Advances in Horticulture Vol. 10 – Plantation and Spice Crops Part 2 (1994). Eds: *K.L. Chadha and P. Rethinam*

Diseases of Cocoa

R. CHANDRA MOHANAN

1. INTRODUCTION

Until quite recently, cocoa plantings have tended to be relatively small, especially when compared with the other plantation crops. With the expansion of area under cocoa and with the increase in age of the plantations, diseases are becoming more important. Loss due to diseases affecting the crop could be one of the most important factors contributing to low yield. Among the many important diseases of cocoa, only a few have been reported from India.

A detailed survey has been conducted during 1980 in the major cocoa growing areas of Kerala, Karnataka and Tamil Nadu states to study the occurrence and distribution of various diseases affecting this crop. Black pod disease, cherelle rot, foliar infection caused by *Colletotrichum*, stem canker, charcoal pod rot and zinc deficiency were recorded as the major problems (Chandra Mohanan and Kaveriappa, 1981). Percentage of cocoa gardens showing different diseases is given statewise in Table 1. The major

Table 1 : Incidence of cocoa diseases in South India (Chandra Mohanan and Kaveriappa, 1981)

Diseases	Kerala			Karnataka			Tamil Nadu			Total		
	a	b	%	a	b	%	a	b	%	a	b	%
Black pod	43	40	93.02	40	37	92.50	8	8	100	91	85	93.40
Cherelle rot	43	28	65.11	40	20	50.00	8	7	87.5	91	55	60.43
Charcoal pod rot	43	10	23.25	40	18	45.00	8	2	25.0	91	30	32.96
Canker	43	14	32.55	40	6	15.00	8	0	0	91	20	21.97
Pink disease	43	2	4.65	40	0	0	8	0	0	91	2	2.19
Vascular streak dieback	43	1	2.32	40	0	0	8	0	0	91	1	1.09
Flowery gall	43	1	2.32	40	0	0	8	0	0	91	1	1.09
Knob gall	43	1	2.32	40	0	0	8	0	0	91	1	1.09
Colletotrichum leaf spot	43	39	90.69	40	38	95.00	8	8	100	91	85	93.40
Zinc deficiency	43	7	16.27	40	9	22.50	8	5	62.5	91	21	23.07

a—Total number of gardens surveyed.
b—Number of gardens with disease incidence.

diseases occurring in India and current strategies for their control have been summarised here.

2. NURSERY DISEASES

Though nursery diseases are very common during south-west monsoon period (June-Sept.) they are of little importance. The severity of these diseases indicates that management practices adopted in the nursery are sub-optimal. Correction of such undering causes usually brings about the economic level of control.

2.1 Seedling Dieback

This disease is severe on younger seedlings and occurs during rainy season. It has been observed in the nurseries of Kerala, Karnataka and Tamil Nadu. The infection starts either from the tip of the stem, from the cotyledonary stalk or from the collar region as dark brown discolouration. It generally starts from the tip of the stem and progresses downwards as dark brown to black, water soaked linear lesions. The lesions also extend to the leaves through the petiole resulting in wilting and subsequent defoliation of the seedlings (Fig. 1). Defoliation and dieback of the seedlings are the symptoms of advanced stages of the disease. The infection initiating from the cotyledonary or collar region is also found spreading upwards and downwards causing wilting, defoliation and ultimately death of the seedlings (Chandra Mohanan, 1979).

Fig. 1 : Seedling dieback in cocoa.

Seedling dieback is caused by the fungus *Phytophthora palmivora* (Butl.) Butl. The disease may be controlled by improving the drainage in the nursery and by drenching the seedlings with bordeaux mixture (1%) or any other copper oxychloride just before the onset of monsoon and thereafter at frequent intervals. All the infected and dead seedlings should be removed from the nursery and destroyed. A combination of seed dressing and soil drench with Kocide at a concentration of 0.91 kg in 45 l of water has been found to be very effective in controlling pre- and post-emergence seedling deaths

caused by *P. palmivora* (Asare-Nyako *et al.*, 1972). However, very little work has been done on *Phytophthora* infection of cocoa seedling and, therefore, it needs further investigations.

2.2 Other Diseases

Foliar infection caused by *Colletotrichum gloeosporioides* Penz. is also common in nurseries. This fungus causes blight or 'shot-hole' symptom on flush leaves. Recently, severe incidence of white thread blight caused by *Marasmius scandens* Massee leading to dieback of 6 months old seedlings was observed in one of the nurseries in Karnataka during the rainy season of 1990. High humidity and less aeration and sunlight due to thick shade are found to be the pre-disposing factors for the occurrence of white thread blight disease.

3. POD ROTS

Among the diseases affecting cocoa pods only very few have been reported to be of any serious proportion in India. Pod rots caused by *P. palmivora, C. gloeosporioides* and *Botryodiplodia theobromae* Pat. have been recorded as the major diseases. Diseases of cocoa caused by *Phytophthora* are common in most cocoa growing countries (Thorold, 1975). In India too, *P. palmivora* is the most destructive of all the other fungal pathogens of cocoa.

3.1 Black Pod Disease

Black pod disease was first reported from Guyana and West Indies by Jenman and Harrison in 1897. Since then it has been reported from various cocoa growing countries. Even though the occurrence of *P. palmivora* was confirmed earlier on several hosts, black pod disease of cocoa was reported for the first time from India in 1965 (Ramakrishnan and Thankappan).

The disease occurs in the rainy season (June-September) when the humidity is high with a constant low temperature. Pods of all ages are susceptible to the disease. The infection appears as one or more small, chocolate brown, circular lesions anywhere on the pod surface. The lesions increase rapidly and cover the whole pod surface. As the lesion advances, a whitish growth of the fungus consisting of mycelia and sporangia is produced over the dark brown pod surface (Fig. 2). Ultimately, the whole pod and beans are invaded by the fungus and the pod turns black in colour. Hence, the name black pod disease. The beans in a ripe pod may escape partly or wholly from infection as the beans get separated from the pod husk on ripening.

The disease spreads rapidly under conditions of high rainfall and long periods of high humidity. Sporangia of the fungus are produced abundantly on the infected pods (Fig. 3). They are spread by rain splashes, insects and rodents. In the presence of water, sporangia germinate and produce zoospores. They swim in water and eventually come to rest and germinate. The germ tubes penetrate the pod tissue and typical

Fig. 2 : Black pod disease : Note the whitish growth of the fungus, *Phytophthora palmivora*, on the dark brown pod surface.

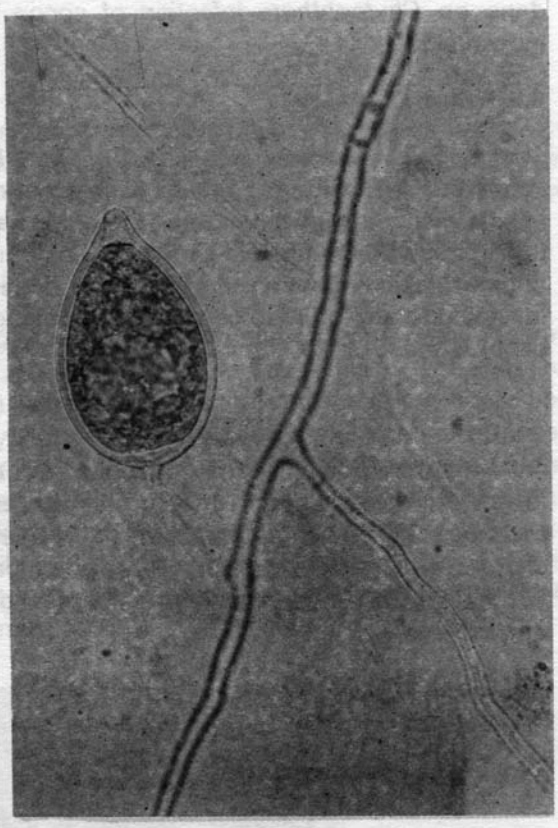

Fig. 3 : Sporangium of *Phytophthora palmivora.*

symptoms appear on the pod surface within a few days of infection (Gregory, 1974; Thorold, 1975).

Padwick (1956) estimated the losses due to black pod disease as 10 per cent of world production. It may be much more now as the intensity of the disease increases with the expansion of planting. Disease incidence vary annually. From the districtwise distribution of cocoa diseases and the percentage of garden showing disease incidence in India, black pod has been found to be the most important cocoa disease in this country (Chandra Mohanan and Kaveriappa, 1981). Based on the studies in five unsprayed cocoa plantations in Dakshina Kannada district of Karnataka state, Chandra Mohanan (1985) reported that black pod incidence varied from 12.93 to 29.78 per cent and it was 22.83 to 40.84 per cent on nearly mature pods alone. The disease incidence varies from locality to locality as well as from garden to garden. The intensity of black pod may increase year by year with the inoculum build up in the garden and become increasingly severe as the tendency is to plant higher yielding material. The disease will become more serious, if the new planting material is more susceptible than existing types.

3.1.1 *Etiology*

Black pod disease is caused by the fungus *P. palmivora*. From the detailed studies on the morphological characters of the fungus collected from various localities, Sreenivasan and Chandra Mohanan (1984) concluded that the *Phytophthora* inciting black pod disease and chupon blight of cocoa and the *Phytophthora* present in cocoa soils in D.K. district of Karnataka state is *P. palmivora*. *P. palmivora* was the only species recognised as the causal organism of black pod disease until 1975. Work done in other countries revealed the existence of five more species, viz., *Phytophthora megakarya, P. palmivora* MF_4 (=*Phytophthora capsici), Phytophthora citrophthora, Phytophthora megasperma* (Zentmyer, 1987) and *Phytophthora katsurae* (Liyanage and Wheeler, 1989) as the pathogens of cocoa. But *P. palmivora* is the only species so far reported on cocoa from India. Further investigations are in progress to find out the *Phytophthora* species associated with cocoa in the cocoa growing areas of India.

3.1.2 *Control*

Though black pod disease is one of the major constraints in cocoa production in India, very limited work has been done on the control aspects in this country. Spraying with a fungicide is the present measure when control of black pod deemed necessary. For over 80 years, fungicide trials to control black pod disease have been carried out. The most popular method of control of black pod has been by spraying fungicides. This method has proved difficult because of the heavy rainfall in cocoa growing areas. Breeding for resistance appears to be the most practicable approach to solve this problem. However, at present, the following control measures may be adopted to reduce the disease intensity.

3.1.3 *Removal of Diseased Pods*

Since the infected pods will form the main source of secondary spread, all disease affected pods should be cut and removed at weekly intervals during the rainy season. The infected pods should be dumped into disposal pits and covered with soil. This will help to reduce the spread of the disease to a great extent. If the diseased pods are not removed, it is difficult to get better control from fungicide application alone. Since high humidity and low temperature are favourable for disease development, cocoa should not be planted very closely. Proper pruning of cocoa plants is also very essential to minimise the shade.

3.1.4 *Chemical Control*

Copper fungicides, such as bordeaux mixture, copper oxychloride, cuprous oxide or copper hydroxide are generally recommended for the control of black pod disease. Spraying the pods with bordeaux mixture (1%) or any other effective copper fungicide may be taken up just before the onset of monsoon and thereafter at frequent intervals. Spraying copper fungicide at an interval of two weeks during the peak period

of disease incidence along with weekly removal of infected pods will give better control of the disease.

The results of the field trials conducted in Dakshina Kannada district of Karnataka revealed that spraying of bordeaux mixture (1%) at 15-day interval or higher concentration of copper oxychloride at monthly interval along with weekly removal of infected pods is effective in reducing black pod incidence.

3.2 Cherelle Rot

Rotting of cherelles and young pods was generally considered to be due to physiological factors. But recent investigation showed that a considerable percentage of pod rot of cherelles and young pods is due to *Colletotrichum* infection (Fig. 4). *Colletotrichum* disease of cocoa is wide spread in India.

Fig. 4 : Cherelle rot in cocoa caused by *Colletotrichum gloeosporioides.*

The symptoms of pod rot mostly start from the stalk end, particularly at the point of attachment of stalk to the pod. The infection proceeds towards the tip of the pod as dark brown discolouration with a diffused yellow halo. The infection also extends to the stalk and reaches the cushion, but does not spread further in the cushion. The infected stalk becomes highly shrunken and can be easily distinguished from a healthy stalk. As the infection progresses, the internal tissue of the pod also becomes discoloured. In rare cases, the infection also initiates from anywhere on the pod surface other than stalk region as dark brown sunken lesion. Lesions coalesce and form bigger lesions. Under conditions of high humidity, abundant conidia of the fungus are produced as pinkish slimy mass on the lesions. Ultimately the pod turns dark brown to black and remains on the tree as mummified fruit. At this stage, these pods could be easily confused for pods affected by cherelle wilt, which is a physiological phenomenon.

The physiological wilt begins as a general yellowing of the cherelles followed by browning and blackening. The characteristic dark brown lesion caused by *Colletotrichum* infection is not seen on these pods and thus the cherelle wilt is distinguishable from cherelle rot. *Colletotrichum* pod rot is found only on cherelles and young pods with the maximum incidence on cherelles (Chandra Mohanan and Kaveriappa, 1983). In general, *Colletotrichum* infection on pods is seen during January-May, when the susceptible stages of pods, viz., cherelles and young pods are plenty in the garden. Thus, critical period for disease incidence on pods is February-May (Chandra Mohanan *et al.*, 1989).

Cherelle rot is caused by the fungus *Colletotrichum gloeosporioides* Penz. Microscopic examination of the infected pods reveals the presence of acervuli with setae and abundant conidia of *C. gloeosporioides.*

Bavistin WP (carbendazim) (0.05 per cent) and Indofil M-45 (Mancozeb) (0.2 per cent) were reported as the promising fungicides for the control of *Colletotrichum* infection on cocoa (Chandra Mohanan and Kaveriappa, 1984).

3.3 Charcoal Pod Rot

It is found throughout the year with severity during summer months. Pods of all ages are susceptible. The infection takes place through wounds generally caused by rodents, other pests and insects. The infection appears as dark brown to black spot anywhere on the pod surface and spreads rapidly. As a result of which the pods turn black and remain on the tree as mummified fruits. On the surface of the affected pods, spores appear as black powdery mass resembling soot. The infection spreads to the internal tissue and the affected beans turn black in colour.

The disease is caused by *Botryodiplodia theobromae* Pat. Spraying with one per cent bordeaux mixture is recommended for the control of this disease. Since *B. theobromae* causes infection through wounds, measures to control insects and rodent pests will also help to reduce the incidence (Nambiar and Nair, 1972).

4. TRUNK AND BRANCH DISEASES

4.1 Canker

Stem canker of cocoa is generally observed during December-February after the south-west monsoon period. Incidence and intensity of the disease vary from locality to locality as well as from garden to garden. In nature canker lesions are observed on 2-16 years old plants with varying intensities. Usually the external lesion appears as round to oval, greyish brown or dark brown, water soaked lesion on the external bark of the main stem and branches. A reddish brown liquid oozes out from the lesion which later dries up to form a rusty deposit (Fig. 5). Tissues beneath the outer lesion always appear as reddish brown discolouration due to rotting of the tissue, which can be clearly distinguished from the healthy tissue around the infected area. Presence of cankers

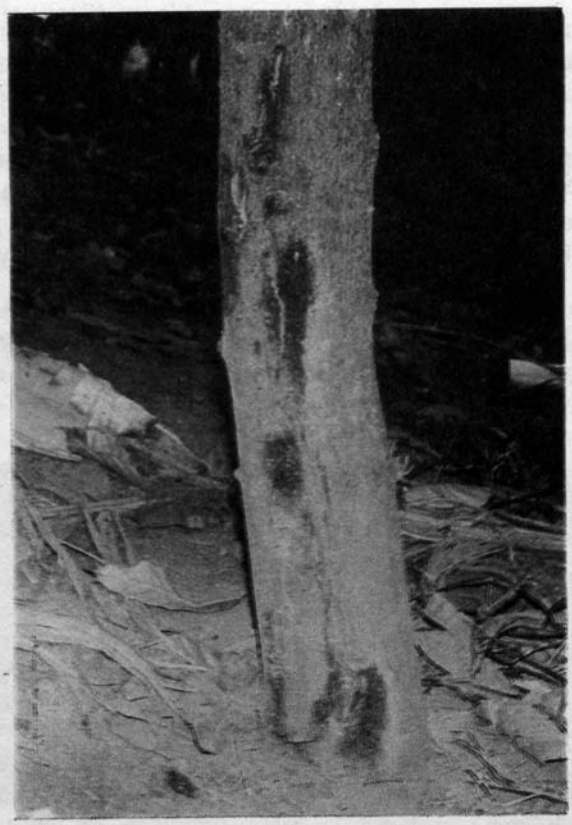

Fig. 5 : Stem canker in cocoa : Reddish brown liquid oozed out from the lesions, dried up and forming rusty deposit.

can be confirmed easily by removing external bark and observing the reddish brown discolouration of the internal tissue (Fig. 6). The internal spread of the infection is always faster than the spread in the outer bark. Infection spreads from the cortical tissues reaching wood. Infection in the wood appears as dark brown to black with black streaks.

Early stages of canker can be identified only by closer examination. When the cankers girdle the main stem or branches, the pods present on the tree wilt, leaves discolour and defoliate. Thus the branches show dieback symptoms and eventually the tree dies. Usually the disease is noticed only in advanced stages, when defoliation and dieback of twigs occur (Chandra Mohanan, 1978).

Based on the detailed studies on the etiology and pathogenicity, *P. palmivora* has been identified as the causal organism of stem canker. Several workers have connected black pod with canker (Rorer, 1910; Briton-Jones, 1934; Thorold, 1955). They found that the infection spreads from the pod to the peduncle, and then to the cushion and bark. Therefore, infected pods should be removed and destroyed. This disease can

Fig. 6 : Stem canker in cocoa : External bark removed to show the reddish brown discolouration of the internal tissue.

be controlled in the early stages by the excision of diseased bark followed by wound sealing with bordeaux paste or any other copper fungicide.

4.2 Chupon Blight and Twig Dieback

Severe infections on chupons and twigs occur during rainy season. Chupon blight and twig dieback are mainly caused by *P. palmivora.* The infection usually initiates in the axils of leaves at the tip of twigs or chupons. It also starts from anywhere on the leaf lamina or petiole and extends to the stem. The characteristic symptom is the appearance of water soaked lesions turning brown to black. When the lesions girdle the stem, the portion above the point of infection dies causing twig dieback or chupon blight. The infection results in severe defoliation (Chandra Mohanan *et al.*, 1979).

The disease can be controlled by removing and destroying the infected twigs and chupons. In cases of severe incidence, the plants may be sprayed with one per cent bordeaux mixture or any other copper fungicide after removing the infected twigs and chupons.

4.3 Pink Disease

This disease becomes severe under humid conditions. It may cause serious damage when major branches are affected. The disease is characterised by the presence of a pinkish powdery coating on the stem.It causes wilting of shoots, shedding of leaves and ultimately drying up of branches.

The control measures include reducing overhead shade, proper pruning to improve aeration inside the garden, pruning of smaller infected branches and fungicidal treatments. The disease can be checked effectively by pruning the affected branches and swabbing the cut ends with bordeaux paste. Its incidence can be prevented to a greater extent by spraying one per cent bordeaux mixture at regular intervals during the rainy season.

4.4 White Thread Blight

This disease has been reported to occur in Kerala and Karnataka states. It is found to be more severe under conditions of heavy rainfall and high humidity.

White thread blight is caused by the fungus *Marasmius scandens* Massee. The white mycelial threads of the fungus spread longitudinally and irregularly along the surface of the stem of young branches and enter the leaf along the petioles. On the leaf lamina, it spreads extensively and forms a much branched system of fine threads. The fungus grows very rapidly on the stem and leaves under favourable condition of high humidity. The fungus invades the cortical tissues which eventually turn dark brown to black. The affected leaves also turn dark brown. Such dead leaves eventually get detached from the stem, but remain suspended by the mycelial thread (Fig. 7). The extensive death of the young branches and suspended leaves in rows are the common field symptoms.

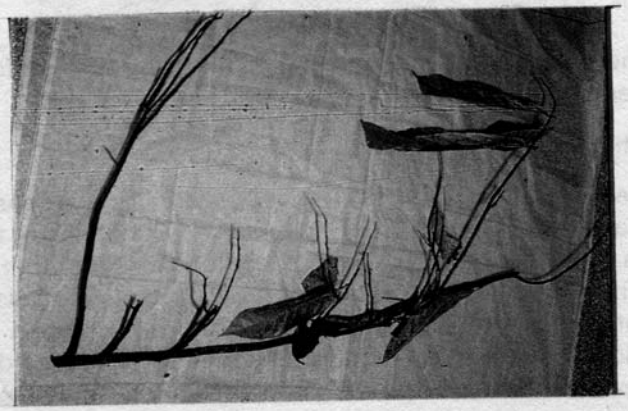

Fig. 7 : White thread blight in cocoa.

The disease generally spreads from plant to plant through the dead leaves with the mycelial mat which are easily carried by wind. Removal and burning of affected plant parts and removal of heavy shade will help in the control of disease.

4.5 Vascular Streak Dieback

This disease is a serious problem in Papua New Guinea, Malaysia and the Pacific Islands. In India, at present, vascular streak die-back (VSD) has been observed in Thiruvananthapuram, Kottayam, Idukki, Kozhikode and Wayanad districts of Kerala state.

The initial symptom of VSD is the yellowing of a single leaf in the middle portion of a twig (Fig. 8a). This leaf is the one in the second or third flush from the tip of the twig. Thus, a single leaf turns yellow with small islets in the lamina remaining green and fall off prior to the older leaves on the same branch. Further, leaves up and down the stem from the first fallen leaf develop similar symptoms and are lost. This leads

to a distinctive appearance where the youngest and oldest leaves are still present but all the middle ones have fallen. At a later stage, dieback symptoms appear on these branches. As the leaf fall progresses, the bark in the leaf fall region of the branch becomes rough due to the swelling of the lenticels. The axillary buds of the fallen leaves sprout and then rapidly die (Fig. 8b). The VSD infection can be easily diagnosed by stripping the bark or by splitting the affected stem longitudinally. The xylem vessels turn brownish which appear as streaking within the vascular tissue. The discoloured vascular traces are visible when the infected leaves are removed. In wet weather, fruiting bodies of the fungus appear as white crust around the leaf scars.

VSD is caused by the fungus *Oncobasidium theobromae* Talbot and Keane (Basidiomycotina : Tulasnellales). The disease is spread by the basidiospores that are carried by wind. The spores that fall on young, tender cocoa leaves germinate and penetrate the tissue and from the leaf the fungus grows into the stem through the veins.

The disease is controlled by regular pruning of infected branches. For this, the branches are split open from the tip to reveal the extent of brown streaking in the wood.

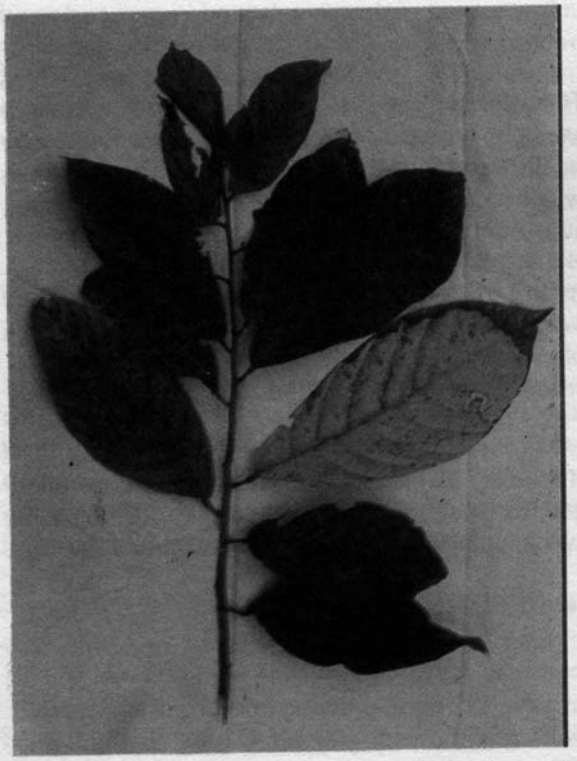

Fig. 8a : Vascular streak dieback of cocoa: Initial symptom—yellowing of a single leaf.

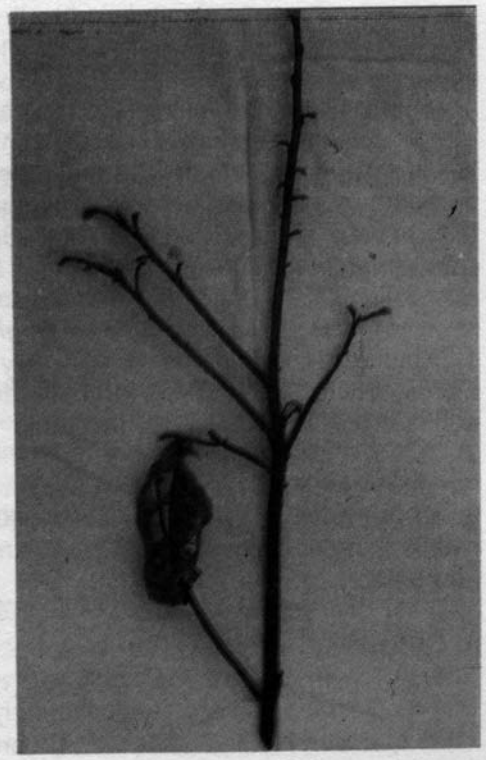

Fig. 8b : Vascular streak dieback of cocoa: Axillary buds sprouted and died.

Then they are cut off 30 cm below the last point of visible streak as the fungus may be present beyond the brownish streaks. Removal of the prunings from the garden is not necessary because the fungus cannot live in dead and decaying plant parts (Prior, 1980).

5. FOLIAR INFECTIONS

Leaf blight and 'shot hole' are the major field symptoms caused by *C. gloeosporioides*.

5.1 Leaf Blight

The infection starts anywhere on the leaf lamina, but more usually from the tips or margins as round to slightly irregular chlorotic spots which later turns to brown with a clear yellow halo. Such spots enlarge or coalesce to form large blighted areas with an even margin. Defoliation occurs when such lesions cover a major portion of leaf lamina. Occasionally acervuli with setae appear as black, erumpent, globular structures on dead blighted areas of the leaves.

5.2 Shot Hole

It is mostly seen on flush leaves. The infection starts anywhere on the leaf lamina as minute, pin point sized, round, sunken, light brown spots with distinct yellow halo. When such spots attain 4-6 mm diameter, the centre of the necrotic area shrivells and drops off forming shot holes. These spots, when enlarge, coalesce with adjacent spots to form bigger spots. Shrivelling of the leaves occurs in advanced stages. In very severe cases, defoliation occurs.

Foliar infection caused by *C. gloeosporioides* is found throughout the year (Fig. 1). But the intensity increases from July following the frequent rains in June and reaches a peak during September-November, decreases thereafter and reaches the lowest level during April-June (Chandra Mohanan *et al.*, 1989).

In nurseries, the foliar infection caused by *C. gloeosporioides* can be controlled by spraying Indofil M-45 (mancozeb) (0.2%) or Bavistin WP (carbendazim) (0.05%). In cocoa plantations, control measures are necessary only if the disease attains a serious proportion.

6. CUSHION GALLS

Cushion gall is a serious malady in several cocoa growing countries. Mainly five kinds of cocoa cushion galls viz., green point gall, flowery gall, knob gall, disc gall and fan gall are recognised (Thorold, 1975). Of these, only fan gall and knob gall are reported from India (Chandra Mohanan *et al.*, 1984).

6.1 Fan Gall

The flower cushions of the affected trees produce profusely branched small stem like outgrowths bearing numerous flowers. The branches of these outgrowths with the flowers are closely packed and appear like a loose gall on a cushion. Occasionally, small leaves are found at the tip of the outgrowths resembling that of a fan branch. The length of each such outgrowth is usually 7-9 cm. Though numerous flowers are produced on these cushions, there is no pod setting.

6.2 Knob Gall

The galls are produced on the cushions as hard woody swellings with a smooth surface and do not bear flowers. Several such galls are found on an affected tree.

The etiology of these two types of galls is not known.

7. ZINC DEFICIENCY

Severe incidence of zinc deficiency leading to foliar abnormality and twig die-back has been observed in certain gardens of Kerala, Karnataka and Tamil Nadu states. Chlorosis of the leaves is the initial symptom of zinc deficiency in cocoa. It appears in patches and in advanced stages the green portion is seen only along the sides of the veins, giving a vein banding appearance. Affected leaves show mottling and crinkling with wavy margin. Most of the younger leaves are narrow and sickle shaped. Twig symptoms include rosette and dieback. Rosette type of growth is due to shortening of internodes. Premature defoliation and dieback of the branches occur in severe cases.

Foliar spray of a mixture of 0.3 per cent zinc sulphate and 0.15 per cent (w/v) lime has been reported to be an effective and quick method of correcting zinc deficiency in cocoa (Chandra Mohanan *et al.*, 1981).

Diseases, such as swollen shoot (virus disease), witches' broom, monilia pod rot and green point gall which are all of fungal etiology are known to occur in severe form in other countries. But these diseases are not seen in India. The possibility of new diseases occurring must also be recognised. Once the pathogen has become established, control becomes more difficult. With the expansion of cocoa cultivation in India, strict quarantine measures may be necessary to prevent the introduction of these diseases.

REFERENCES

Asare-Nyako, A., Amponash, J.D. and Nuamah, G.E.A. 1972. Nursery diseases of cocoa in Ghana. 1. Pre and post emergence deaths of seedlings caused by *Phytophthora palmivora*. *Ghana J. Agric. Sci.*, **5** : 127-33.

Briton-Jones, H.R. 1934. *The Diseases and Curing of Cacao.* Macmillan and Co. Ltd., London. pp. 161.

Chandra Mohanan, R. 1978. Cacao canker caused by *Phytophthora palmivora*. *Plant Dis. Reptr.*, **62** : 1080-82.

Chandra Mohanan, R.1979. Cocoa seedling dieback. *Indian Cocoa, Arecanut & Spices J.*, **3** : 5-6.

Chandra Mohanan, R. 1985. Incidence of cocoa black pod disease in Dakshina Kannada District (Karnataka) —A major cocoa growing area in India. *Indian Cocoa, Arecanut & Spices J.* **8** : 91-92.

Chandra Mohanan, R., Anandaraj, M. and Joshi, Y. 1979. Studies on *Phytophthora* diseases of cacao occurring in India. *Proc. PLACROSYM II*, 1979. pp. 335-42.

Chandra Mohanan, R. and Kaveriappa, K.M. 1981. Occurrence and distribution of cocoa diseases in South India. *Proc. 8th International Cocoa Research Conference*, 18-23 October 1981. Cartagena, Columbia. pp. 445-49.

Chandra Mohanan, R. and Kaveriappa, K.M. 1983. Symptomatology of Colletotrichum disease of cocoa in India. *Planter*, Kuala Lumpur, **59** : 333-38.

Chandra Mohanan, R. and Kaveriappa, K.M. 1984. Efficacy of fungicides to control three virulent isolates of *Colletotrichum gloeosporioides* on cocoa. *Proc. PLACROSYM VI*, 16-20, December 1984, Kottayam, India. pp. 159-69.

Chandra Mohanan, R., Kaveriappa, K.M. and Nambiar, K.K.N. 1989. Epidemiological studies of *Colletotrichum gloeosporioides* disease of cocoa. *Ann. appl. Biol.*, **114** : 15-22.

Chandra Mohanan, R., Menon, M.A., Yadukumar, N. and Naik, B.G. 1981. Zinc deficiency in cocoa : Diagnosis and correction. *Planter, Kuala Lumpur*, **57** : 120-24.

Chandra Mohanan, R., Subramonian, N. and Balasimha, D. 1984. Cushion galls of cocoa in India. *J. Plant. Crops*, **12** : 23-29.

Gregory, P.H. (Ed.) 1974. *Phytophthora disease of cocoa.* Longman groups Ltd., London. pp. 348.

Jenman, G.S. and Harrison, J.B. 1897. Pests affecting cacao plantations. pp. 120-1. In *British Guiana Report* on the Agricultural Work in the Botanic Gardens for the Years 1893-95. Georgetown, Demarara. pp. 127.

Liyanage, N.I.S. and Wheeler, B.E.J. 1989. *Phytophthora katsurae* from cocoa. *Plant Path.*, **38** : 627-29.

Nambiar, K.K.N. and Nair, R.R. 1972. Charcoal pod rot of cacao. *Indian Phytopath.*, **25** : 595-97.

Padwick, G.W. 1956. Losses caused by plant diseases in the colonies. *Phytopath. Pap.*, **I** : 1-60.

Prior, C. 1980. Vascular streak dieback. *Cocoa Growers' Bull.*, **29** : 21-26.

Ramakrishnan, K. and Thankappan, M. 1965. First report of black pod disease of Cacao in India. *South Indian Hort.*, **13** : 33-34.

Rorer, J.B. 1910. The relation of black rot of cacao pods to the canker of cacao trees. *Bull. Dep. Agric.*, Trinidad, Tobago, **9** : 38.

Sreenivasan, T.N. and Chandra Mohanan, R. 1984. *Phytophthora* associated with cocoa in South Kanara district, Karnataka, India. *Trop. Agric.* (Trinidad), **61** : 186-87.

Thorold, C.A. 1955. Observations on black pod disease (*Phytophthora palmivora*) of cacao in Nigeria. *Trans. Br. mycol. Soc.*, **38** : 435-52.

Thorold, C.A. 1975. *Diseases of Cocoa.* Clarendon Press, Oxford. pp. 423.

Zentmyer, G.A. 1987. Taxonomic relationships and distribution of species of *Phytophthora* causing black pod of cacao. *Proc. 10th International Cocoa Research Conference*, 17-23 May 1987. Santo Domingo, Dominican Republic. pp. 391-95.