoon period (June-September/October). Pods of all ages are susceptible to the disease. The beans in ripe pod usually escape partly or wholly from infection as the beans get separated from the pod husk on ripening. If the infected Pods are not removed especially during the end of rainy season, they remain on the tree as black mummified fruits with growth of the fungus on the pod surface which appears as dull white powdery coating. In general, the disease can be easily diagnosed in field under natural condition from the chocolate brown coloured lesion with dull white coloured fungal growth (Fig.1). But variability in symptoms of the disease like lesion colour and shape, fungal growth on the lesion and nature of spread of lesion exists in nature due to various factors such as variability in cocoa accessions/cultivars, environmental conditions and pathogen variability. As field diagnosis of the disease is mainly based on symptomatology, it is very much imperative to have a thorough knowledge of the variability in BPD symptoms caused by *Phytophthora palmivora*, the predominant species pathogenic on cocoa in India.

Random surveys were undertaken from July to November for three consecutive years in cocoa growing areas of Kerala, Karnataka, Tamil Nadu and Andhra Pradesh for BPD symptomatology. A

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total of 490 gardens were covered during the survey. Symptoms of BPD as observed in nature were recorded in detail as variability in colour, shape, size and appearance of the lesions were observed in different locations.

Symptomatology

A brief description of different kinds of symptoms noticed in nature during the survey of four states is given below.

1. Based on the constant field observations, various workers reported the natural symptoms of black pod disease. All of them reported the most striking and conspicuous symptom caused by *Phytophthora* species as rotting popularly known as black pod. Chocolate brown lesion starting from anywhere on the pod surface was the usual lesion colour noticed in nature. It mostly started from the stalk end or tip (distal end) of the pod as chocolate brown discoloration and spreads around the pod from extreme proximal or distal end. When the infection initiated from other parts of the pod, the lesion appeared round to elliptical in shape. BPD was observed on Pods of all ages. As the lesion enlarged dull white to white abundant mycelial growth appeared on the lesion surface especially under high humid condition. Microscopic examination of the fungal growth on the external lesion surface revealed the presence of luxurious mycelial growth of *Phytophthora palmivora* with abundant sporangia and chlamydospores. The lesions enlarged rapidly causing rotting of the whole pod including beans. With the progress of infection, the whole pod turned dark brown and ultimately black in colour. (Fig.1). During rainy season, rotting of such pods increased as several secondary invaders viz., fungi (like *Fusarium*) and bacteria started growing on the infected pods. Pods infected at the end of the rainy season turned completely black with dried mass of fungal growth on the pod surface and such pods appeared as dried mummified pods remaining on the tree. (Gregory, 1974; Thorold, 1975; Dennis and Konam, 1994; Chandra Moahan, 2002). But an array of variations in the symptoms of black pod disease (Fig. II, 2-14) from that reported earlier was noticed during the survey.
2. In some of the cocoa accessions where the pods are light green in colour with very smooth and shiny (waxy) husk surface, the lesion appeared as almost round to ellipsoid with even advancing margin. Such lesions when covered the whole pod surface they appeared as reddish brown discoloration of the entire pod with dull white and sparse to moderate (under continuous very high humid condition) mycelial growth on pod surface. Rarely in melon shaped pods with smooth pod surface, abundant mycelial growth of *Phytophthora* was observed on the infected pod surface. Saprophytic growth of other micro-organisms especially fungi in the rotting tissue caused further decay of pods and ultimately the whole pod surface was covered with thick, white, cottony fungal growth of the secondary invaders combined with the growth of *P. palmivora*.
3. Lesion caused by *P. palmivora* was also found spreading continuously in the form of concentric rings of reddish brown and light brown discoloration. The advancing margin of such lesion is almost uniformly and evenly distinct. There was no visible or very negligible mycelial growth of *P. palmivora* on the lesion surface. The rate spread of lesion was as fast as the usual symptoms observed in nature.





4. The cocoa accession with crimson red colour pods like that in red axil or Trinitario type the lesion of *Phytophthora* infection appeared as light to dull black colour with wavy or uneven advancing margin. There was no visible mycelial growth of *Phytophthora* on the lesion surface.
5. Lesion spreading slowly without any particular pattern of spread or shape was observed in pods with thick and dark green coloured husk. Such lesion appeared as brown or dark brown with broadly diffusing (fading) margins. Later such lesions were found spreading irregularly with a dull dark brown to black colour. Negligible amount of mycelial growth of *Phytophthora* was rarely found on such lesions.
6. Light reddish brown lesion with irregular margin was observed in several gardens. Though the lesions were almost round to elliptical, the margins were highly irregular. In advanced cases where the lesion covered more than 50% of the pod area, very sparse mycelial growth was observed on lesion surface.
7. Dark brown to black lesions were observed rarely due to *Phytophthora* infection. The lesion was found spreading very irregularly. When a major portion of the pod surface was covered with the lesion, abundant mycelial growth of *Phytophthora* was found on the pod surface which appeared distinct in the dark brown to black background.
8. In the case of pods with slightly warty surface, soft husk and light green colour (like Trinitario types) the lesion spread was very fast. The colour of the lesion appeared as attractive chocolate brown with abundant woolly mycelial growth of *Phytophthora* which appeared very prominently on lesion surface.
9. Multiple lesions of different lesion colour like light brown, dark brown, black and varying shapes were found in most of the gardens surveyed. But it was not the usual type of disease symptom.
10. Shiny dark brown to black lesion with irregular spread was observed rarely. The lesion margin was highly irregular and fungal mycelial growth was not observed on the lesion surface even after the lesion spreading to a considerable area. Such symptoms were rarely observed on Amelanado types.
11. Very black round to irregular lesions were observed only in few of the gardens surveyed. This type of symptom was not very common. The lesion was found spreading slowly. In the initial stage, the lesion appeared as if painted with black paint on pod surface. Rarely, dark brown discoloration was found along the margin of the black lesion. Mycelial growth on the lesion was not observed in the initial stages of lesion spread.
12. Dark brown to black lesion spreading irregularly without any particular patterns was also observed. The spread of such lesion was not continuous. *Phytophthora* mycelial growth was not observed on the lesion surface. But the lesion gave a variegated appearance of brown, dark brown and black colour interspersed with islets of light green patches of healthy pod surface.
13. When ripe pods were infected, the lesion usually appeared as light brown to brown discoloration. The infection appeared spreading fast. The lesion margin was even to





slightly wavy. There was poor to moderate mycelial growth of *Phytophthora* on the lesion surface. *Phytophthora* infection of ripe pods was always found to be due to delay in harvesting.

14. Infection appeared as small black irregular spot and found spreading irregularly and longitudinally in a zig zag manner. Such adjacent lesions coalesced and formed an irregular network of lesion. Rarely, a very diffuse yellow halo appeared around the irregular lesion. The rate of spread of lesion appeared to be very slow. The infection was observed only superficially on the outer layer of husk. It was not found spreading to the internal tissue.

Isolations of causal organism from the infected pods with the 14 types of symptoms yielded *P. palmivora*. Symptom variability observed during the survey of cocoa gardens in South India may be due to different factors such as clonal variations, microclimate, degree of resistance/susceptibility of the plant etc. Among the 14 different kinds of symptoms of black pod disease observed, one type of symptom appeared to be most interesting from the point of disease resistance. In this case, the lesion spread was very slow or negligible, irregular and superficial on the pod husk. The black irregular linear lesion appeared to be very distinct from all other symptoms. This symptom was observed only in a particular accession in Thrissur district of Kerala. Isolation of causal organism from such lesions also yielded only *P. palmivora*. When this

isolate was wound inoculated on pods of other accessions, it took up infection and showed typical symptoms of black pod disease. On the other hand, when *P. palmivora* was inoculated on pods of this particular accession without wound, it did not show any symptoms of infection. But, it took up infection when wound inoculated by cork borer method. Hence the variation in symptoms observed may not be due to pathogen. Therefore, it may be attributed to the resistance of the accession. This accession was multiplied by soft wood grafting and planted in the field for further studies on its susceptibility to *Phytophthora* infection. The study also reveals the importance of symptomatology in disease diagnosis as well as disease resistance.

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Fig 1. Symptoms of black pod disease





Fig 2 . Variability in symptoms of black pod disease

