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Diseases of Spice Crops

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1. INTRODUCTION

Crop loss due to severe disease and pest incidence has been identified as one of the major production constraints in spice crops in India. Disease problems are more serious in black pepper, cardamom, ginger, turmeric and grain spices like cumin and coriander. However, tree spices at present are not having any severe disease problems. In general, majority of the diseases are caused by fungi which are soil-borne. This is further complicated by the involvement of more than one organism in different cropping systems rendering the disease management more complex. Considerable progress has been made in understanding of these disease problems ever since the first review by Chattopadhyay (1967). The research efforts on plant protection of these crops have been only during the last three decades. The disease management of spices has been reviewed recently by Sarma *et al.* (1990). The present status of disease problems of major spices in India, their management and the future thrusts have been outlined. However, the diseases of seed spices have been dealt in a separate chapter.

2. DISEASES OF BLACK PEPPER (*PIPER NIGRUM* L.)

Western Ghats of India is considered as the place of origin of black pepper and the plant has been domesticated as an important spice crop which migrated to other Asian countries like Indonesia, Malaysia, China and also to South American countries like Brazil and Madagascar. As such, in general, the disease problems are also similar in all these countries except for minor variations. Seventeen disease problems have been listed in India both as major and minor. *Phytophthora* foot rot and slow decline (Nair and Sarma, 1988) are the most destructive. Anthracnose and little leaf diseases are becoming increasingly important in certain regions. Black pepper being a perennial crop, disease management in nurseries to ensure healthy and robust rooted cuttings has become very important (Sarma *et al.*, 1988).

2.1 *Phytophthora* Foot Rot

Severe incidence of black pepper vine death was reported in Wynad region of Kerala as early as 1902 (Menon, 1949) and was investigated by Barber (1905) and later by Butler (1918). Though *Phytophthora* isolation from black pepper was reported earlier

(Venkata Rao, 1929), the first authentic report was by Samraj and Jose (1966) who established the pathogenicity of *Phytophthora* in black pepper and adopted the identification of Muller (1936) as *P. palmivora* var. *piperina*. Since then the problem was reviewed by Nambiar and Sarma (1977), Sarma and Nambiar (1982) and disease was loosely referred to as quick wilt disease of black pepper, based on the sudden wilting and death of the vine. However, the terminology of the disease has been changed to *Phytophthora* foot rot (Nair and Sarma, 1988).

2.1.1 *Crop Losses*

The disease is known to occur in all major tracts of black pepper. However, precise crop loss figures are not available except the reported vine death to the extent of 20 per cent in Cannanore (Samraj and Jose, 1966) and 25-30 per cent in Cannanore and Calicut districts (Nambiar and Sarma, 1977). Systematic surveys carried out in Calicut (including Wynad) and Cannanore districts showed crop losses of 119 and 905 tonnes of black pepper per annum with an incidence of 3.7 and 9.4 per cent, respectively (Balakrishnan *et al.*, 1986; Anandaraj *et al.*, 1989) (Table 1).

2.1.2 *Symptoms*

All parts of black pepper are prone to infection and as such both foliar, collar and root infections are known to cause varying degrees of damage (Figs. 1, 2 & 3).

2.1.2.1 *Foliar infection* : Foliar infections are more severe in areca-black pepper mixed cropping system although they are seen in pure plantations also. Dark brown leaf spots ranging from 0.5-3 cm are noticed. The infection starts as water soaked spot on the lower surface of the leaf which later becomes discernable on the upper surface with fimbriate margins and occasionally with concentric zonation (Fig. 4). The lesions later enlarge rapidly involving 25-70 per cent of the lamina. During May-June, with the onset of south-west monsoon, runner shoots arising from the base of the vine are often infected. When the infection occurs on the mature stem, the leaves beyond the point of infection show symptoms of flaccidity and droop. This results in die-back and all the green branches arising from this show typical vertical lines due to shrinkage. Tender spike infection results in spike shedding. The immature berries when infected also results in spike shedding.

Table 1 : Crop losses due to *Phytophthora* foot rot of black pepper in Kerala

District	Period of survey	Total vine deaths	Per cent vine death	Yield loss in MT
Calicut	1982-1984 (3 years)	1,88,947	3.7	119.6
Cannanore	1985-1986 (2 years)	10,16,425	9.4	904.9

Source : 1) Balakrishnan *et al.*, 1986;
2) Anandaraj *et al.*, 1989.

Fig. 1 : Foot rot affected black pepper vine.

Fig. 3 : Root infection culminating in foot rot.

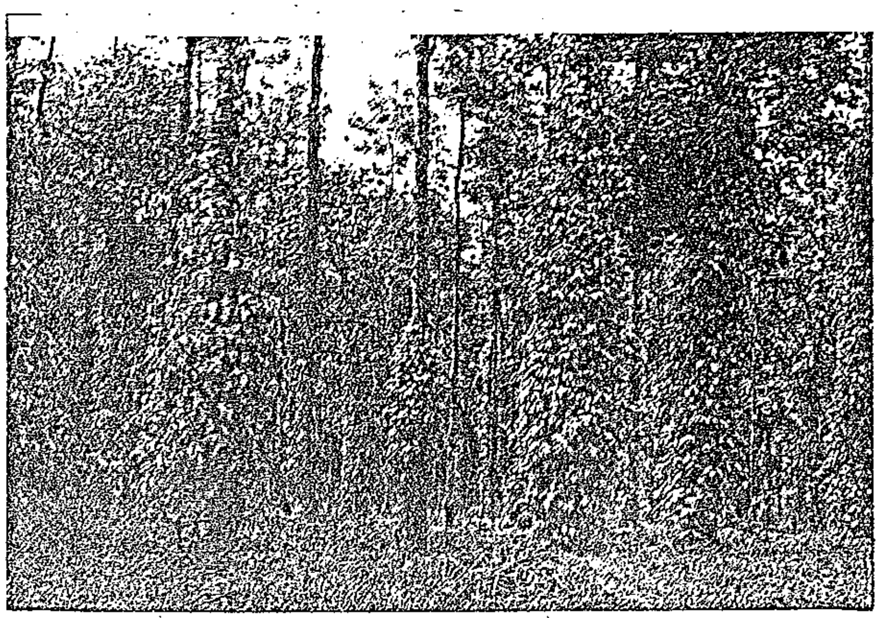


Fig. 2 : Foot rot affected black pepper plantation.

The infected immature berries turn black and dry up. Foliar infection leads to varying degrees of defoliation and in severe cases it causes vine death.

2.1.2.2 *Foot rot* : Infection noticed on the main stem at the ground or just below the ground (collar or foot) is fatal. This causes sudden death and hence the term 'quick wilt'. Infection occurs as wet patch at the foot region and the rotting progresses both upwards and downwards causing varying degree of rotting of the main stem. Runner shoot infection that reach the main stem also leads to foot rot occasionally. Foot rot induces foliar yellowing, drooping and gradual drying up of leaves, breaking off of tender stems at the nodal region and spike shedding ultimately leading to vine death.

2.1.2.3 *Root rot*: Feeder root infection causes varying degrees of root rot. Recent studies under simulated field conditions have shown that root rot results in general decrease in the canopy size, foliar yellowing and gradual vine death, typical of slow decline symptoms and vines of all age groups (1-5 years) tested were found susceptible. Cumulative feeder root rot ultimately reaches the main root system culminating in foot rot (Anandaraj *et al.*, 1990).

2.1.3 *Causal Organism*

Phytophthora capsici has been identified as the causal agent of the disease, the taxonomy of which received considerable attention. It was often referred to as *P. palmivora*. The black pepper *Phytophthora* isolates from India have now been identified as *P. capsici* [*'P. palmivora'* MF_4 (morphological form 4)] which exhibit different degrees of morphological variation (Sarma *et al.*, 1982a; Tsao *et al.*, 1985; Sastry and Hegde, 1989; Sarma *et al.*, 1991).

2.1.3.1 *Host range* : Black pepper *Phytophthora* infects *Piper betle*, *P. longum* and *P. attenuatum*, cacao pods, tender leaves of rubber, leaves of castor, cardamom capsules and arecanuts (Sarma and Nambiar, 1982). It also infects citrus fruit apart from areca and cacao (Sastry and Hegde, 1989).

2.1.4 *Biology*

Detailed studies have been carried out on the variability and biology of the organism (Sarma, 1985; Sastry and Hegde, 1987; Santhakumari, 1987; Prabha, unpublished). The fungus often exhibit umbellate sporangial ontogeny with caducus sporangia with long pedicels. Sporangial shape varies from ovoid to pyriform with a tapering base. The fungus grows luxuriantly at 25-30°C on carrot-agar medium.

The growth of the fungus varied at different pH levels (3-6) and was maximum at pH 6.0. Sporangial production was abundant under continuous light and zoospores germinated within 15-20 minutes after encystment. Occurrence of both A1 and A2 mating types have been reported (Sastry, 1982; Sarma, 1985; Sastry and Hegde, 1982). Toxin production by the fungus has also been reported (Anon., 1977).

2.1.5 *Epidemiology*

Recent studies carried out lead to a better understanding of the epidemiology of foot rot of black pepper (Sastry, 1982; Nambiar and Sarma 1982; Anandaraj *et al.*, 1990). *Phytophthora* is exacting in its ecological requirements for its growth, sporulation and infection. Micro-climatological factors under different cropping systems would determine the type of infection, in a given location. The precise methods of detection of the disease, specifically root infection in its very early stage are lacking. The foliar yellowing and declining symptoms due to root rot might be the culmination of the cumulative infection over several years.

Soil and infected plant debris in a plantation are the main sources of inoculum (Nambiar and Sarma, 1982; Sastry, 1982). The isolation from soil was positive throughout, except during summer months. This indicated its presence in a plantation throughout. The studies on spatial distribution of *Phytophthora* propagules in a plantation showed that inoculum was more up to 30 cm from the base and in upper layers of soil. It decreased with increase in depth and distance from the base of the vine (Ramachandran *et al.*, 1986). Besides, the rooted cuttings raised from runner shoots collected from infected gardens always passively carried inoculum which lead to foliar infection or root infection that remains undetected. Planting of such cuttings would lead to gradual inoculum build up from its early stage of the growth. Since direct isolation of the fungus from the soil for quantification of inoculum was found unsuccessful, baiting the soil with various baits like castor seed (Nambiar and Sarma, 1982; Sastry and Hegde, 1982), pepper leaf discs (Ramachandran, *et al.*, 1986) and leaflets of *Albizia falcatarea* (Anandaraj and Sarma, 1990) was found useful in detection of *Phytophthora*.

In a areca-black pepper mixed cropping system, high rainfall (about 3000 mm) and the micro-climatic conditions like high relative humidity (84-99%), low temperatures (22.27-29.6°C) and shorter sunshine hours (2.8-3.5 h/day) favoured the disease increase (Ramachandran *et al.*, 1988). A positive significant correlation was noticed between weekly incidence of disease and relative humidity, rainfall and number of rainy days, while the maximum temperature and increased bright sunshine hours showed significant negative correlation with disease, in a pure black pepper plantation. Based on these results, a disease prediction model following a multiple regression equation, was suggested (Unnikrishnan Nair *et al.*, 1988). This needs further critical study in view of the long incubation periods of root infections involved.

2.1.6 *Disease Spread*

In the case of foliar infection, both vertical and lateral spread of the disease was noticed due to the rain splashes (Ramachandran *et al.*, 1990a). The pre-monsoon showers trigger the new flush formation and runner shoot production at the base of the vine. With the build up of soil moisture, the inoculum gradually builds up (Nambiar and Sarma, 1982). The abundance of sucept tissue, especially runner shoots and tender leaves at the base of the vine in the vicinity of soil inoculum, lead to infection, due to soil splashes. The sproulating infected runner shoots and leaves serve as the secondary source of inoculum and disease spread. With intermittant rain splashes, the disease gradually spreads to the upper region of the bush in a ladder wise fashion and also across the bushes along the wind direction. Splash spread of the disease has been well established (Nambiar and Sarma, 1982; Ramachandran *et al.*, 1990a). Termites and slugs were found to be passive carriers of inoculum. Movement of inoculum through soil water has been established (Sarma *et al.*, 1981).

Foot rot and root rot infection start at isolated patches and subsequent spread occurs in a centrifugal fashion (Nambiar and Sarma, 1982). The disease spread in pure plantation indicated the compound interest type of disease model and the apparent rate of spread was estimated to be 0.67 per infected plant/year (unpublished). The infection might spread to adjacent vines through root contact but this needs further investigation.

In Kerala and Karnataka states, *Phytophthora* infections are common on rubber, coconut, arecanut, black pepper and cardamom, because of conducive climatic conditions that prevail. Based on the cross inoculation tests, it was opined that *Phytophthora palmivora* from arecanut, rubber, cocoa, coconut and cardamom serve as the collateral hosts for black pepper infection (Manmohandas and Abicheeran, 1985). This, however, needs a reinvestigation. In multistoreyed cropping system, where more than one *Phytophthora* spp. are involved infecting different crops, the possibility of evolution of new virulent *Phytophthora* strains was implicated, based on the production of *Phytophthora* hybrids in culture (Santhakumari, 1987). Inspite of positive pathogenicity of different *Phytophthora* spp. on black pepper, they may not be of epidemiological significance unless the black pepper strain (*P. capsici*) is isolated from the natural infections of the above hosts (Sarma and Nambiar, 1982) and pathogenicity established with more number of isolates.

2.1.7 *Disease Management*

An integrated disease management involving cultural, biological and chemical methods of control combined with host resistance is the suggested strategy to tackle this elusive problem (Sarma *et al.*, 1988; Ramachandran *et al.*, 1990b).

2.1.7.1 *Cultural practices*

i) *Plant hygiene—Disease-free nursery stock* : Raising rooted cuttings in fumigated nursery mixture from the runner shoots collected from the disease-free gardens or raising single node cuttings through bamboo method of multiplication (Bavappa *et al.*, 1978) that would ensure disease-free planting material has been stressed (Sarma *et al.*, 1988). This is necessary since some of the incipient root infections at nursery stage go unnoticed and would lead to gradual decline when planted in the field.

ii) *Roguing of infected vines* : Soil and infected plant debris being the primary source of inoculum, removal of infected vines from the plantation is essential to reduce the inoculum build up. Besides, discouraging the frequent movement of personnel and farm implements from diseased to healthy garden is essential.

Since high soil moisture levels favour *Phytophthora* survival, multiplication and root infection, efficient drainage should be ensured. This is particularly important in areca-black pepper mixed cropping system where the plantations are often irrigated.

Maintenance of green or legume cover in a plantation and mulch around the vine reduced the disease incidence. This might be due to the reduced soil splash and water movement.

Minimum tillage farm operation involving no root damage and pruning-off of the runner shoots lying on the ground or tying them back to the main vine would reduce the chance of infection.

2.1.7.2 *Biological control* : Isolation of potential antagonists of *P. capsici* from the soils of undisturbed ecosystem like Silent Valley forests would support the possible operation of biological control in the field. This needs an indepth study to understand the disease suppressive nature of such soils. Application of neem cake (Sadanandan *et al.*, 1990) helped in reducing the disease incidence. Soil amendments with cotton seed and groundnut meal suppressed *P. palmivora* of black pepper population and *Talaromyces wartmanii* and *Penicillium variable* were found antagonistic to *P. palmivora* (Dutta, 1984).

2.1.7.3 *Chemical control* : Prophylactic application of Bordeaux paste to the collar once during May-June period and spraying the foliage and drenching the soil with 1 per cent Bordeaux mixture (Sasikumaran *et al.*, 1981) or 0.2 per cent copper oxychloride twice as a pre-monsoon and post monsoon treatments reduced the disease (Sarma and Ramachandran, 1984). In view of the possible heavy leaching losses of protectant fungicides during heavy rain fall and consequent vulnerability of the vine to infection, systemic fungicides like phenylmides (metalaxyl, metalaxyl-ziram and oxadixyl), ethylphosphonates (fosetyl-Al), carbamates (Previcur-N) and aromatic hydrocarbons (terrazole) were tested for their *in vitro* efficacy. Based on their efficacy, metalaxyl-ziram, fosetyl-Al and terrazole were tested for their efficacy under field conditions. Metalaxyl-ziram was found effective in checking infection and fosetyl-Al was the next best. Besides, metalaxyl was found compatible and synergistic with the insecticides like endosulfon and quinalphos, the pesticides used in black pepper pest control (Ramachandran and Sarma, 1985a; 1985b; 1988; 1989; Ramachandran, 1990; Ramachandran, *et al.* 1990b). In addition, detectable levels of metalaxyl were not observed in dried black pepper berries from vines treated four and six months after fungicide application (Ramachandran, 1990) indicated that it is not hazardous to use metalaxyl. In view of the reported development of metalaxyl resistance in several *Phytophthora* spp., monitoring of *Phytophthora* population for metalaxyl sensitivity in metalaxyl-ziram or metalaxyl-mancozeb treated vines is essential.

2.1.7.4 *Disease resistance* : Techniques for mass screening of open pollinated seedling progenies and to assess relative degree of tolerance/ resistance of rooted cuttings to *P. capsici* have been developed (Sarma and Nambiar, 1979; Sarma *et al.*, 1990). Although high degree of resistance could not be identified so far, tolerance to *P. capsici* has been identified in open pollinated seedling progenies, hybrids and cultivars (Table 2) which are under various stages of field evaluation. Of the 41 cultivars and 73 wild types of *Piper* spp. tested, cultivars Narayakodi, Kalluvally, Uthirankotta and Balankotta were found tolerant and the rest susceptible (Sarma *et al.*, 1982). Cultivar Karimunda, which is known for its productive potential, was found highly susceptible. *P. colubrinum* was immune to *P. capsici* and its adaptability as root stock to black pepper was poor. Breeding programmes are in progress involving highly productive but susceptible cultivars like Karimunda to isolate tolerant/resistant genotypes. It would be possible to obtain resistance through transgressive segregation and recombination.

Table 2 : Reaction of black pepper types to *Phytophthora capsici*

Sl. No.	Accession No.	Name	Lesion* length (mm)	Rot** rating	Reaction
1.	Acc. 1047	Neelamundi	6.0	3.0	T
2.	Acc. 1095	Unidentified	7.8	3.6	T
3.	Acc. 847	Arakulamunda	14.2	2.0	T
4.	Acc. 993	Mundi	8.7	8.1	T
5.	Acc. 971	Balankotta	11.1	3.0	T
6.	HP 780	Panniyur × Karimunda	5.5	3.7	T
7.	HP 104	Narayakodi × Neelamundi	7.2	3.0	T
8.	P 24	Perambramundi (OP)	12.0	3.0	T
9.	P 1178	Kalluvally (OP)	1.0	2.9	T
10.	P 339	Cholamundi (OP)	8.0	2.8	T
11.	KS 155	Karimunda	21.0	1.4	S
12.	KS 183	Karimunda	41.3	1.3	HS

Sarma *et al.*, Unpublished

* Lesion Rating		** Rot Rating	
1. No lesion	Immune	No rotting	1. Immune I
2.	1-5 mm Resistant	Hypersensitive fleck	2. Resistant R
3.	6-20 mm Tolerant	6-24%	3. Tolerant T
4.	21-30 mm Susceptible	25-75%	4. Susceptible S
5.	30 mm Highly susceptible	75% and above	5. Highly susceptible HS

***O.P. — Open pollinated.

2.2 Slow Decline Disease

Slow decline, which was earlier known as slow wilt, is considered as fungal nematodal complex coupled with soil moisture stress and malnutrition (Nambiar and Sarma, 1979). The pathogenicity of both root-knot nematode, *Meliodogyne incognita* and burrowing nematode, *Radopholus similis* has been established and their major involvement in slow decline has been established (Ramana and Mohandas, 1986; 1987;

Mohandas and Ramana, 1987; Ramana *et al.*, 1987a, 1987b; Venkitesan, 1976). Disease resistance to *R. similis* in black pepper has not been located (Ramana *et al.*, 1987b) and only one cultivar resistant to root-knot nematode has been identified (Ramana and Mohandas, 1986). However, *P. colubrinum* has been found to be resistant both to root-knot and *R. similis* (Anon., 1989). Neem cake application at 1 kg/vine reduced *M. incognita* population under field condition (Ramana, 1990) and also phorate application at 3 g a.i./vine/twice a year has been found effective against both nematodes (Anon., 1985).

In view of the absence of spatial segregation of both *Phytophthora* and nematodes in the soil under field condition, both in pure and mixed crop systems, it is imperative to adopt a strategy which can check the combined infections caused by these pathogens, to boost up the health and productivity of the vine. Lack of proper recovery of slow decline affected vines with phorate application alone indicated involvement of more than one agent. Recovery of about 45 per cent of the slow decline affected vines with metalaxyl + phorate treatment compared to 18 and 30 per cent in phorate and metalaxyl treated further confirmed the absence of spatial segregation of *Phytophthora* and nematodes in the field situation (Anon., 1989). In view of its multiple resistance, transferring resistance in *P. colubrinum* to black pepper through biotechnological tools appears to be promising (Sarma and Ramadasan, 1990). Association of vesicular-arbuscular mycorrhizae, viz., *Glomus fasciculatum, G. macrocarpa, G. microcarpa, Gigaspora gigantea* and *G. gilmorei* (Ramesh, 1982; Manjunath and Bagyaraj, 1982) with black pepper has been reported. However, their role in suppression of nematodes and *Phytophthora* infections needs critical study. Preliminary studies indicated *G. mosseae, G. fasciculatum. Gigaspora margarita* and *Acaulospora laevis* showed varying degrees of suppression of root-knot infection in black pepper (Anandaraj *et al.*, 1990a; Sivaprasad *et al.*, 1990).

Thus, bio-control and hypo-virulence in *Phytophthora*, if any, effect of organic amendments and nutrients on disease suppression and host resistance, besides development of horizontal resistance to the major pathogens and pests and cost effective agro-techniques that could ensure optimum health and productivity of black pepper would be the priorities.

2.3 Anthracnose

Leaf spot and berry split caused by *Colletotrichum gloeosporioides* (Penz.) Sac. is becoming increasingly important in plantations (Fig. 5) where prophylactic plant protection measures with Bordeaux mixture against *Phytophthora* infection are seldom adopted. This also called as fungal 'Pollu' was earlier reported to be caused by *C. necator* (Ramachandra Rao, 1926).

2.3.1 *Crop Losses*

Precise information on reduction in yield due to foliar infection is lacking. However, spike shedding due to anthracnose ranged from 1.93 to 9.5 per cent. Early infection resulted in up to 77 per cent weight loss of berries and late infection up to 56 per cent (Unnikrishnan *et al.*, 1987).

2.3.2 *Symptoms*

Infection occurs on leaves causing angular to irregular brownish spots with a chlorotic halo. Infection in severe cases caused foliar yellowing. Infection of stalk as dark spot results in spike shedding. Infection of tender berries causes darkening of the pericarp, affects their subsequent development and occasionally dry up resulting in chaffey berries. Hence, the name 'pollu', the hollow berry. Infection on mature berries occurs causing dark brown crack or split.

2.3.3 *Causal Organism*

Colletotrichum gloeosporioides and *C. necator* are the reported pathogens.

2.3.4 *Epidemiology*

The disease is generally noticed both in pure plantation and in mixed cropping systems. However, maximum disease incidence (28-34%) is noticed during August-September period (Unnikrishnan Nair *et al.*, 1987). *Dioscorea triphylla* has been reported to be an alternate host for the anthracnose (Wilson, 1960). The inoculum perpetuates in a plantation due to overlapping infections that occur throughout the season. In coconut-black pepper mixed cropped system, the percentage of berry infection was 23.2, 19.0, 16.3, 9.8 and 9.3 in Panniyur-1, Balankotta, Narayakodi, Kottandan and Karimunda, respectively (Radhakrishnan and Jayaprakash Nair, 1983).

2.3.5 *Disease Management*

In a field control trial consisting of 20 treatments, based on the time and frequency of spraying with 1 per cent Bordeaux mixture, the infection varied according to early or late infection. Irrespective of early or late infection, three rounds of spray during June-July, followed by June-late July and late August were found superior to control in reducing infection (Unnikrishnan Nair *et al.*, 1987).

Apart from anthracnose, bacterial leaf spot caused by *Xanthomonas campestris* pv. *beticola* (Mathew *et al.*, 1978), thread blight caused by *Corticium solani* (Ramakrishnan, 1957), stump rot caused by *Rosellinia bunodes* (Butler, 1918), red rust caused by *Cephaleuras mycoides* are some of the diseases of minor importance. Dodder, an angiosperm parasite *Cuscuta* sp. parasitising black pepper has been noticed in Wynad, Kerala (Sarma *et al.*, 1990). The disease problems in nursery have been reviewed recently (Sarma *et al.*, 1987). *Rhizoctonia-Pythium-Colletotrichum* complex (Mammootty and Sukumara Pillai, 1988a), *Sclerotial*/basal wilt (Chowdhary, 1943; Brahma *et al.*, 1980) caused by *Sclerotum rolfsii*, leaf spot/rot caused by *'P. palmivora'* MF_4 and root infection caused by *M. incognita* and *R. similis* are some of the nursery diseases noticed (Sarma *et al.*, 1988).

2.4 Diseases of Unknown Etiology

Little leaf and phyllody diseases are considered as diseases of unknown etiology (Paily *et al.*, 1981; Sarma *et al.*, 1988a, 1988b). Recent EM studies of the latter showed the association of typical MLO's with the disease (unpublished). This disorder was noticed in a small pocket in Wynad, in Kerala and is negligible.

2.5 Stunted Disease

This is seen increasingly in Wynad and Idukki districts. The leaves of diseased plants are chlorotic with varying degree of reduction in the leaf size and crinkling. Besides, the inter-nodal distance reduced considerably causing stunting. Occasionally affected vines exhibit witche's broom symptoms (Sarma *et al.*, 1988a) (Fig. 6).

Besides velvet blight, black and brown spot diseases and white/yellow leaf spots probably of lichen are some of the other minor disorders the etiology of which is yet to be known.

3. DISEASES OF CARDAMOM (*ELETTARIA CARDAMOM* MATON)

Small cardamom cultivation is mainly confined to the evergreen forests of Western Ghats of South India.

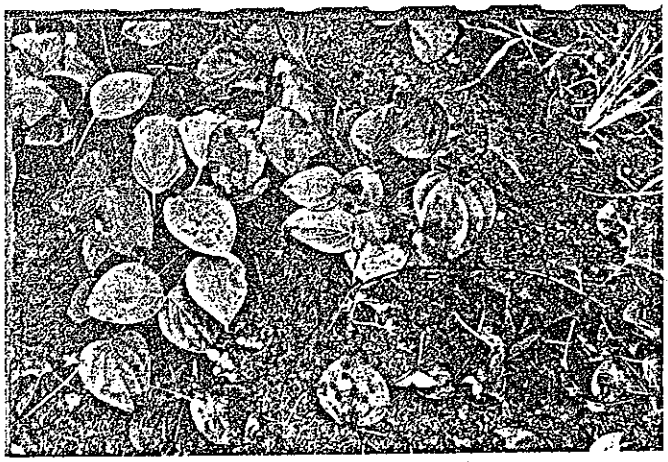
Among the important diseases of small cardamom, 'katte' or mosaic disease caused by poty virus and 'Azhukal' disease caused by *Phytophthora* spp. are the most serious diseases incurring heavy crop losses. Nursery leaf spot caused by *Phyllosticta elettariae*, clump rot caused by *Pythium*, damping off disease in nursery, leaf blotch, Vythiri spot capsule, etc., are on increase in recent years. Fungal and bacterial diseases have been reviewed in this chapter. Virus and nematode disease problems have been reviewed in a separate chapter. The disease problems of cardamom have been reviewed recently (Agnihothrudu, 1987).

3.1 'Azhukal' Disease of Cardamom

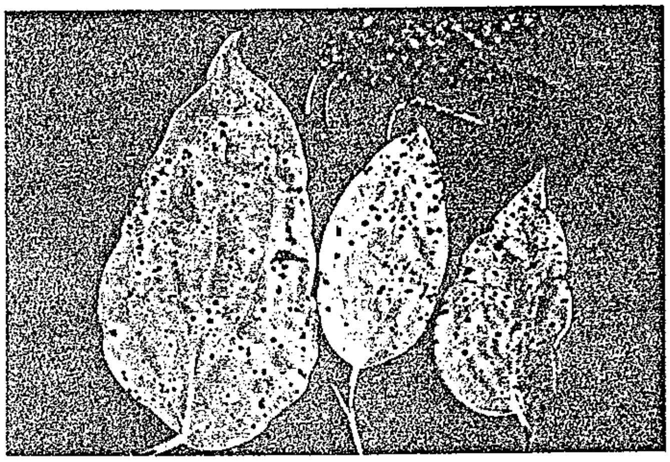
'Azhukal' (means 'rotting' in Malayalam vernacular) or the capsule rot disease (Fig. 7) is only next to 'katte' disease in its importance causes severe crop losses. In certain areas, it is more serious than 'katte'. The disease was reported from Idukki (Menon *et al.*, 1973) is prevalent mainly in Kerala and to a small extent in Karnataka. The problem has been reviewed recently (Nair and Menon, 1982; Agnihothrudu, 1987).

3.1.1 *Crop Losses*

Even though precise crop loss figures are not available, losses up to 30 per cent have been reported in Iddukki district of Kerala (Nambiar and Sarma, 1974).



⇐ Fig. 4 : *Phytophthora capsici* infection on black pepper leaves.



⇐ Fig. 5 : Anthracnose on black pepper leaves and spikes.

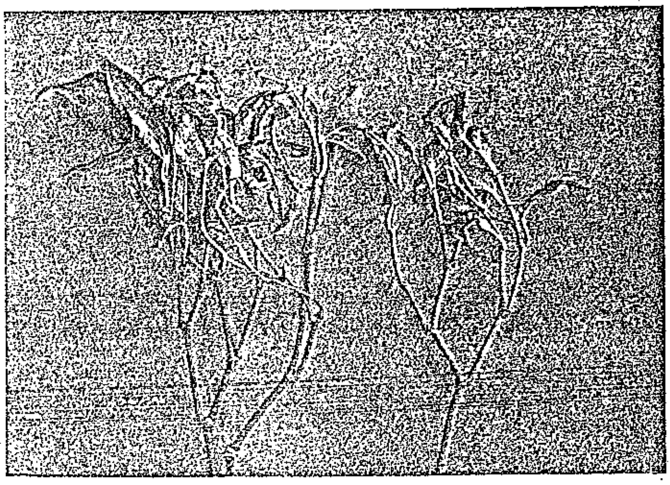


Fig. 6 : Little leaf disease on black pepper.

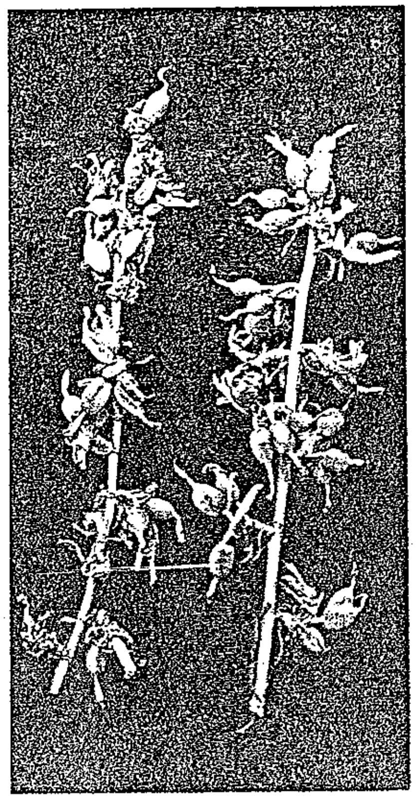


Fig. 7 : Capsule rot of cardamom.

3.1.2 *Symptoms*

Panicles and capsules are the major targets of infection because of their susceptibility and proximity to the soil which is the main source of infection. Infection starts as brown discoloured spot at any point of the rachis and gradually enlarge causing rotting. The panicle portion beyond the point of infection dries up. From the main rachis, infection spreads to the secondary rachis and capsules. Both tender and semi-mature capsules are infected. The infected capsules turn greyish green to olive brown from grass green colour. Infected capsules turn soft in advanced stages and emit foul smell. Leaf infection is also noticed in certain areas. The lesion starts as a water soaked spot and gradually enlarges. If infection occurs early, the leaves fail to open. The mature infected leaves show typical rotting and shredding. Pseudostems and roots are also infected (Nair, 1979). However, critical studies are needed on root infection and their role in the capsule rot as well as in rhizome rot.

3.1.3 *Causal Organism*

The disease was first reported to be caused by *Phytophthora nicotianae* var. *nicotianae* Breda de Haan (Thankamma and Radhakrishna Pillai, 1973). Though involvement of *Pythium vexans* was also reported (Nambiar and Sarma, 1976), it is now known to be predominantly caused by *Phytophthora* spp. Recently *P. medaii* of A_2 mating type causing capsule rot and leaf blight of cardamom also has been reported from Idukki areas of Kerala (Anon., 1986). *Fusarium* sp also has been reported with capsule rot (Wilson *et al.*, 1979a)

3.1.4 *Biology of the Organism*

The fungus could be selectively isolated on BNPRA + HMI medium and clean isolation was obtained when seeds from infected capsules are plated (Nair, 1979). Morphology of *P. nicotianae* from cardamom has been described in detail (Thankamma and Radhakrishna Pillai, 1973; Nair, 1979). *P. nicotianae* showed good growth and abundant sporulation in lima bean agar. The isolates were heterothallic, since oospore formation was reported when cardamom isolates were paired with *P. meadii* isolates from rubber (Thankamma and Radhakrishna Pillai, 1973). However, *P. nicotianae* isolates from soil formed oospores in 25-day old cultures raised in oat meal at 25°C (Nair, 1979).

P. meadii isolates grew and sporulated well on carrot agar medium and isolates showed variation in their growth rate at 25°C. The L:B ratios ranged from 1.8 to 2.0 and the isolates are of A_2 mating type (Anon., 1990c).

3.1.5 *Epidemiology*

The disease starts during May, reaches its maximum during August (11.0%) coinciding with south-west monsoon and gradually decreases thereafter. Disease incidence is directly correlated to the amount of rainfall, relative humidity and soil moisture. The wet and humid conditions and a low temperature prevailing in the plantations are highly favourable for the disease development. During August, when maximum disease incidence was noticed, the rainfall, relative humidity and soil moisture were 400 mm, 90.5 and 37.6 per cent compared to 99.6 mm, 44.2 and 16.5 per cent respectively during April when disease incidence was absent. During May-August, the ambient temperature range was 26-21°C, was ideal for infection (Nair and Menon, 1982). The disease spread in the case of *P. meadii* was maximum during July-September when the temperature ranged from 22-24°C, relative humidity ranged from 85 to 92 per cent. Mean day temperatures of 27-29°C and relative humidity of 51-64 per cent were unfavourable for the disease development (Anon., 1990c). To assess the disease potential index in the soil, baiting technique using leaves of *Albizia* and *Sesbania* has been standardised to detect *P. meadii* in the soil (Anon., 1990c). During August, the infection propagule density of *P. nicotianae* was about 786.6/g soil compared to 11.2/g soil during April (Nair, 1979).

Fungus survives in the form of chlamydospores. The fungus in infected rhizomes survived for 32 weeks in air dry soil and 48 weeks in moist soil. Soil pH between 6 and 7 was more favourable for the survival of the pathogen (Nair, 1979). As such, the soil and infected plant debris served as the primary source of inoculum. Disease incidence and propagule population was more at higher soil pH. Propagules and disease incidence reduced as pH decreased. *Colocassia* plants are reported as collateral hosts of this fungus (Nair, 1979).

3.1.6 *Disease Management*

3.1.6.1 *Cultural practices* : Phytosanitation is of utmost importance. Removal of infected panicles and rhizomes from the plantation and burning them reduced the disease incidence. This was demonstrated in observational trials taken up in Wynad region (Western Ghats) of Kerala. Phytosanitation coupled with three rounds of Bordeaux mixture treatment during May, June and July reduced the disease incidence (capsule rot) to 5.74 per cent compared to 36.27 per cent in control (Anon., 1990c).

Movement of planting material as rhizomes from diseased areas to disease-free areas should be avoided. This disease was absent in Wynad region prior to 1975 and was introduced by 1976 probably through the soil along with planting material from Idukki region of Kerala.

3.1.6.2 *Shade regulation* :Lopping of the branches of shade trees just before the monsoon ensured light penetration which is likely to alter the micro-climate unfavourable to the disease development.

3.1.6.3 *Biocontrol*: Soil amendments with neem cake resulted in decrease of *Phytophthora* propagules (*P. nicotianae*) and increased fungal and actinomycete population (Nair, 1979). Incidentally, neem cake application reduced root-knot infection in cardamom (Ali, 1987). Isolation and identification of biocontrol agents in such situation and exploiting them for field application should receive priority.

3.1.6.4 *Chemical control*: In view of the high rainfall pattern in major cardamom growing areas, fungicides with considerable tenacity are of importance. Spraying the panicles twice with Bordeaux mixture (1%), once during May-June (pre-monsoon) period and again during August-September (post-monsoon) reduced the disease incidence. Of the 11 fungicides tried, Bordeaux mixture (1%) spray reduced the capsule rot incidence to 2 per cent compared to 28 per cent in control (Nambiar and Sarma, 1974). The efficacy of this treatment was further confirmed by large scale adaptive field trials (Nair *et al.*, 1984). Three rounds of Bordeaux mixture treatments were also recommended (Menon *et al.*, 1973) for an effective control. Bordeaux mixture and dexon (100 ppm) reduced the pathogen propagules by 86 and 83 per cent respectively (Nair 1979).

Field control trials using systemic fungicides viz., Aliette and Ridomil MZ 72 alone and also alternating with Bordeaux mixture for three rounds showed that the disease incidence was high in untreated control (15%) and Aliette and Bordeaux mixture combination (10.4%) compared with a better disease suppression with Aliette, Ridomil MZ, Bordeaux mixture and Ridomil MZ and Bordeaux mixture combination with disease incidence of 5.7, 5.7, 5.4, 5.1 respectively which were on par (Anon., 1990c). Of the 11 fungicides tried with 3 rounds of application, Bayer 5072 (fenaminosulf) at 4 kg/acre was found effective resulting in rhizome and capsule rot incidence of 0.99 and 8.3 per cent compared to 24.4 and 15 per cent respectively in the untreated control. (Alagianagalingam and Kandasamy, 1981). Efficacy of fenaminosulf in controlling 'Azhukal' disease of cardamom was further confirmed (Balakrishnan and Joseph, 1982).

3.1.6.5 *Disease resistance*: All the three popular cultivars Mysore, Malabar and Vazhukka were found equally susceptible (Anon., 1977). There is an urgent need to identify resistance sources in the available germplasm. Induction of somaclonal variation through tissue culture techniques and also resorting to *in vitro* screening with fungal toxins of *P. nicotianae* and *P. meadii* would be priorities. A screening technique to locate tolerance/ resistance has been standardised by inoculating seedlings with zoospore suspension (Peethambaran *et al.*, 1991; Anon., 1990c).

Adoption of phytosanitation coupled with timely fungicidal treatments on a collective and cooperative basis would be of greater relevance to check the crop losses due to 'Azhukal' of cardamom.

3.2 Rhizome/Root Rot and Damping-off Disease

The disease has become increasingly important in nurseries and also in older plantations causing serious concern among cardamom planters. It is noticed in primary and secondary nurseries and also in older plantations both in Kerala and in Karnataka states. When the disease is seen in primary nurseries, it is referred to as damping-off and when it infects roots and rhizomes of the mature plants causing decline and death, it is referred to as rhizome rot or clump rot. The disease was reported earlier from the erstwhile Madras, Mysore and Kerala states (Thomas, 1938; Mayne, 1942; Wilson *et al.*, 1979b).

3.2.1 *Crop Losses*

In a survey carried out in Idukki during 1985-86, this disease incidence ranged from 20 to 60 per cent (Joseph Thomas *et al.*, 1988). In a recent surveys (1987-89) carried out in Idukki district, rhizome rot ranged from 9 to 19.2 per cent and seedling death (damping off) ranged from 2 to 20 per cent (Anon., 1990c).

In Mudigere region of Karnataka, disease incidence up to 9 per cent has been reported (Siddaramaiah *et al.*, 1988).

3.2.2 *Symptoms*

In the primary nursery, the affected seedlings exhibit light discolouration at collar region which become dark brown, leading to death of the affected seedlings. The affected seedlings show root rot and leaves exhibit typical flaccidity symptoms to start with and later wilt and dry up. In older plantations, affected plants exhibit typical pale and yellowish foliage. Typical root and rhizome rot could be noticed in such plants. The pseudostem of the affected plants exhibited olive to dark brown discolouration and occasional water soaking at the advancing margins of the discoloured regions. Pseudostems of the affected clumps break-off and older leaves die prematurely. The shoots arising from such clumps appear weak and unhealthy.

3.2.3 *Causal Organism*

More than one pathogen is involved in this disease. Nematodes and *Rhizoctonia solani* were reported earlier (Subba Rao, 1938, 1939). *Cephalosporium* sp. pathogenic to young rhizomes was reported (Thomas, 1938). Damping-off seedlings in primary nursery caused by *R. solani* was reported from Idukki (Wilson, *et. al* 1979b). In Mercara and Bhagamandala area of Karnataka, involvement of both *P. vexans* and *R. solani* pathogenic to cardamom seedlings has been reported (Anon., 1989). *Fusarium* sp. *F. oxysporum, P. vexans, Phytophthora* sp. and *R. solani* were the organisms associated with damping-off and rhizome rot in Mudigere area of Karnataka and were found pathogenic (Siddaramaiah *et al.*, 1988). The variability of pathogen profile in different agroclimatic regions might be due to the adoption of the pathogen to the particular region.

3.2.4 *Epidemiology*

The disease is soil borne and the apparently normal seedlings from infected nurseries would serve as the carries of inoculum to the main field. The clump rot at least in older plantation might be the culmination of prolonged root rot and needs an indepth investigation. Poor drainage was considered as the main predisporing factor for the disease initiation (Mayne, 1942).

Rainfall influenced the disease development and more than 80 per cent of infections occur during June-October coinciding with the south-west monsoon (Anon., 1989). About 98 and 82 per cent disease incidence were noticed during south-west monsoon in rainfed and irrigated plantations respectively (Anon., 1990a).

The disease spread in the slopy areas is along the gradient and in the flat areas it spreads in a centrifugal fashion from the focus of infection. In the high rainfall area in the trench system of planting, disease spread is along the trenches (Anon., 1988). Both *P. vexans* and *R. solani* survived in plant debris for about 15 months (Anon., 1990a) which indicated its potential as inoculum source.

3.2.5 *Associated Organisms*

Root-knot infection did not influence the root rot and clump rot infection. Interaction studies with *P. vexans* and *M. incognita* on cardamom seedlings did not show any increased disease incidence in presence of both (Anon., 1988). However, root grub (*Nodostoma fulvicorne*) infestation appears to predispose the plant to infection. Root grub infected plants when inoculated with *P. vexans* and *R. solani* showed 80 and 68 per cent infection respectively (Anon., 1989).

3.2.6 *Disease Management*

3.2.6.1 *Phytosanitation* : Roguing of infected plants in older plantations and change of site of nursery would reduce the chance of inoculum build up (Ananda Rau and Venkataramani, 1949). Raising of nurseries in the fumigated soils/nursery beds would ensure disease-free seedlings. The apparently normal seedlings with incipient infections from ill managed nurseries would become potential source of infection in the fresh plantations when used for fresh planting.

3.2.6.2 *Soil management* : Since ill-drained conditions predispose the plants to infection, provision of good drainage in the plantation should be ensured. Removal of affected clumps and application of lime in such pits was suggested (Mayne, 1942). Application of ammonium phosphate or calcium superphosphate at 569/clump checked this disease and supported good root development and growth (Marudarajan, 1948). Application of pongamia cake and *Eupatorium* leaves as mulch reduced the damping-off (Anon., 1990b).

3.2.6.3 *Chemical control* : Treating the nursery beds with formaldehyde (1:5) at 151/m^2 15 days prior to sowing ensured god germination and production of vigourous and healthy seedlings and reduction in disease incidence (Pattanshetty *et al.*, 1974, 1973). In nurseries, out of the 7 fungicides tested, Emisan (0.2%) or Dithane M-45 (0.4%) when applied thrice as soil drenches at 20 days intervals checked the disease (Joseph Thomas *et al.*, 1988). In older plantations, out of nine fungicides tested as soil drenches at 3 l/clump, four times at monthly interval, Emisan and Brassicol (0.2%) and foltaf (0.2%) gave maximum reduction of the disease and were at par (Joseph Thomas *et al.*, 1988). In Karnataka, cardamom nurseries sprayed with Bordeaux mixture showed 28 per cent disease incidence compared to 78 per cent in untreated beds. The severe incidence was attributed to raising of the nursery in the same site for a long time. Out of 4 fungicides in 5 different combinations tested as seed dressings, Bavistin + TMTD gave maximum germination (81%) compared to 52 per cent in control followed by Bavistin alone and Bavistin + Captan. Of the 6 fungicides tested in 3 combinations as foliar sprays at 20 days intervals from March onwards, Dithane M-45 (0.2%) + Ridomil (0.1%), Bavistin + Ridomil (0.05 + 0.1%), Ridomil (0.1%) alone showed 7.9, 13, 16 and 23 per cent disease incidence respectively compared to 77.3 per cent in control (Siddaramaiah *et al.*, 1988).

Since three different pathogens with different growth requirements are involved in the disease, combination of fungicides with different modes of action would be ideal to check the disease.

Association of VAM fungi, viz., *Glomus macrocarpa, G. fasciculatum, Gigaspora, coralloidea* with cardamom plants has been reported (Manjunath and Bagyaraj, 1982; Rohini Iyer *et al.*, 1989). Since VAM is also known to suppress the soil-borne diseases, it is necessary to test their efficacy in disease suppression. Biocontrol agents such as *Trichoderma* spp. and hyperparasites like *Pythium acanthophoron* need be tested for their efficacy in disease suppression. Soil fumigation or soil solarisation of the nursery beds, combined with soil infestation with VAM and biocontrol agents would be a better approach to suppress this disease in nurseries. It is also important to alter the sites of nurseries regularly to reduce the chances of inoculum build up. In the mature plantation, phytosanitation combined with soil drenches with fungicides and provision of good drainage would be important. Application of superphosphate and also different organic amendments like neem cake need be tested for the disease suppressive effects. Thus, a multipronged disease management strategy is of relevance in this to check crop loss.

3.3 Nursery Leaf Spot Disease

The disease is prevalent in all the plantations wherever cardamom is grown and is a major limiting factor especially in the primary nursery and is next only to damping-off. The disease was first reported in 1939 (Subba Rao, 1939).

3.3.1 *Crop Losses*

The infection causes extensive foliar damage of the seedlings affecting their growth and occasionally leading to death of affected seedlings.

3.3.2 *Symptoms*

Minute water soaked leaf spots appear on the lower surface of tender leaves of the seedling which are later noticed on upper surface. They turn necrotic and the mature lesion appear circular to oval shaped reaching 2-3 mm with a greyish colouration. The centre of the lesion appears sunken with dark coloured pycnidia present in the tissues. When the weather is wet, the adjacent lesions coalesce forming large necrotic patches leading to leaf shredding symptom. When the weather is dry, the lesion remain discreet with a definite light brown coloured margin surrounded by a chlorotic halo.

3.3.3 *Causal Organism*

Phyllosticta elettariae is the causal organism (Choudhary, 1958).

3.3.4 *Epidemiology*

The disease appears in severe form where nurseries are exposed during the monsoon, probably due to forcible impact of rain drops and less under thatched sheds without much of dripping. Clear cut correlation could not be obtained between the disease incidence, temperature, relative humidity (Naidu, 1981). However, the age of the plant to susceptibility showed a good correlation. Uppermost tender leaves were highly susceptible while the lower leaves appear resistant to infection. Seedlings developed resistance as they grew old. The percentage of death was 96 and 84 in 15 and 30 days old seedlings. Percentage of leaves rotten at 60, 90, 180, 270 and 360 days were 79, 72.3, 52.6 (only youngest 2-3 leaves), 20.4 per cent (spots remain isolated) and 5 per cent (necrotic spots only on the youngest leaves) respectively. Disease spread appears to be typically splash borne since disease spread is rapid during intermittant showers. The fungus was found to survive in infected leaves for about 12 months and can serve as the primary source of inoculum.

The fungus is known to produce a host-specific toxin which is yet to be confirmed (Brahma, unpublished).

3.3.5 *Disease Management*

Thatched nursery sheds without dripping would be ideal to reduce the disease, since under heavy dripping and also under exposed condition the disease spread appears to be rapid.

3.3.5.1 *Chemical control*: In *in-vitro* studies, captafol and ferbam was inhibitory to the growth of the fungus even at 25 ppm (Prasad *et al.*, 1978). Sprays with captafol (0.3%) were found effective in checking the disease (Rao and Naidu, 1974). Timely application of Bordeaux mixture was suggested as the disease control measure (Mayne, 1942).

Disease resistance, though reported for some varieties is of little consequence since breeding for resistance to leaf spot is not a priority. Among the wild relatives of cardamom, *Amomum subulatum, Alpinia speciosa, Hedychium coronarium* were found highly resistant, Alleppey Green, Nevara, Singhampatti selection of cardamom were found resistant. Ceylon erect., Vazhukka moderately susceptible; Cl. No. 1259, Cl. No. 57, Cl. No. 58 were susceptible; and Cl. No. 53, Cl. No. 1258, Cl. No. 1228, Hema-4, Malai, Manjirabad, APG-1, APG-2, APG-3, APG-4, APG-5, APG-6 highly susceptible (Naidu, 1981). Early detection of the disease and timely application of fungicidal sprays and changing the nursery site periodically would check the disease to economic level of control.

3.4 'Chenthal' Disease

This is a foliar disease, the occurrence of which was first reported from Vandenmettu area of Idukki during 1975-1977 (George *et al.*, 1976). It is seen in entire cardamom belt of Kerala and also in some areas of Tamil Nadu and Karnataka (George and Jayasankar, 1980).

3.4.1 *Crop Losses*

Though the disease is foliar, it had an adverse effect on fruit set. Flowers produced in the infected plants. failed to set capsules. Disease did not affect the growth of the plant. A decrease in the weight of the capsules with increase in severity of disease was noticed. Maximum reduction in the yield of 7-13 per cent was seen in Mysore variety (Dileep Kumar *et al.*, 1989).

3.4.2 *Symptoms*

The disease is generally noticed on second leaf as elongated water soaked lesions of varying sizes on the abaxial surface of young leaves. The water soaked lesions later turn to dark colour with a yellowish halo around. The lesions develop near leaf margin and progress inwards towards the midrib. As the withering progresses, pseudostems wilt. The panicle in the affected plants dry up from tip downwards. The severely affected garden gives a burnt appearance.

3.4.3 *Causal Organism*

Corynebacterium sp., a rod shaped gram positive bacterium was reported as the causal organism (George *et al.*, 1976). This needs further confirmation.

3.4.4 *Epidemiology*

The disease is generally not seen on the first leaf in clump, and disease develops from second leaf onwards. In the healthy plant, the youngest leaf is silky to touch but leathery in diseased plant. Pathogenicity tests carried out by spray inoculation with bacterium showed that lesions developed in 12 hours at 22-24°C and 90-95 per cent RH. In about 3-6 days, the characteristic lesions develop and affected leaves wither in a fortnight. The disease is generally seen in exposed plantations, whereas in heavily shaded areas disease was not noticed.

Significant negative correlation was seen between shade and intensity of the disease. The cardamom plantation with red gum as shade tree showed severe disease incidence because of heavy exposure. About 59 per cent of the plots receiving organic fertiliser remained disease-free and 19 per cent of the plots receiving inorganic fertiliser showed disease incidence (George and Jayasankar, 1980). In a study on the correlation of the nutrient status of cardamom to the disease, it was found that nutritional factors didn't predispose the plant to infection but the disease appears to be associated with imbalance especially the ratios of K to Ca and Mg in the soils as well as in the plant. There was considerable reduction in the P and K status of diseased plants (Dileep Kumar *et al.*, 1989). *Zingiber officinale* and *Aframomum malegueta* were reported as collateral hosts of *Corynebacterium* pathogenic to cardamom (George and Jayasankar, 1987). Field symptoms were noticed on *Alpinia malaceens, Hedychium coranarium, A. malegueta* and *A. calcarata.*

3.4.5 *Disease Management*

Since weeds and ginger have been reported as collateral hosts for this pathogen, it is desirable to remove such weeds from the plantation and also avoid planting of ginger in the vicinities of cardamom plantation.

3.4.5.1 *Chemical control* : Out of six antibiotics tried, penicillin was most effective *in vitro* assays as well as in field in checking the infection when the plant was sprayed with 100 ppm. About 10 litres, of spray fluid was found sufficient for 10-12 plants (George and Jayasankar, 1977).

However, the etiology of the disease remains controversial and even suspected to be caused by *Cercospora* sp. (Agnihothrudu, 1987).

3.5 Minor Disease of Cardamom

Leaf rot was caused by *Phaeodactylium alpiniae* Sawada Syn. *Phaeodactylium venkatesanum*, Agnihothrudu (Agnihothrudu, 1968).

Leaf spot caused by *Cercospora zingiberi* (Rangasamy *et al.*, 1968). *Sphaceloma cardamomum* (Muthappa, 1965) cardamom leaf rust by *Uredo ellettariae* Thirum (Thirumalachar, 1943) Capsule canker suspected to be caused by bacterium (Vythirispot) (Agnihothrudu, 1987), anthracnose of cardamom capsules (Suseela Bhai *et al.*, 1988) and *Fusarium* capsule rot (Wilson *et al.*, 1979a) are some of the other diseases reported which are of minor importance at present.

Cercospora leaf spot (Ram and Rao, 1978) and *Sphaceloma* leaf spot were found severe in Coorg area. Of the 20 cultivars screened under field condition, Ceylon Erect and Alleppey Green were free from disease and considered resistant to both the diseases. APG Nos. 2,3,4, Manzirabad, CL. No. 1259, CL. No. 1257 were highly susceptible to both the diseases. Others showed variable reaction (Naidu, 1978).

4. DISEASES OF LARGE CARDAMOM (*AMOMUM SUBULATUM* ROXB.)

'Chirke' and 'Foorkey' are the two important viral diseases of large cardamom causing considerable crop losses and have been reviewed recently (Agnihothrudu, 1987). However, in recent years, leaf streak, leaf blight and spike rot are becoming increasingly serious in Sikkim and Darjeeling districts. The information available on these is very meagre.

4.1 Leaf Streak Disease

The disease is characterised by elongate translucent streaks on leaves along the veins which turn to reddish brown within 3-4 days. The mature lesion appear as straw coloured necrotic area surrounded by prominent dark brown margin. They measure 5-20 mm long and 2-4 mm wide. Emerging folded leaves and younger leaves are more susceptible.

The disease is caused by two species of *Pestalotiopsis* viz., *P. royenae* (D. sacc) and *P. versicolor* (Speg) Steyaert. (Srivastava and Verma, 1989a, 1989b). The variety 'Golsey' was found to be more susceptible. All the eleven fungicides, viz., Dithane M-45. Dithane Z-78, Bavistin, Blitox, Calixin, Folpet, Cuman L, Topsin N, Foltaf, Captaf, Fytolan were effective in checking the disease. However, copper fungicides were more effective (Anon., 1990b).

4.2 Spike Rot

This is considered as disease complex associated with *Rhizoctonia* sp. and *Fusarium* sp., insect pests and 'chirke' infection. Continuous and heavy rain fall during flowering season may also result in spike rot. Cultivar 'Sawney' recorded maximum spike rot (32.7%) and 'Ramla' recorded minimum incidence (19.7%). The cultivars 'Golsey' and 'Ramsey' are moderately affected (Karibasappa, *et al.*, 1991). Detailed studies are warranted on the etiology and epidemiology of these less known diseases which are now becoming serious, to plan effective control measures.

5. DISEASES OF GINGER (*ZINGIBER OFFICINALE* ROSC.)

Ginger is affected by fungal, bacterial and viral diseases. The diseases affecting rhizome causing rhizome rot are very serious and have been reviewed in a separate chapter. However, foliar diseases are of considerable importance and are dealt in this chapter. Among leaf spot diseases like *Phyllosticta* leaf spot, anthracnose, *Helminthosporium* leaf spot and others, *Phyllosticta* leaf spot has become serious in recent years.

5.1 *Phyllosticta* Leaf Spot

Phyllosticta leaf spot disease is becoming increasingly important in many of the states due to severe leaf rot and blight that it causes. The disease was first reported from Godavari district of Andhra Pradesh and Malabar area of Kerala, erstwhile Madras State (Ramakrishnan, 1942). Later, it was reported from Himachal Pradesh (Sohi *et al.*, 1964), Maharashtra (Kaware, 1974) and Madhya Pradesh (Shukla and Haware, 1972).

5.1.1 *Crop Losses*

Disease causes severe leaf blight during wet weather conditions destroying the major photosynthetic area which indirectly affected the yield. During the early rhizome development phase and also at the harvest stage, there was significant difference in diseased plants with respect to fresh and dry weight and volume of the rhizome. The reduction in dry weight of the rhizomes from affected clumps ranged from 13.4 to 66.7 per cent (Brahma and Nambiar, unpublished).

5.1.2 *Symptoms*

The disease starts as water soaked lesion discernable on the lower surface with a pinhead sized whitish centre. As the lesions enlarge, they appear oval to elongated with a whitish centres surrounded by dark brown margin with a yellowish halo around the spot. The adjacent lesions coalesce resulting in large necrotic patches, leading to varying degrees of leaf blight and shredding.The mature lesions show mass of dark pycnidia in the infected tissues.

5.1.3 *Causal Organism*

Phyllosticta zingiberi s been established as the causal agent of the disease.

5.1.4 *Epidemiology*

Younger foliage is highly susceptible and the susceptibility decreased with increase in maturity of leaves. The disease is noticed right from June onwards with pre-monsoon showers. It gradually increased during July-August and continues with increase in rainfall, relative humidity, decrease in temperature and reaches its maximum during September. A temperature range of 23-28°C with intermittant showers favoured the disease development (Brahma and Nambiar, 1984). The disease spread is through rain splashes and is typically splash borne. Pycnidia are produced in infected tissue. The number of pycnidia and pycnidiospores per unit area were proportional to lesion area. With a drop of water in the lesion, the pycnidia releases pycnidiospores in the form of cirrus. Rain splashes would lead to splash dispersal of pycnidiospore both horizontally and vertically from the focus of infection (Brahma and Nambiar, 1984). It is not the amount of rainfall but the frequency of rain fall that is conducive for this disease development. During September, the disease incidence was maximum when temperature ranged from 22.6 to 29.2°C with a relative humidity from 77 to 93 per cent and number of rainy days of 17.3 (Brahma and Nambiar, 1984). Thereafter, it decreased with increase in temperature and decrease in rainfall.

Infected plant debris served as the primary source of inoculum. The pycniospores of the pathogen remained viable in the leaf debris present in the soil for about 14 months. The viability decreased with increase in depth of the soil with time. It was also established that the disease is seed borne (Brahma and Nambiar, 1982).

The disease incidence is more in pure crop where it is grown in exposed condition. Where ginger is grown as intercrop in coconut gardens or under partial overhead shade, the disease incidence and severity was less. Forcible and direct impact of rain droplets on the foliage under exposed conditions in pure crop and consequent fast dispersal of the inoculum might be the reasons for the severity of the disease, whereas under shaded condition in coconut gardens, the impact of rain droplet would be less and consequently the minimum dispersal of splash borne inoculum. The fungus produced a toxin which is host specific (Brahma, personal communication).

5.1.5 *Disease Management*

The disease is seed-borne. Selection of healthy seed from disease-free garden would reduce the chance of infection.

5.1.5.1 *Chemical control* : Timely spraying the foliage with fungicides would help in checking the disease. Once one or two plants found infected in the field, fungicidal spray should immediately follow, lest the disease spread would be faster. Bordeaux mixture (1%) spraying once or twice during the season would check the disease (Ramakrishnan, 1942). Spraying the foliage with Dithane Z-78 six times at fortnightly intervals gave a good control. Dithane M-22 (0.2%), Flit 406 (0.3%) and Bordeaux mixture spray also were recommended (Sohi *et al.*, 1973). Since seed rhizomes are treated with fungicides for rhizome rot control, it would be interesting to monitor leaf spot incidence in such fields. This would help to increase or decrease the frequency of fungicidal application which would be helpful for the control of both the diseases. There is a need to use systemic fungicides for the control of this leaf spot disease.

5.1.5.2 *Disease resistance* : None of the available cultivars showed high degree of resistance. Variable results were obtained by different workers and this might be due to prevailing environmental conditions at different location of study. Cultivar Taffingiva was reported to be highly tolerant followed by Maran, Bajpai and Nadia (Nybe and Nair, 1979) under Kerala conditions. Cultivars Maran and Karakkal were found to be comparatively resistant whereas cultivars Wynad-Mananthody, Wynad-Kunnamangalam, Arippa, Narasapattom, Thingpuri, Burdwan, Vengara, Tura, Wynad local, Jugijan, Ernad-Chernad and Taiwan were highly susceptible under Kerala condition (Premanathan *et al.*, 1982). In Himachal Pradesh, cultivars IC 26818, IC 26802, IC 26868, IC 26814, IC 29914 and IC 29781 were found to be moderately resistant (Dohroo *et al.*, 1986).

There is a need to screen more cultivars for their reaction to this disease and efforts should be made to locate productive types with multiple resistance to rhizome rot and leaf spot disease. Since the pathogen also is known to produce a toxin, this could be utilised for *in vitro* screening of callus and cell cultures to develop resistant types.

5.2 Minor Diseases of Ginger

At present, besides the *Phyllosticta* leaf spot, there are several other leaf spot diseases reported which are of minor importance. Among these *Helminthosporium maydis* from Bihar (McRae, 1917; Mitra, 1931), *Leptosphaeria gingiberi* from Meghalaya

(Dhar *et al.*, 1981), *Curvularia brachyspora* Boedjin (Kore and Bide, 1976) *Pyricularia zingiberi* (Rathaiah, 1979) from Assam, *Cercoseptoria zingiberi* (Rathaiah, 1981), *Septoria zingiberis* (Sundaram, 1961), *Colletotrichum zingiberis* (Sundar) Butler and Bisby (Butler and Bisby, 1931; Nema and Agarwal, 1960); *Cercospora* leaf spot (Ramakrishnan, 1956) and thread blight caused by *Pellicularia filamentosa* (Pat) Rogers (Sundaram, 1953) are some of the fungi causing leaf spot/leaf rot diseases.

5.2.1 *Mosaic Disease*

The disease was reported from Kerala (Nambiar and Sarma, 1975). The disease starts as chlorotic flecks on leaves which later develop into spindle shaped chlorotic streaks which enlarge further. This chlorotic patches interspersed with green shades give the appearance of mosaic symptom. Sap transmission from ginger to ginger, ginger to *Nicotiana tabacum* var. Harrison special, *N. tabacum* var. *rustica*, *Nicotiana* var. *xanthi*, *N. glutinosa*, cardamom, turmeric (*Curcuma longa*, *C. aromatica*) were negative. It is not clearly known whether it is a strain of wheat streak mosaic virus, which was transmitted from wheat to ginger (Ganguli and Raychaudhuri, 1971). Hot water treatment of infected rhizomes at 45-50°C for 3, 6 and 12 h did not alleviate symptoms. Out of the 31 types studied for their disease reaction under field conditions, disease incidence ranged from 13.30 in Gujarat 11 to 76.16 per cent in Pune. The disease did not have any apparent effect on the yield, but it is necessary to check for any change in the quality parameters of the rhizome.

6. DISEASES OF TURMERIC (*CURCUMA LONGA* LINN.)

Foliar diseases of turmeric are only next to rhizome rot in their importance, since the loss of active photosynthetic area of the leaves affects the yields considerably. The diseases were reviewed earlier (Joshi and Sharma, 1982).

6.1 *Taphrina* Leaf Spot

The disease is widely distributed in the southern states and the Gangetic plains in Uttar Pradesh and Bihar. This was first reported from Gujarat, Saharanpur (UP) and Rangpur (East Pakistan) (Butler, 1911).

6.1.1 *Crop Losses*

Though precise crop loss figures are not available, the foliar destruction it causes would reduce the yields considerably especially when the disease starts in its early stages of crop growth (Butler, 1918).

6.1.2 *Symptoms*

The disease starts as small scattered oily looking translucent spots on the lower leaves when the plants are in 3-4 leaf stage. The leaf spots later turn dirty yellow and deepens to colour of gold and some times to bay shade. The adjacent individual leaf spots of 1-2 mm in diameter coalesce forming reddish brown blotches leading to varying degrees of leaf blight (Butler, 1911).

6.1.3 *Causal Organism*

Taphrina maculans has been identified as the causal organism.

6.1.4 *Epidemiology*

The pathogen infects most of the leaves leaving 2-3 leaves at the top. The disease incidence is influenced by soil-borne inoculum and prevailing weather condition. Moist cloudy weather with temperature of 25-30°C during August-September were found (Upadhyay and Pavgi, 1967c) conducive for the disease initiation. It was also reported that primary infection occurs on the lower leaves during October-November when temperatures of 21-23°C and relative humidity of 80 per cent prevail (Ahmed and Kulkarni, 1968b).

Young leaves, two weeks after unfurling remain susceptible for about a month, and susceptibility gradually decreases with age. However, they remain susceptible considerably for a longer period irrespective of their age provided environmental conditions and inoculum are at optimum level (Upadhyay and Pavgi, 1967c). The secondary infection is by ascospores discharged from successively maturing asci which grow into octosporous microcolonies and infect fresh leaves without any dormancy. The primary infections are less harmful than the secondary infection inciting profuse spotting covering a large foliage (Upadhyay and Pavgi, 1966).

The disease perpetuates from one season to other through viable ascogenous cells borne on the infected leaf debris in the fields after harvest as well as through desiccated ascospores and blastospores ejected from mature asci during the crop season and over-summering in the soil and leaf trash (Upadhyay and Pavgi, 1967b). However, this mode of perpetuation was disagreed (Ahmed and Kulkarni, 1968b).

The fungus has been cultured (Pavgi and Upadhyay, 1964; Ahmed and Kulkarni, 1968a).

T. maculans has been reported to infect *C. amada* (Upadhyay and Pavgi, 1967a), *C. angustifolia*, *Zingiber cassumnar*, *Z. zerumbet* and *Hedychium* sp. (Butler, 1911).

6.1.5 *Disease Management*

6.1.5.1 *Crop rotation* : In view of the perpetuation and over-summering of the pathogen in leaf debris in the soil, crop rotation becomes important to reduce the inoculum build-up.

6.1.5.2 *Chemical control* : Aureofungin, an antifungal antibiotic at 2.5 g/ml was highly inhibitory to the growth of *T. maculans* (Thirumalachar *et al.*, 1969). Foliar sprays with

Dithane Z-78 (0.35%) reduced infection while 0.45 per cent Hexaferb increased rhizome yield (Upadhyay and Pavgi, 1974). Zineb (0.1%) (Nirwan *et al.*, 1972) and Dithane Z-78 (0.2%) followed by Dithane M-45, Blitox 50, Bavistin and Cuman (Srivastava and Gupta, 1977) were also effective as foliar sprays.

6.1.6 *Disease Resistance*

Variable reaction of cultivars to *T. maculans* and *Colletotrichum capsici* was reported (Reddy *et al.*, 1963). A turmeric clone selected from a local susceptible variety remained immune for three cropping seasons in Banaras area (Upadhyay and Pavgi, 1967a). Varieties CLL 320 Amalapuram, CLL 324 Ethamukala, CLL 316 Gorakhpur, CLL 326 Mydukur, Karhadi Local, Muvattupuzha, Ochira, No. 74 and Alleppey among longa types, Ca 68 Dhagi, Ca 67 Jobedi, Kasturi among aromatica types remained free from disease for three seasons under field conditions at Kasaragod, Kerala (Nambiar *et al.*, 1977). Development of field resistant/tolerant types coupled with resistance to rhizome rot and *C. capsici* would be of priority to check the disease, since chemical control would not be a feasible proposition.

6.2 *Colletotrichum* Leaf Spot

The disease is prevalent in majority of the turmeric growing areas in India. This was first recorded in Coimbatore district of erstwhile Madras State (McRae, 1917), Andhra Pradesh (Ramakrishnan, 1954) and is severe in southern states specially in Tamil Nadu and Andhra Pradesh.

6.2.1 *Crop Lcsses*

Being a foliar infection, the yield loss would be due to foliar damage, resulting in the loss of effective photosynthetic area and consequent effect on the yield. When the infection is severe resulting in drying up of the whole foliage losses would exceed 50 per cent (Ramakrishnan, 1954). Reduction in the dry rhizome weight by 62.7 per cent was also reported due to foliar infection by *C. capsici* (Nair and Ramakrishnan, 1973).

6.2.2 *Symptoms*

Leaf spots elliptic to oblong of various sizes enlarge into 4-5 cm long and 3 cm wide occupying the major portion of leaves. The mature spot appear greyish white at centre with a brown margin surrounded by a yellowish halo. The whitish centre with dark acervuli often becomes papery and gets torn off.

6.2.3 *Causal Organism*

Vermicularia curcumae Syd. was first reported as the causal agent (McRae, 1917). *V. curcumae* and *V. capsici* were considered as synonymous (Sundararaman, 1926). Later, it was revised as *Colletotrichum curcumae* (Butler and Bisby, 1931). Based on the measurement of conidia and cross inoculation studies, merging of *C. curcumae* with *C. capsici* was suggested (Ramakrishnan, 1947). It is now considered as *C. capsici*. However, some workers consider *C. capsici* and *C. curcumae* separately (Kar and Mohapatra, 1981; Palarpawar and Ghurde, 1989a).

6.2.4 *Epidemiology*

The disease generally appears in August-September when the crop is about 4-5 months old (Ramakrishnan, 1954). The disease starts in the younger leaves and spreads to the other leaves. The younger leaves were found more susceptible compared to older leaves, which was attributed to loss of carbohydrates and phenol and more of total nitrogen in younger leaves compared to older leaves (Nair, 1972).

The time of planting influenced the onset and severity of the disease. The crop sown between 12 June and 17 July under Coimbatore condition showed severe disease incidence (Subbaraja, 1981). Late planting (July-August) recorded severe disease incidence (Nair, 1972). Disease conducive environmental factors and the age of the host plant might be the reasons for this severe incidence.

Weather factors in relation to disease incidence showed a positive correlation of total rainfall to disease incidence at 90 days crop growth phase. At 120 days, there was positive correlation between relative humidity and disease incidence (Subbaraja, 1981).

The fungus could infect *Aristolochia bracteata*, seedlings of *Gossypium herbaceaum*, chickpea, brinjal fruit, chillies and *Whitiana sominifera*.

The disease spread is mainly during wet weather. Of the 13 plant species tested, pigeonpea, cluster beans, *jowar*, ginger and papaya were found susceptible to *C. curcumae* (Palarpawar and Ghurde, 1989b). *C. capsici* was considered to perennate in the scales of the rhizomes as dormant stromata (Sundararaman, 1925). This was disputed since, under high temperature, the fungus might not survive in the stromata (Ramakrishnan, 1954). However, the infection might come from other hosts since the fungus is reported to infect a variety of crops. *C. curcumae* was found to survive in the field and laboratory for about 9 and 12 months respectively which could be potential source of primary inoculum (Palarpawar and Ghurde, 1989b).

6.2.5 *Disease Management*

6.2.5.1 *Cultural*: Fertilizer application showed definite influence on the disease incidence. When nitrogen was applied at 120 kg/ha, the disease incidence reduced irrespective of the split doses applied. Similarly, potash application also reduced the disease incidence. Higher doses of potash at 70 and 120 kg/ha reduced the disease, the disease incidence was 21.8 and 18.6 per cent, respectively compared to 46.3 per cent in control (Subbaraja, 1981).

6.2.5.2 *Chemical control*: Spraying the crop with Bordeaux mixture (1%) during August checked the disease (Ramakrishnan, 1954; Govinda Rao, 1951). Spraying the foliage with Flit 406 (captan) and Dithane Z-78 at monthly intervals during September-December reduced the disease (Dakshinamurti *et al.*, 1966). None of the fungicides were found effective in checking the disease except zineb which gave maximum protection followed by copper oxychloride + zineb and Bordeaux, which gave disease incidence of 2.6, 3.2 and 3.3 per cent, respectively, compared to 6.1 per cent in control (Nair, 1972). Bavistin (0.2%) was found very effective in disease suppression and it also increased yields (Subbaraja, 1981). Of the 13 fungicides tested, hinosan (0.1%) with 5 rounds of spray at 15 days intervals starting from 15 June to 15 September was found to check the disease caused by *C. curcumae* effectively (Palarpawar and Ghurde, 1989c). Six sprays of Dithane M-45 at 0.25 per cent at an interval of 15 days reduced this disease incidence and increased yield by 0.975 tonnes (dry)/ha. The rate of decrease of yield due to unit increase of disease was found to be 0.42. The cost benefit ratio for Dithane M-45 worked out to be 2.44. Though Bavistin was slightly superior to Dithane M-45 in disease reduction, it was not commensurate with yield (Rao and Rao, 1987).

6.2.6 *Disease Resistance*

None of the varieties screened at Pedpalem (A.P.) were found resistant either to *T. maculans* or *C. capsici* (Reddy *et al.*, 1963). Of the 19 types screened, none of them was found resistant. The least susceptible selections were TS-2, TS-4, TS-79, TS-83, TS-88 (Patel and Moniz, 1973). Of the 150 types screened, 14 types were found resistant (Score 5-20%) and Sugantham was the best (Subbaraja, 1981). Of the 14 cultivars screened in the field under artificial inoculation condition, Bhendi, Gadhavi, Kasturi and Krishna were found resistant. Sugantham was found highly susceptible. Only three cultivars, viz., Bhendi, Gadhavi and Kasturi were resistant to both *C. curcumae* and *C. capsici* (Palarpawar and Ghurde, 1989a). Incidentally, Sugantham which was found to be highly susceptible under West Bengal condition (Palarpawar and Ghude, 1989a) was found resistant under Tamil Nadu condition (Subbaraja, 1981). This indicated the necessity for the uniformity of the material and screening methodology for resistance screening under different agro-climatic conditions. Sugantham was also highly susceptible to *T. maculans* (Nambiar *et al.*, 1977).

The foregoing information indicates that there is a need for variety with dual resistance to *T. capsici* and *T. maculans* coupled with high yield and quality which can be integrated with fungicides like Dithane M-45 to make disease control cost effective.

6.3 Minor Diseases of Turmeric

Apart from these two major leaf spot diseases, few minor diseases also have been recorded on turmeric. Leaf spots caused by *Phaeorobillarda curcumae* n. spec., *Phyllosticta zingiberi, Cercospora curcumae-longae* sp. nov., *Myrothecium roridum* Toxde Ex. Fr. (Pavgi and Upadhyay, 1967), *Pyricularia curcumae* on *C. longa* (Rathaiah, 1980a), *Thirumalacharia curcumae* on *Curcuma* sp. and leaf blight caused by *Corticium sasakii*

(Saikia and Roy, 1975) are some of the minor diseases which are not of economic importance at present.

7. DISEASES OF TREE SPICES

Clove, nutmeg, cinnamon and allspice are generally referred to as tree spices. The disease problems of these crops are less compared to the other spices and as such detailed studies on disease management are lacking. Tree spices are generally restricted to three southern states, i.e., Kerala, Karnataka and Tamil Nadu. Based on the survey carried out earlier, some of the disease problems in these crops have been identified and described (Nair *et al.*, 1977).

7.1 Diseases of Clove (*Syzygium Aromaticum* (L) Merr and Perry.)

Leaf rot, leaf blight and little leaf are some of the diseases of clove.

7.1.1 *Leaf Rot*

Leaf rot caused by the fungus *Cylindrocladium quinqueseptatum* and is noticed both in the nursery as well as in grown up plants. In nursery, the disease become severe occasionally resulting in heavy defoliation and death of seedlings.

7.1.1.1 *Symptoms* : The lesions start from the margins or from the tip as water soaked lesions which merge to form chocolate brown coloured areas exhibiting leaf rot symptoms (Sarma and Nambiar, 1978). Mixed leaf infections of *C. quinqueseptatum* as well as *Colletotrichum capsici* have been reported (Wilson *et al.*, 1979).

7.1.1.2 *Epidemiology*: The disease is seen during July-September coinciding with south-west monsoon but occur in a mild form throughout the year. Whitish fungal growth appears on the necrotic areas supporting abundant sporulation. During rainy season with the intermittant rain splashes, the disease spreads fast. In June, the disease severity is more in open conditions compared to the nursery maintained under thatched sheds. *C. quinqueseptatum* was found to infect *Eugenia jambolana, Pimenta dioica, Eucalyptus grandis, E. maculata* and *E. globulus.*

7.1.1.3 *Disease management*: The disease control programme includes timely sprayings of the nursery with 1 per cent Bordeaux mixture to keep disease under check. Infected seedlings are to be removed from the nursery to avoid subsequent disease spread.

7.1.2 *Seedling Wilt*

The mortality of seedlings in the nursery has been reported to range from 5 to 40 per cent (Nair *et al.*, 1977).

The affected seedlings lose natural lustre. The leaves tend to droop and ultimately die. The root system and collar of the seedlings show varying degree of discolouration. Several pathogens were reported to be responsible for this (*Rhizoctonia bataticola, Cylindrocladium* sp. and *Phytophthora* sp.).

7.1.3 *Leaf Spots*

Gloeosporium sp. has been reported to cause leaf spots which require initial injury (Jose and Paily, 1966). *Colletotrichum capsici, C. crassipes* were also recorded on cloves which cause leaf spots (Wilson and Vijayan, 1980; Chandramohanan and Kaveriappa, 1986), *Corynespora cassiicola* is recorded on clove in Assam (Saikia and Sarbhoy, 1981).

7.1.4 *Twig Blight and Flower Shedding*

Glomerella cingulata is reported to cause twig blight and flower shedding. The pathogen survives on the weed *Clerodendron infortunatum* which is found in clove plantations (Karunakaran and Nair, 1980c; Karunakaran *et al.*, 1980).

7.1.5 *Little Leaf*

This is characterised by stunted growth due to the development of branches in acute angles and the reduced size of leaves and internodes. Primary and secondary branches also get reduced and the trees fail to flower. It is suspected to be caused by mycoplasma. Affected seedling showed recovery after 5 biweekly sprays with 200 ppm tetracycline (Balasubramanyam, 1957; Karunakaran and Nair, 1980b).

7.1.6 *Plant Parasitic Nematodes*

Several genera of nematodes have been reported to infect roots of clove, which includes *Meloidogyne* sp and *Helicotylenchus* sp (Sundararaju *et al.*, 1979). Incidentally clove plants have been reported to be mycotrophic. The colonisation of mycorrhiza was 48.9 per cent (Nair and Girija, 1988). The role of this association in suppression of nematode infection needs indepth study.

7.2 Diseases of Nutmeg (*Myristica Fragrans* Houtt.)

7.2.1 *Fruit Rot*

Three fungi, viz., *Phytophthora* sp., *Diplodia natalensis* and *Colletotrichum gloeosporioides* have been reported to cause fruit rot. *Phytophthora* causes wet rot and the later two cause dry rot. Symptoms include appearance of water soaked lesions on the pedicel which turn brown. This extends to the rind and the immature fruits develop splitting of pericarp and are shed. In advanced cases, the mace also is infected (Ramakrishnan and Damodaran, 1954; Nair *et al.*, 1977). In case of *Colletotrichum gloeosporioides* anthracnose, small greasy blister like spots measuring 3-4 mm in diameter are noticed on fruit stalk. In advanced stages, the blister erupts. In some cases, the infected fruits become mummified (Sankaran *et al.*, 1980). *Thielaviopsis (Ceratocystis) paradoxa* is also reported to cause fruit rot (Rao *et al.*, 1976).

7.2.2 *Leaf Rot and Shot Hole*

Colletotrichum sp. is reported to cause shot hole symptoms. The infection may start on the leaf lamina as small brown spots which spreads gradually and appear as oblong or oval spots delimited by veins.The necrotic spots develop acervulii and are dropped off creating shot hole symptoms (Menon and Remadevi, 1965; Sankaran *et al.*, 1980). Leaf rot is caused by *Cylindrocladium quinqueseptatum.* The rotting starts from the tips of the leaves and spread downwards resulting in marginal necrosis and rotting of leaves (Nair *et al.*, 1977). Leaf blight caused by *Pestalotiopsis palmarum* has been also reported (Radhakrishnan, 1986).

7.2.3 *Die-back*

The tips of branches and twigs often start drying up from tip downwards exhibiting die-back symptom. This is caused by *D. plodia natalensis* (Wilson and Sathiarajan, 1974). Pruning-off of the affected branches and application of Bordeaux paste checks the disease.

7.2.4 *Thread Blight*

Marasmius sp. has been reported to cause two types of thread blights. White thread like hyphal aggregation traverse along the stem and ventral side of the leaves spreading in an irregular fashion. The affected leaves blight and remain attached to the stem by the fungal hyphae. The second one resemble horse hair blight with black silky threads on stem and leaves (Nair *et al.*, 1977). The former is caused by *M. pulcherima* and the latter is caused by *M. equicrinus*. Bordeaux mixture spray checks this disease.

7.2.5 *Seedling Wilt*

Seedling wilt is a serious problem in nurseries. This results in 5-40 per cent mortality of the seedlings (Nair *et al.*, 1977). The leaves of the affected seedlings lose natural lustre, tend to droop and collar of seedlings show varying degrees of discolouration and decay. Several fungi, viz., *Cylindrocladium* sp., *Fusarium* sp., *Colletotrichum* sp., *Rhizoctonia bataticola* and *Phytophthora* sp. have been implicated. *Fusarium* sp. was found to be pathogenic to 1-3 years old seedlings (Phillip *et al.*, 1973; Raju and Leelavathy, 1987). *Cylindrocladium camelliae* is reported to cause wilting and death of eight years old nutmeg plants (Rahman *et al.*, 1981).

7.3 Diseases of Cinnamon (*Cinnamomum Verum presl*)

Cinnamon is affected by a few foliar diseases.

7.3.1 *Leaf Spots and Die-back*

Colletotrichum gloeosporioides (Glomerella cingulata) is reported to cause leaf spot and die-back of cinnamon (Karunakaran and Nair, 1980a; Sampathkumar, 1983; Raju and Leelavathy, 1987). *Cacoma keralencis* is reported to cause hypertrophy and witche's broom of young shoots (Hosagauder, 1984).

7.3.2 *Seedling Blight*

Diplodia sp. has been reported to cause light brown patches on the stem which later blights (Nair *et al.*, 1977). *Cephaleruas* sp., an algal parasite, causes leaf spots.

7.4 Diseases of Allspice (*Pimenta Dioica* (L) Merr.)

7.4.1 *Leaf Rot*

Grey to brownish grey coloured discolouration appears on the margin of leaves which extend inward causing leaf rot. Affected leaves drop off causing varying degree of defoliation. The disease is caused by *Cylindrocladium quinqueseptatum*. Lower surface of the infected leaves show downy growth due to production of abundant conidia. The disease is generally noticed during July-September. In addition, *Pestalotiopsis* also causes leaf rot. The brown lesions of *Pestalotiopsis* exhibit dark brown advancing margins. The fungus produce conidia in acervuli on the upper surface of affected leaves which could be seen as black dots. In severe cases both these fungi cause die-back (Anandaraj and Sarma, 1992). Spraying the foliage with 1% Bordeaux mixture checks this disease.

Detailed investigations on the diseases of spice crops especially the etiology and epidemiology are very recent. Concerted efforts are warranted for indepth studies on these lines to arrive at effective disease management strategies. Except for the location-specific problems like foliar diseases where specific control measures become important, in general, a holistic view of the overall health of the spice crops should be taken into consideration with an aim to suppress all pathogens that affect the plant health, to boost up their vigour and productivity. This becomes all the more relevant since majority of the diseases are soil-borne and crops are grown in various combinations in mixed and intercropping systems where an array of pathogens affecting these crops would render the disease management more complex. Many of the spice crops being perennial, a systematic approach in disease management, involving planting of disease-free material and adoption of regular prophylactic measures with an integrated approach would be a practical strategy to check the crop loss due to these diseases. Spices being export oriented crops any pesticide residues to the produce render it unsuitable for export. Integrated disease management should aim to reduce dose of pesticides to the minimum and encourage organics for disease suppression.

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