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Chapter 15

Leaf diseases

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1. INTRODUCTION

Most of the rubber growing tracts of India receive an annual rainfall ranging from 1500 to 4000 mm. About 70 per cent of the total rainfall is received during the southwest monsoon in the months of June, July and August. The remaining portion of the rainfall is contributed by the northeast monsoon during October and November. Very often the northeast monsoon is unreliable and scanty in most of the northern belt of the traditional rubber growing area. Drought conditions prevail in these areas for more than six months. These unfavourable climatic conditions adversely affect growth and yield of rubber plants and also act as predisposing factors for various diseases.

Of the many leaf diseases affecting rubber plants, abnormal leaf fall and powdery mildew are the most economically significant ones noticed in India. The others include shoot rot, *Corynespora* leaf disease, *Gloeosporium* leaf disease, bird's eye spot, anthracnose and thread blight.

2. ABNORMAL LEAF FALL

The most destructive disease of rubber in India is abnormal leaf fall. The disease occurs annually during southwest monsoon months of June, July and August. It infects pods, leaves and tender shoots causing heavy defoliation and die-back of tender twigs.

The first report on this disease from India was in 1910 from estates near Palapilly, in Trichur district, Kerala state (McRae, 1918). In due course, the disease spread to all other rubber growing districts. Later, the disease was reported from Sri Lanka and Burma (Petch, 1921). Subsequently pod rot and leaf fall were also reported from Cambodia, Vietnam, Liberia, Ghana, Nigeria, Cameroon, Congo, Brazil, Peru, Nicaragua, Costa Rica and Venezuela. In Malaysia, a serious outbreak of this disease was noticed during 1966 (Chee *et al.*, 1967; Chee, 1969). Pod rot and leaf fall due to *Phytophthora* attack have been reported from Thailand also (Chee and Greenwood, 1968). Though this disease occurs in several countries, severe incidence necessitating adoption of control measures every year is observed only in South India.

2.1 Disease development and symptoms

Rainfall is the most important predisposing factor for the initiation and spread of the disease. In the traditional rubber cultivated areas in India, a continuous spell of 250 to 350 mm rain for 7 to 10 days without intermittent hot sunshine, with minimum and maximum temperatures within the range of 22 to 25°C and 26 to 30°C respectively and relative humidity (RH) above 90 per cent are most congenial for the outbreak of the disease. Under such conditions of low temperature and very high atmospheric humidity, the disease spreads rapidly and assumes epidemic proportions. Under normal monsoon, the disease starts by the middle of June and reaches the peak by the middle of July. However, when monsoon is late, very heavy incidence is noticed from the middle of July to middle of August. In certain years, the disease is noticed during May if sufficient pre-monsoon showers are received.

Inoculum development starts with the germination of previous season's oospores, which are resting spores, present in the infected dried pods, leaves and twigs deposited on the soil as well as remaining on the trees (George and Edathil, 1975). The infection appears on the green pods either remaining on the trees or fallen on the ground. The affected pods rot, turning into dull grey colour with water-soaked lesions. Drops of latex ooze out from the lesions and form dark spots on the infected surface (Plate 41. a). The fungal mycelia ramify inside the pericarp and also penetrate into the endosperm of the seed. The pericarp rots very soon and a white fluffy growth of the fungus develops on the surface of the fruits. The pathogen produces enormous number of sporangia which appear as a thick, white, cheesy coating on the surface of the rotting pods under continued wet weather (Plate 41. b). The infected fruits very often do not produce viable seeds. The vertical and horizontal spread of the disease are assisted by rain splashes (Peries, 1969) containing sporangia in small water particles blown by wind and also by insects, carrying large quantities of sporangia on their body parts (Edathil and Pillay, 1976).

On leaves, the petioles are the main seat of infection, though lesions are observed on the stalk of leaflets, midrib and lamina. On the petioles water-soaked lesions which are dark brown or in various shades of black colour appear with a drop of latex coagulated in the middle (Plate 41. c). The affected leaves fall off with the leaflets intact while they are still green. Occasionally, the infected leaves turn copper red before falling. Water-soaked lesions are also formed on the leaf lamina with dull green colour which turn to various shades of black (Plate 41. d). Under favourable climatic conditions, the leaf fall is so heavy that the fallen leaves cover the entire ground forming a green carpet (Plate 42. a, b). After defoliation, the pathogen invades leaf-bearing twigs and causes extensive die-back.

Apart from *Hevea*, *Phytophthora* spp. infect a large number of plants. *Areca catechu*, *Anacardium occidentale*, *Artocarpus* spp., *Borassus flabellifer*, *Bougainvillea* sp., *Citrus* spp., *Cocos nucifera*, *Colocasia* spp., *Elettaria cardamomum*, *Eugenia caryophyllata*, *Jatropha curcas*, *Dendrophthoe* spp. (*Loranthus* spp.), *Mangifera indica*, *Psidium guajava*, *Punica granatum*, *Piper nigrum*, *Spondias mangifera* and *Theobroma cacao* are a few economically important plants affected by this pathogen.

2.2 Causal organism

Different species of *Phytophthora* are reported to be causing pod rot, bark rot, patch canker and leaf fall diseases of rubber in various countries. In India, four species of *Phytophthora* viz. *P. palmivora* (Butler) Butler, *P. meadii* McRae., *P. nicotianae* var. *parasitica* (Dastur) Waterhouse and *P. botryosa* Chee were isolated from infected specimens (Thankamma *et al.*, 1968; Edathil and George, 1976; 1980). However, the species most common in the traditional areas is *P. meadii*.

P. faberi Maubl., *P. heveae* Thompson, *P. capsici* Leonian, *P. citrophthora* (Smith & Smith) Leonian, *etc.* are the other species associated with this disease in other countries (Petch, 1921; Ramakrishnan and Pillay, 1961a; Chee, 1969).

Hyphae of the fungus are found to ramify inside the tissues of the infected portions intercellularly or intracellularly. Sporangia are found emerging externally through the stomata. The shape and size of the sporangia vary according to the species. During favourable climatic conditions, the pathogen resorts to the production of profuse asexual sporangia (Plate 42. c), which aid in quick dispersal and rapid spread of the disease. The sporangia liberate binucleate, biciliate, reniform zoospores which swim in the available water and on contacting the green tissues, produce germ tubes, thus establishing a fresh infection on the host. Sporangia may also germinate directly producing germ tubes which also causes fresh infection. The pathogen gains entry into the host tissue through stomata (Thankamma *et al.*, 1975).

The pathogen also produces asexual resting spores called chlamydospores. These spores are observed to germinate readily in favourable weather. Sexual reproduction involving antheridia and oogonia resulting in the formation of thick-walled oospores (Plate 42. d), was noticed in culture as well as on infected plant parts. Oospores produced in culture or on infected plant parts, as well as those present in the soil could germinate and establish new colonies (Thankamma, 1969; George and Edathil, 1975). The pathogen can oversummer in the soil and in the infected dried tissues with the help of these thick-walled oospores which serve as resting spores (George and Edathil, 1975).

2.3 Economic importance

On young rubber up to three years and in nursery plants, leaf fall and shoot rot occur causing extensive die-back. In such cases, growth is retarded resulting in an extended period of immaturity. In mature plantations, extensive defoliation results in considerable loss of crop. Field trials on three clones have indicated that this disease can cause yield loss of 38 to 56 per cent when left unsprayed for one disease season (Ramakrishnan, 1960). Extensive die-back of leaf-bearing twigs also results in loss of vigour of the affected plants. In an attempt to simulate the defoliation effect of this disease by clipping off the leaves from yielding Gl 1 plants to different canopy densities, yield was reduced by 23 and 31 per cent when the defoliation was 50 and 75 per cent respectively (Pillay *et al.*, 1974). Further trials on yield loss in high yielding susceptible clones of 10 to 25 years age by leaving the area unsprayed for one season indicated 9 to 16 per cent yield reduction due to this disease. The disease adversely affected growth and bark renewal of the trees. Yield in the subsequent year was also affected adversely in unsprayed areas even though those areas were sprayed during the subsequent season. Increase in plugging index, reduction in DRC of latex and more weed growth were also some of the other effects of the disease (Jacob *et al.*, 1989).

2.4 Clonal susceptibility

In general, all high yielding clones and clonal seedlings are susceptible to abnormal leaf fall disease under Indian conditions. Clones like PB 86, PB 235, PB 260, PB 311, PB 28/59, RRIM 600, RRIM 628, RRIM 703, RRII 5, PR 255, PR 261 and Tjir 1 are observed to be susceptible to the disease. But clones like RRII 105, PB 217, GT 1 and Gl 1 are observed to retain more leaves than the susceptible clones under similar prophylactic spraying (Ramakrishnan and Pillay, 1961c; Rubber Board, 1993). However, these clones are also observed to be moderately affected by this disease, if left unsprayed.

2.5 Control measures

2.5.1 Physical control

McRae (1918) recommended field sanitation and removal of all infected and dried up twigs, fruits and fruit stalks of the previous season from the trees, to destroy the potential source of the primary inoculum. He also suggested deblossoming and defruiting to prevent primary pod infection and subsequent large-scale multiplication of the pathogen. However, these methods were found uneconomic and ineffective and were abandoned by the planters.

2.5.2 Cultural control

Crown budding of high yielding susceptible clones using resistant clones was tried on an experimental basis to combat the disease. Clones like RRII 33, Fx 516 and F 4542 were used as crowns. It was observed that the immaturity period was delayed by about one year in case of crown-budded plants. The yield data indicated that the yield of RRIM 600 and RRIM 628 panel clones which were crown budded with the above three clones was more than that of plants which were not crown budded. However, in the case of GT 1 the yield of crown-budded plants was less (Pillay *et al.*, 1986).

2.5.3 Chemical control

Chemical control of this disease was first propounded by Ashplant (1928), who recommended prophylactic spraying of rubber plants with 0.75 per cent Bordeaux mixture and this method soon became very popular. Later experiments revealed that one per cent Bordeaux mixture was more effective for the control of this disease and is being adopted extensively by rubber planters. For protecting young rubber and nursery plants, repeated rounds of spraying is essential. Spray volume in this case varies depending on the canopy size. Addition of stickers will be beneficial during heavy rains. Depending on the canopy spread of the mature plants, up to 3000 L per ha of spray fluid may be necessary for effective control (Idicula *et al*, 1989). It was noticed that addition of 0.5 per cent zinc sulphate to 0.5 per cent Bordeaux mixture could give adequate protection to the clones RRIM 600 and RRII 105 and reduced the cost of spraying by about 35 per cent when compared to spraying with one per cent Bordeaux mixture (Idicula *et al.*, 1994). The labour force required for this type of high volume spraying is large and an enormous quantity of water is required for the preparation of the mixture. Under tropical conditions the maximum potency of copper fungicides persists only for four to six weeks. Therefore, spraying has to be undertaken as close to the monsoon as possible but before its onset. Moreover, high volume spraying of Bordeaux mixture (Plate 42. e) is a slow operation and an area of about 0.4 ha of mature rubber can only be covered in a day using one rocker sprayer by employing 10 to 15 labourers, resulting in high spraying cost.

As an alternative to Bordeaux mixture, copper oxychloride (COC) dispersed in agricultural spray oil sprayed through low volume applicators proved effective for the control of this disease. Low volume spraying using micron sprayers (Plate 42. f) from the ground or aerial application through helicopters (Plate 42. g) is also being recommended for the control of this disease (Pillay and George, 1973). Using a micron sprayer and five to six labourers, an area of 4 to 5 ha can be covered in a day. Depending on the payload of the helicopter and weather conditions, about 300 ha of mature rubber can be sprayed per day. Between these two, micron spraying is cheaper. Lighter sprayers *viz.* Microspray power 400 and ASPEE Turblow sprayer have been found very effective (Jacob and Jayarathnam, 1993). Tractor-mounted sprayers have also been tried in some estates. Fogging machines like Tart, Tiga and Pulsfog were also experimented. With Tiga, reasonably good control of the disease was obtained (Edathil *et al.*, 1984a), but fire hazards and frequent breakdown are the major defects.

Two formulations of oil-dispersible copper oxychloride are available for spraying on rubber. Oil-based copper in a paste form containing 40 per cent metallic copper is being used for low volume spraying on rubber. Oleocop and Fycol-8 are two such products which have been marketed. Oil-dispersible copper oxychloride in powder form containing 56 per cent metallic copper is also being used extensively. This material is cheaper and has better shelf life in contrast to oil-based copper. The product is marketed in the trade names Chlorocop, Fycop, *etc.* Oil-dispersible formulations of mancozeb are also being tried experimentally (Jacob *et al.*, 1994).

Copper fungicides dispersed in spray oil will seriously scorch rubber plants if sprayed through ordinary high volume sprayers. Spray oil marketed by Indian Oil Corporation (IOC), Cochin Refineries Ltd. (CRL) and a few other companies are approved for use in rubber plantations. For micron spraying, about 30 to 37 L of COC-spray oil mixture mixed in 1 : 5 proportion is recommended per ha of mature rubber. For aerial application, 8 kg of oil-dispersible copper oxychloride in 40 L of spray oil is recommended per ha (Pillay, 1977). The efficacy of the dose was found to be related to the clone and the prevailing local rainfall pattern (Edathil *et al.*, 1994).

2.5.4 Biological control

Natural control of abnormal leaf fall disease is obtained by moderate incidence of *Oidium* during flowering season, thus affecting production of fruits, which are the primary source of inoculum for abnormal leaf fall. *Trichoderma* spp. were observed to inhibit the growth of *P. meadii* and cause lysis of oospores (Vanitha *et al.*, 1994).

3. SHOOT ROT

During the southwest monsoon period, this disease infects tender portions of nursery plants as well as immature and mature trees in the fields and is associated with abnormal leaf fall disease. The causal organism is *Phytophthora* spp.

3.1 Disease development and symptoms

Initial symptom of this disease is noticed on the terminal portions, especially on the purple-coloured leaflets. Dark or water-soaked lesions appear either at the tip or along the margins of the infected leaflets. Within 24 to 48 h, the leaflets become limp and dark-coloured and the rotting extends up to the petiole. In a short time, infection spreads to other leaflets also. Subsequently, infection spreads to the stem and progresses from apex to downwards. The affected portions of the stem initially assume dark brown colour later turning black and become shrunken with water-soaked appearance. The rotting of the shoot may extend from 15 to 75 cm in length, depending on the nature of growth and severity of disease (Plate 43. a). The diseased portion dries up and later new branches arise from below the infected portion. The affected plants get stunted and about three to six months growth is lost (Fernando, 1955; Ramakrishnan, 1957b).

3.2 Clonal susceptibility

All clones which are susceptible to abnormal leaf fall disease are severely affected by this disease. In nursery plants and immature phase of plant growth, shoot rot occurs even on clones tolerant to *Phytophthora* leaf fall.

3.3 Control measures

The disease could be controlled by prophylactic spraying with copper fungicide for mature and immature plants in the field. Repeated spraying with one per cent Bordeaux mixture or 0.5 per cent Bordeaux mixture + 0.5 per cent zinc sulphate at an interval of 7 to 10 days is required to protect the young plants in the nursery and field during the monsoon period (Idicula *et al.*, 1992). Recent experiments at RRII have indicated that phosphorous acid at 0.16 per cent and metalaxyl MZ at 0.2 per cent are also effective in checking the disease (Idicula *et al.*, 1998). Stickers/wetting agents like Sandovit, Tenac, Triton A E and Teepol can be used along with the copper fungicide to obtain better sticking of the fungicide on tender foliage (Ramakrishnan, 1957b).

4. POWDERY MILDEW

Powdery mildew disease was first reported from Indonesia (Arens, 1918). Subsequently, it was reported from Uganda (Small, 1924) Sri Lanka (Stoughton-Harris, 1925) and Malaysia (Sharples, 1926). In India, the disease was reported in 1938 (Mitra and Mehta, 1938). Since then, the disease has been reported from almost all rubber growing countries. Rubber plants of all age groups are infected.

4.1 Disease development and symptoms

The disease affects the immature leaves of rubber when the trees refoliate after annual wintering and causes leaf fall. Tender leaves at the brown or light green stage are highly susceptible. The presence of dull cool weather with intermittent light showers during the refoliation period predisposes the plants to severe disease attack. Prevalence of mist, dew and cloudy days with 75 to 80 per cent relative humidity are favourable for disease development. In plantations at high elevations, the disease is prevalent throughout the year because of the cool climate, heavy dew and mist. Although light showers favour disease development, heavy rains and bright sunny periods are inimical to the development of the fungus. Early wintering clones usually escape from the disease because the climatic conditions during their refoliation period are not favourable for the disease development. Late wintering clones are usually severely affected. Dry weather conditions during wintering period encourage early and rapid wintering and consequent escape from the disease. In India, the disease is severe in Kanyakumari, Idukki and Wynad districts of South India and in the north-eastern states.

The fungus survives on the rubber tree itself. Semi-mature leaves, when infected, do not shed, but are retained with brownish necrotic spots which serve as a source of inoculum. The primary inoculum develops on off-season tender flushes on broken branches, young flushes in nurseries and self-sown seedlings. Although alternative hosts like *Jatropha curcas, Manihot glaziovii, Bixa orellana* and *Dendrophthoe* sp. are also suggested as sources of primary inoculum, the fungus is not readily transferable from one species to another (Ramakrishnan and Pillay, 1962).

The optimum temperature for germination, infection and sporulation ranges from 25 to 30°C (Liyanage *et al.*, 1985). The fungus is disseminated by air-borne conidia. The peak sporulation is around noon.

In mature rubber, severe disease incidence occurs when trees refoliate after wintering. The infected young copper brown or apple green leaves lose their shiny appearance and become dull with white powdery masses covering their entire surface or in patches (Plate 43. b). The leaflets shrivel, curl inwards and fall off leaving the petioles still attached to twigs, giving a broomstick-like appearance (Plate 43. c). The fallen leaflets form a black carpet on the ground. Petioles and tender shoots may also be infected. When partially mature leaves are infected, they remain on the tree with irregular powdery patches which later turn into brown scabby lesions causing distortion of leaf lamina. The tissues in the centre of the lesion may get dried and fall off forming shot holes. The inflorescence and young fruits are also affected by this disease, thus reducing fruit set and causing scarcity of seeds.

Since the nursery plants produce new flushes throughout the year, powdery mildew is seen all through the year. Plants growing under shade are more severely affected. Immature plants in the field are also affected and if the incidence is severe, die-back of twigs is common. The symptoms on young plants are similar to that on mature trees, but repeated defoliation and refoliation lead to depletion of food reserves and drying of young plants (Liyanage and Jacob, 1992).

4.2 Causal organism

Oidium heveae Steinm., an obligate parasite, is responsible for the disease. The fungus produces superficial, branched, hyaline, septate hyphae. The hyphae are anchored on the host tissue with haustoria which help in deriving nutrients. The fungus has simple erect conidiophores which bear elliptical or barrel-shaped vacuolated conidia with round ends. The sexual stage has not yet been reported.

4.3 Economic importance

Leaf fall due to powdery mildew adversely affects the growth and yield of rubber trees. Wastie and Mainstone (1968) have reported a crop loss of 8.1 per cent in the clone PB 5/51 over a period of nine months, in Malaysia. Increased bark renewal and girth increment of trees protected against powdery mildew compared to unprotected trees were also observed. Tan and John (1985) have reported 6.3 to 10.3 per cent yield increase by controlling powdery mildew disease. In India, it was observed that in clone PB 86, 8 to 12 per cent more disease in unprotected plots when compared to protected, resulted in 21 to 32 per cent crop loss. Similarly, 8 to 18 per cent more disease in unprotected RRIM 600 caused 14 to 29 per cent crop loss. The disease caused reduction in yield throughout the year (Jacob *et al.*, 1992).

4.4 Clonal susceptibility

Disease resistance has been reported only in the clone LCB 870 from Sri Lanka. But this clone is not popular due to poor yield. In India, clones PB 86, GT 1, Gl 1, PR 107, PB 5/139, RRIM 703, RRII 208 and PB 310 show some tolerance. The clones Tjir 1, PB 5/51 and RRIM 605 are highly susceptible. RRII 105, RRII 118, RRII 300, PR 261, PB 217, PB 235, PB 280 and PB 311 are also susceptible.

4.5 Control measures

Dusting with sulphur gives effective control of powdery mildew disease (Plate 43. d). Spraying wettable sulphur is preferred only in the nurseries and young rubber plantations as repeated spraying in mature areas is expensive and impracticable. Sulphur dust having a minimum of 70 per cent sulphur is generally used for dusting. The dust should be dry, free flowing and should pass through 325 mesh-sieve (particle size 40 microns). Dusting is done at the rate of 11 - 13 kg per ha at an interval of 7 - 10 days. Three to six rounds of dusting are usually required. First round of dusting is done when 10 per cent of the trees start refoliation. Micron duster is employed for this purpose. The duster should be carried along every fourth row of trees at a speed of 3 to 4 km per h. With one duster, nearly 10 to 12 ha can be covered in a day. Sulphur dusting should preferably be done early in the morning so that the dew on the leaves helps in sticking of the dust. The still air in the morning hours also helps to raise the dust to reach the canopy.

Thermal fogging of tridemorph (Calixin), a systemic fungicide, at three per cent concentration was found effective (Edathil *et al.*, 1984b) but not widely practised due to fire hazards in fogging. Tridemorph 1.5 per cent dust formulation has been used effectively for the control of the disease (Edathil *et al.*, 1988a). An integrated approach using tridemorph and sulphur in dust form was found to be more effective (Edathil *et al.*, 1992). Carbendazim (Bavistin) 1.5 per cent dust has also proved to be effective and could be used in integration with sulphur (Jacob *et al.*, 1996).

In young plants grown in nurseries as well as in the field, spraying of wettable sulphur (0.2% a.i.) at fortnightly intervals is recommended. Carbendazim (Bavistin 0.05% a.i.) was also found to give effective control (Edathil *et al.*, 1988b). Integrated application of 0.025 per cent carbendazim and 0.1 per cent wettable sulphur is also effective (Edathil *et al.*, 1992).

In Malaysia, artificial defoliation of rubber trees has been attempted to induce early wintering so that they escape from powdery mildew disease (Rao and Azaldin, 1973). But the practice is not widely adopted (Lim, 1982). Crown budding of susceptible trees with tolerant crown (LCB 870) had also been attempted (Van Emden, 1954) but did not become popular due to delayed maturity of the trees.

5. *CORYNESPORA* LEAF DISEASE

Corynespora cassiicola (Berk. & Curt.) Wei. causes leaf spot and leaf fall diseases. *Corynespora* leaf spot disease was first reported in India from seedling nurseries (Ramakrishnan and Pillay, 1961b). The disease was reported from Malaysia (Newsam, 1963) Nigeria (Awodern, 1969), Indonesia (Soepena, 1983), Sri Lanka (Liyanage, *et al.*, 1986) and Thailand (Kajornchaiakul, 1987). The disease has now been found in almost all rubber growing regions (Chee, 1988). Severe leaf fall due to infection of *Corynespora* was reported from Sri Lanka (Liyanage *et al.*, 1986) and from Malaysia (Tan, 1990) and Indonesia (Sinulingga, *et al.*, 1996).

5.1 Disease development and symptoms

Young leaves (up to four weeks) are most susceptible to *Corynespora* infection. The disease appears in mature plantation during refoliation period. The environmental factors favouring disease development are high humidity, a temperature of 28 to 30°C, humid air and cloudy weather (Situmorang *et al.*, 1996). The conidia of the fungus, produced abundantly on infected leaves, are carried by wind and cause rapid spread of the disease. The spore release increases steadily from morning and reaches the peak by noon and thereafter falls to very low levels (Chee, 1988). The spore load in air has been negatively correlated to rainfall (Radziah *et al.*, 1996). Conidia remain viable for about a month. Although the host range of *Corynespora* is wide (Liyanage *et al.*, 1986), cross infectivity is doubtful (Chee, 1988).

In leaf spot infection, minute spots develop initially when the leaves are in the brown colour stage and these enlarge with the growth of the leaves. The spots appear circular (1 to 10 mm diameter) or irregular with a brown or papery centre surrounded by a dark brown ring and an yellow halo (Plate 44. a). Concentric striations are sometimes seen on the lower side. The central part may disintegrate and fall off forming a shot hole. Severe leaf spot incidence leads to shrivelling of leaves and defoliation (Plate 44. b).

In the severe form of the disease, a characteristic browning and blackening of veins forming a 'fishbone'- or 'railway track'- like appearance is noticed (Plate 44. c). Even a single leaf spot can cause defoliation. Severe infection on the midrib causes leaf blight. When leaf petioles are infected, greyish black lesions are formed causing defoliation without any symptoms on the lamina. Repeated defoliation and refoliation lead to shoot die-back (Plate 44. d).

The fungus produced a toxin in synthetic medium which when applied to leaves of *Hevea* (0.001 ml of crude toxin) induced symptoms characteristic of infection by *Corynespora* and was suggested as an efficient tool for rapid screening of clones for susceptibility (Liyanage and Liyanage, 1986; Breton *et al.*, 1997). The toxic compounds produced by the fungus reduce CO_2 assimilation rate even in apparently healthy tissues of affected leaves by bringing about changes in photosynthetic mechanism (Nugewela *et al.*, 1989).

5.2 Causal organism

Corynespora cassiicola produces conidia on both sides of infected lesions on leaves. The conidia are obovate or cylindrical, straight or slightly curved often thick-walled, multi-septate, tapering towards the apex, pale brown with prominent hilum. Spore size is 40 - 120 x 8 - 18 µm. The conidia are produced singly or in chains on brown septate conidiophores of 55 - 300 x 6 - 10 µm size. The conidia are connected to conidiophores or other conidia by a hyaline isthmus. The conidia germinate by producing germ tubes often from the end cells.

5.3 Economic importance

Severe incidence of *Corynespora* leaf disease was noticed in Sri Lanka from 1985 to 1989. The disease appeared in a polybag nursery of the clone RRIC 103 in 1985. Since then, the disease spread rapidly to all rubber growing regions of the island devastating nearly 4000 ha by 1989. Through an island-wide campaign the clone RRIC 103 was uprooted. The clone RRIC 103 which was high yielding and otherwise very promising, had to be withdrawn from the recommendation (Liyanage *et al.*, 1989).

In Malaysia, *Corynespora* disease was first noticed on field planted rubber in 1975 and subsequently large areas were affected. In a survey, 35 out of 63 clones studied were reported as susceptible (Tan, 1990). In Indonesia, the disease had spread to nearly 1200 ha of which 400 ha had to be uprooted (Sinulingga *et al.*, 1996)

In India, sporadic incidence of *Corynespora* on mature trees was reported from Kodumon, Chittar, Shaliacary, Kaliyar and Cheruvally during 1969 to 1976 (George and Edathil, 1980). A severe outbreak of the disease was observed in Nettana area of Karnataka during 1996-97 (Rajalakshmy and Kothandaraman, 1996).

5.4 Clonal susceptibility

Among the rubber clones, RRIC 103 is the most susceptible one. Other clones reported as susceptible from Sri Lanka include RRIC 104, RRIM 600, RRIM 725, Tjir 1, RRIC 110 and RRIC 133 (Jayasinghe and Silva, 1996). In Malaysia, the most commonly-affected clones are RRIM 600 and GT 1. The disease was observed in many clones like PB 5/51, PB 217, PB 235, PB 260, PR 107, RRIM 901, RRIM 905 and Tjir 1 (Tan, 1990). RRIM 725, FX 25 (Chee, 1988), KRS 21, PPN 2058 and PPN 2447 (Shukor and Hidir, 1996) are also observed to be susceptible. AVROS 2037, BPM 24 and RRIC 100 are reported as tolerant from Indonesia (Azwer *et al.*, 1993). Studies conducted in France indicated PB 260 to be highly susceptible and GT 1 to be tolerant (Breton *et al.*, 1997).

In India, clones found susceptible include RRII 105, RRII 118, RRII 300, RRII 305, PR 107, PR 255, PR 261, RRIM 600, PB 86, PB 235, PB 255, PB 260, PB 311, Gl 1 and Tjir 1 of which the susceptibility of RRII 105 causes serious concern due to the large extent of area under this clone (Jacob, 1997).

5.5 Control measures

5.5.1 Cultural control

Light overhead shading in the nursery reduces disease intensity. Vigorously growing seedlings are usually less affected and hence balanced nutrition reduces disease incidence. Base budding and crown budding of affected RRIC 103 trees with resistant clones were recommended in Sri Lanka but did not gain popularity as there was difficulty in peeling the bark of disease affected trees for budgrafting (Liyanage *et al.*, 1989).

5.5.2 Chemical control

Several fungicides have been recommended for the control of *Corynespora* leaf disease. Spraying of benomyl, mancozeb, captan or propineb is recommended for affected nursery plants in Sri Lanka (Jayasinghe and Silva, 1996). In Malaysia, five to six rounds of benomyl (500 g/ha) spraying is recommended (Hashim, 1994). Four to five rounds of spraying with tridemorph (Calixin 0.6 L/ha) or mancozeb (Dithane M45 1.5 - 3 kg/ha) are recommended for *Corynespora* control in Indonesia (Soepena *et al.*, 1996). In India, Bordeaux mixture (1%) or 0.24 per cent zineb (Dithane Z78) was earlier recommended for control of *Corynespora* disease in nurseries (Ramakrishnan and Pillay, 1961b). Later 0.1 per cent carbendazim (Bavistin) spray was also recommended (Rajalakshmy *et al.*, 1980). In mature plants two rounds of high volume spraying with 0.2 per cent mancozeb (Dithane/Indofil M45), 0.5 per cent carbendazim or Bordeaux mixture (1%) at an interval of two to three weeks during refoliation period gave effective control of *Corynespora* (Jacob, 1997).

6. *GLOEOSPORIUM* LEAF DISEASE

Gloeosporium leaf disease was first noticed in Sri Lanka in 1905 (Petch, 1921) and since then, this disease has been reported from all the rubber growing countries like Uganda, Malaysia, India, Java, Indonesia and Indochina. In Malaysia, the tender leaves produced after wintering are severely affected by this pathogen and *Oidium heveae* resulting in the most important disease complex on mature rubber trees called 'secondary leaf fall' (SLF). In India, even though the disease is not a serious problem in mature rubber it has been observed throughout the rubber growing regions. The disease was earlier confined to seedling and budwood nurseries. However, of late, immature plants in the field are also being seriously affected, causing much damage to plants during the first four years of planting. The disease is generally noticed during April to May, before the onset of southwest monsoon and in August, September and October. However, it can occur at any time of the year whenever wet weather is prevailing. In North East India, the disease is prevalent throughout the year except during winter. In Malaysia, this disease is observed throughout the year and becomes more severe with the onset of rain.

6.1 Disease development and symptoms

Weather plays an important role in the incidence of *Gloeosporium* leaf disease. High humidity is a pre-requisite for the formation of sporocarp (acervuli). High temperature and relative humidity favour the disease in North-East India (Deka *et al.*, 1996). The spores are easily released and are carried by rain splashes. Free water is necessary for optimum germination of the fungus. The rapidly spreading epidemic phase of *Gloeosporium* is propagated by the asexual spores (conidia). Germination of spores occurs in a few hours at 100 per cent humidity and longer time is taken at lower levels of humidity (Wastie, 1972; Wimalajeewa, 1967). The disease becomes quiescent in the dry period but spores survive, to cause new infection with the onset of rains.

Leaves are susceptible during the first 10 days of leaf expansion. Tender leaves produced soon after bud burst are more susceptible to infection. If the damage is extensive, the leaves become distorted, turn black, shrivel and fall off, leaving the petioles on the stem for a short period. The infection usually starts at the tip of the leaf and spreads towards the base, forming a necrotic area (Plate 45. a). But if the leaf gets infected at a later stage, it becomes either highly spotted or may be partially damaged along the tip and margin. The remainder of the damaged leaf may be retained on the shoot after the diseased portions shrivel, turn black and fall off. The spots formed on the intact leaves are brown in colour, circular, 1 or 2 mm in size having a narrow brown margin and are surrounded by yellowish halo. As the leaf ages, the margins of the leaf spots become thick and raised above the surface as conical projections, this being the most important diagnostic feature of the disease. Sometimes the centre dries up and falls off, giving a shot hole effect. Appearance of tiny cheesy spore masses over the surface of the leaves is also a characteristic symptom. Lesions are seen on the green stem also. Die-back of the shoots is noticed under severe conditions. Before the commencement of the heavy rain towards the end of May, the pathogen can be seen attacking young green pods causing rotting of pods. The pericarp becomes dull green and covered by innumerable minute acervuli. Such fruits rot easily and fall off or remain attached to the stalks in a shrivelled condition.

6.2 Causal organism

The pathogen is *Gloeosporium alborubrum* Petch. the conidial state of *Glomerella cingulata.*, (Stonem.) Spauld. and Schrenk. The hyphae of the fungus penetrate the tissues of the affected part. Intraepidermal or subepidermal stromata are formed on the infected region. From this, closely packed cylindrical conidiophores develop and rupture the epidermal layer. On these conidiophores, hyaline oblong, single-celled conidia measuring 10 - 20 x 3 - 5 µm are produced.

6.3 Economic importance

A severe incidence in the immature plants in the field may lead to heavy defoliation and shoot die-back resulting in the girth retardation and extension of immaturity period. In Indonesia, the persistence of this disease over a long period resulted in loss of yield up to 50 per cent and delay in maturity of rubber trees up to three years (Basuki, 1992). After three years of continuous artificial defoliation to control SLF, an yield increase exceeding 30 per cent was achieved in Malaysia (Radziah and Hashim, 1990).

6.4 Clonal susceptibility

Several clones including PB 86, RRII 300, RRII 105, RRII 118, RRII 208, and RRII 5 are susceptible to this disease. Conversely, PB 217, PB 260, and RRIM 600 are the clones having some tolerance.

6.5 Control measures

In India, copper oxychloride spraying carried out as a prophylactic measure against abnormal leaf fall disease in April/May, keeps this disease also under check. Mancozeb 0.2 per cent, carbendazim 0.05 per cent, dithianon (Delan) 0.2 per cent, bitertanol (Baycor) 0.025 per cent and Bordeaux mixture (1%) were found effective in controlling the disease in young rubber plantations (Joseph *et al.*, 1994). Dusting with sulphur and mancozeb has been successfully used for the control of secondary leaf fall in Java (Soepadomo, 1975). In Malaysia, chlorothalonil (Daconil) and benomyl (Benlate) were found effective in controlling the disease (RRIM, 1977). Low volume application of chlorothalonil as an oil-water emulsion with mist blower reduced the severity of the disease (RRIM, 1977) and overcame the problem of washing off of water-miscible fungicide during the rainy season. Another measure tried in Malaysia is fogging with oil-based formulation of tridemorph (Lim, 1982). Mechanical fogging of captafol-in-oil (0.6 kg/ha) thrice at weekly intervals during refoliation gave good control of the disease (Tan and John, 1985). Mechanized fogging or spraying with chlorothalonil in oil and in water respectively gave better results than with captafol (Lim, 1982). Fogging of difoltan, propiconazole (Tilt) and penconazole (Topas) reduces the disease on mature plants and weekly spraying of chlorothalonil (0.2%) or propineb (0.2%) is effective in nurseries (Radziah and Hashim, 1990).

An effective and economic method practised in different countries is the avoidance of the disease by defoliating the trees during the dry periods which are non-conducive to disease development. By the onset of the wet period, the leaves are already green, passing the susceptible stage and thus escape severe disease infection. In Malaysia, artificial defoliation by aerial spraying of several chemical defoliants mixed in water is practised (Radziah and Hashim, 1990). In Cameroon, ethephon (3 L/ha) induced defoliation and early refoliation helps in avoiding secondary leaf fall (Senechal and Gohel, 1988).

7. BIRD'S EYE SPOT

Bird's eye spot disease occurs in every rubber growing country, though in many countries it is of minor importance. This disease was first reported from Sri Lanka in 1905 (Petch, 1921). It was reported from Java in 1914 (Rutgers and Arens, 1914), South India in 1918 (Butler, 1918), Sumatra in 1922 (La Rue, 1923) and Malaysia in 1927 (Sharples, 1927). It occurs mainly in seedlings in nurseries, while budded plants are less susceptible. The spots caused by the disease resemble the eye of a bird with a white centre and brown margin and hence the name of the disease.

7.1 Disease development and symptoms

This disease is generally noticed during hot months from November to April. The disease is more severe in light, infertile and freely-drained soils and is favoured by dry and exposed conditions. A study on the effect of environmental conditions on disease showed that an epidemic outbreak may be expected after a period of dry weather on poor soil (Venkataramani, 1949; Hilton, 1952). Nutritional condition of the soil (Bolle-Jones and Hilton, 1957) and lack of shade (Hilton, 1952) are found to be the important factors influencing the extent of damage by this disease. Light has a considerable effect on the growth of the fungus. Very wet condition seems to reduce the attack to some extent, possibly because such conditions promote seedling growth.

Symptoms vary with age of leaf at the time of infection. On very tender leaves the disease first appears as small dark brown spots with a diameter of about 0.2 mm. They give a water-soaked appearance in contrast to the shining red brown healthy leaflets. The leaf margin or the entire leaves become blackened and shrivelled. The rapidly growing leaf becomes severely distorted. Normally the lesions do not enlarge in size but at times such spots may coalesce and the infected area get covered with masses of spores giving a black colour. Such leaflets may fall down exposing the petioles. On leaves with light green colour, the infection appears initially as minute yellow spots, which later on develop a narrow reddish brown margin. The centre becomes white and papery and sometimes the papery thin centre gets torn off leaving shot holes (Plate 45. b). The lower surface of the lesions appears to be chocolate brown in colour due to the presence of a large number of spores of the fungus. On leaves more than two-week -old, the damage is comparatively less. Spots are small and dark brown with no pale centres. Leaves more than three-week-old are immune to the attack. Dark, elongated, stripe-like lesions can be seen on the midribs, petioles and young shoots.

7.2 Causal organism

The pathogen, *Drechslera heveae* (Petch) M.B.Ellis is responsible for the disease. The fungus produces conidia in abundance on the lower surface of the spots. The conidia are brown in colour, multi-celled, slightly curved and tapering towards both ends. They measure 0.1 mm in length and are borne on conidiophores (Hilton, 1952). Spores are mainly disseminated by wind which spread the disease both within and between the nurseries. Rain, dew, and movement of workers through closely-planted nurseries also help in dissemination of spores and spread of the disease.

7.3 Economic importance

The disease kills the plants only very rarely, but a heavy defoliation weakens the plants and retards their growth. A severe attack on seedlings raised for green budding may result in their taking a longer period to attain buddable girth, due to the reduced photosynthetic capacity by defoliation and leaf spotting.

7.4 Control measures

Providing light overhead shade in the nursery is effective in reducing the intensity of the disease (Ananth and Menon, 1965). In India, disease control involves spraying the seedlings with 0.2 per cent mancozeb (Indofil/Dithane M45) or 0.02 per cent carbendazim (Joseph *et al.*, 1987). New flushes must be protected by spraying the fungicide. Copper fungicides have been found effective against the disease in Sri Lanka, Congo and Liberia. In Malaysia, ziram and ferbam gave satisfactory control (Newsam, 1963). Later experiments also proved the supremacy of carbamate fungicides (Newsam, 1967). Carbamate fungicides containing zinc or manganese were found more effective than ferbam in controlling the disease (Wastie, 1969). Fogging using mancozeb or octhilinon (Kathon 4200) has been found to give better and quicker coverage with less wastage and at reduced cost (Zainuddin and Lim, 1979). The disease is effectively managed in Malaysia by weekly application of 0.2 per cent propineb (Antrocol) or 0.2 per cent mancozeb (Radziah and Hashim, 1990).

8. ANTHRACNOSE

Anthracnose or secondary leaf spot has been reported from most of the rubber growing countries. This disease is observed in almost all parts of South India. It has been noticed in nurseries, on young plants in the field and even on older trees from April to October. It is, however, only of minor importance (Ramakrishnan and Pillay, 1961d).

8.1 Disease development and symptoms

This disease is prevalent on rubber under conditions unfavourable for the growth of the plants. In the newly-planted areas, the disease may be observed when the soil around the plants becomes waterlogged or when the shoots grow and the formation of the root is unduly delayed. In older plants, lack of adequate nutrition favours the development of the disease. In Malaysia and the Amazon valley, plants grown on poor soils or those lacking in certain nutrients are affected. Sometimes the disease appears when bright sun intervenes after a long spell of rainy season. Obviously, leaves weakened by sunscorch are first invaded.

The disease is called anthracnose because of the characteristic limited lesions (Plate 45. c) with necrosis and hyperplasia. Lesions of varying sizes and numbers are formed on the leaflet. They may be circular, semicircular or sometimes irregular and occur along the margin or sometimes in the middle also. The lesions are large having a diameter of 1 to 5 cm. Many of them may coalesce and cover large areas of the leaf surface. Each spot is brown with a water-soaked green or yellow margin. The central portion of the spot is light brown, papery and necrotic. The spots show characteristic target-like concentric striations on both surfaces, but are more evident on the upper surface. These striations are because of the formation of a large number of acervuli in concentric patterns and setae which can be seen as bristles. Under moist conditions, spores are produced in large numbers from the acervuli and they appear pink. Leaves affected by anthracnose are unhealthy and yellow in colour and fall off easily.

8.2 Causal organism

Secondary leaf spot is caused by the pathogen *Colletotrichum gloeosporioides* (Penz.) Sacc., the perfect stage of which is *Glomerella cingulata* (Stonem.) Spauld. and Schrenk. The acervuli of the fungus are formed subepidermally. They rupture the epidermis and appear as minute raised dots on either surface of the leaflets. Conidia are hyaline, oblong, sometimes tapering at the ends, one-celled and 10 - 29 x 3 - 5 µm in size. They are borne on conidiophores which are short and closely packed. Blackish brown, septate setae, straight or sometimes curved at the tip measuring 30 - 100 µm in length and 3 - 5 µm in breadth (at the base) are also produced.

8.3 Control measures

The best method of control is avoidance of adverse conditions. Flooding or water-logging should be avoided. Adequate and balanced manuring of the plants are necessary for maintaining vigorous growth of the plants and preventing the disease (Ramakrishnan and Pillay, 1961d). Young plants should be protected from sunscorch. Fungicide spraying is advisable in severely infected nurseries.

9. THREAD BLIGHT

Thread blight is caused by the pathogen *Pellicularia filamentosa* (Pat.) Rogers. It has been reported from India, Peru, Brazil, Colombia and the Amazon valley. The infection is prevalent during rainy season in crowded nurseries and in trees with dense foliage.

9.1 Disease development and symptoms

Symptoms of this disease vary depending on the age of the leaves and environmental conditions. Tender leaves are easily damaged. Infected leaflets lose their natural colour and become pale, crinkled and shrivelled. The infection spreads rapidly to other leaflets and these are often held together by the growth of the fungal mycelium on the surface (Plate 45. d). The mycelium forms a filmy growth with scattered minute buff-coloured masses (sclerotia). Many leaflets fall from their stalks and the mass of white disintegrating leaflets are suspended from the stem by the strands of mycelium. On the stems and petioles also the white granular growth is noticed and the tender portion of the shoots becomes bare due to defoliation and may get killed. On older leaves, white granular growth is noticed on the under surface (basidial stage). Such leaves are green in the beginning but later turn yellow. In others, big lesions about 2 cm or more in diameter are observed on leaves. The spots are white and papery in texture with partly disintegrated central portion. Such lesions appear generally when the progress of the infection is arrested by bright weather (Ramakrishnan, 1957a). A disease called target spot caused by the same fungus has been reported from Central America (Carpenter, 1951).

The disease is not generally very important in India (Ramakrishnan, 1957a). It is observed on Tjir 1 clonal seedlings and mature trees of Tjir 1 and BD 10.

9.2 Control measures

Bordeaux mixture (1%) offers satisfactory protection against the disease in India. In South America repeated spraying with zineb is practised. Dusting with a mixture of sulphur and fermate was reported to be effective. Mist blowing with triadimefon is also useful in controlling the disease (Neto *et al.*, 1983). Wider spacing to avoid overcrowding in the nursery also keeps the disease in check.

10. SOUTH AMERICAN LEAF BLIGHT

South American leaf blight (SALB) is the most damaging disease of Para rubber. This disease is at present confined to South and Central America and the nearby Caribbean islands of Trinidad and Haiti (Compagnon, 1976) and has caused the abandonment of ambitious programmes of extensive rubber cultivation in the South American humid tropics during the early part of the 20th century. In the past, this disease went unnoticed among the widely-scattered wild rubber plants in the dense impenetrable Amazon rain forest.

SALB is present in Bolivia, Brazil, Peru, Ecuador, Colombia, Venezuela, Guyana, Surinam, French Guiana, Trinidad, Panama, Costa Rica, Nicaragua, El Salvador, Honduras, Guatemala, Haiti, Beliz and Mexico (Holliday, 1970; Compagnon, 1976).

10.1 Disease development and symptoms

Conidia and ascospores cause infection and both are equally important in completing the disease cycle (Langford, 1945; Chee, 1976a; 1976b; 1977), while pycnospores are non-infective and serve as spermatia for the formation of the ascigerous stage. Rain plays an important role in the spread of leaf blight. It is believed that rain is the most effective disseminator of large masses of spores and wind is the chief means of dispersal. Brookson (1963) observed that conidia survived for two weeks under normal laboratory conditions. However, the longevity of conidia decreases as RH increases. Under high humidity, conidia survive for three weeks and at 100 per cent RH they are killed within one week. It seems probable that leaf blight could be spread by conidia carried on plants, plant parts or man himself. Outbreaks of leaf blight occur when the daily temperature is under 22°C for longer than 13 h, RH over 92 per cent for a period longer than 10 h and rainfall above 1 mm per day for the previous seven days (Holliday, 1969; Chee, 1976a).

Even though the fungus can affect petioles, green stems, inflorescences and fruits, the most obvious infection is on the young leaves (Plate 46. a). In the primary stage, conidia develop mostly on the abaxial surface of four to nine day old, expanding tender leaves (Plate 46. b). They appear as greyish-black lesions covered with olive-green powdery sporulating masses. On the young infected leaves, lamina distortion, growth arrest, crinkling and shrivelling of leaflets, blackening, drying and abscission are the common symptoms.

The conidial state is known as *Fusicladium macrosporum* (Anstead, 1919). The secondary stage develops on the adaxial surface of the leaves as it hardens. The black pycnidial form increases in number and size, forming clusters and ring-like groups. Spermagonia (pycnidia) are externally similar to ascomata but smaller.

As the leaf matures, the stromata become more and more massive with the formation of ascocarp. Ascomata (perithecia) are globose, mostly adaxial, carbonaceous, superficial, often crowded and sometimes in rings and round the edges of shot holes (Plate 46. c,d) and are frequently fused laterally (Rao, 1973).

It was observed in Trinidad that conidia have maximum dispersal in June and July and peak ascospore concentration occurred from August to November during the wet season (Chee, 1976b). In a mature stand of rubber, a fresh disease cycle probably starts when ascospores are released from leaves which fall due to wintering and also from infected leaves remaining on the trees. As infection builds up on the newly emerging flushes, conidia take over the spread during the wet season to complete the disease cycle.

Hypertrophy is noticed on inflorescence and the fruits also get infected and destroyed (Plate 46. e). Infection on petioles and shoot may lead to curling and twisting of these parts and also results in die-back giving a denuded appearance (Plate 46. f).

10.2 Causal organism

The causal fungus *Microcyclus ulei* (P. Henn.) von Arx & E. Muller (*Dothidella ulei* P. Henn.) is specific to *Hevea* species only. The pathogen has been recorded on four species *viz.*. *H. brasiliensis*, *H. benthamiana*, *H. guianensis* and *H. spruceana*.

Conidia arise from subepidermal stromata. Conidia are borne singly, usually septate but sometimes aseptate, hyaline becoming greyish or olivaceous, obclavate, the proximal cell broader with a truncate end and a very characteristic and pronounced single twist. This twist is absent in the aseptate conidia. Septate conidia measure 23 - 65 x 5 - 10 µm, aseptate conidia 15 - 34 x 5 - 9 µm.

Spermatia (pycnospores) borne on hyphal elements are dumb-bell-shaped and the globose ends are twice as wide as the centre and 6 - 10 µm long. Asci are clavate with 56 - 80 x 12 - 6 µm size containing eight spores. Ascospores are uniseptate, hyaline, constricted at the septum, ellipsoidal, cells unequal, the longer cell with more acute apex lying towards the ascus base. The ascospores measure 12 - 20 x 2 - 5 µm (Langford, 1945; Chee and Holliday, 1986).

10.3 Economic importance

SALB infection results in repeated defoliation, die-back of the shoots and even death of the mature trees (Stahel, 1927; Holliday, 1970; Rao, 1973). In the South American plantations it reduced the yield by over 90 per cent (Altson, 1923). More than 90 per cent of the world's natural rubber requirement is being met by production from the Far East (Holliday, 1970). All the planted African and Asian rubber is extremely susceptible and the climatic conditions present in the rubber growing areas of Asian and African countries are comparable to that of the American tropics. Hence introduction of SALB into these regions could destroy the existing plantations. This has prompted rubber growing countries to implement quarantine regulations (Altson, 1950; Edathil, 1986).

10.4 Clonal susceptibility

Eleven physiologic races (plus an avirulent one) of the pathogen have already been detected. Many clones which were reported to be tolerant / resistant to *M. ulei* have succumbed later with the appearance of more virulent strains. Six species in which natural infection was not reported include *H. camporum*, *H. microphylla*, *H. nitida*, *H.pauciflora*, *H.camargoana* and *H.rigidifolia*. The clones belonging to these species are being used in Brazil for crown budding on high yielding susceptible clones. Some resistant clones which are being used for crown budding are PA 31, IAN 717, IAN 6486, IAN 7388, IAN 7657, FX 25, FX 614 and FX 636 (Holliday, 1970; Pinheiro *et al.*, 1982).

10.5 Control measures

10.5.1 Chemical control

In case of an accidental entry of this disease, despite the phytosanitary measures, immediate adoption of eradication procedures should receive top priority. First two to three rounds of spraying (aerial application) with protectant chemicals such as mancozeb, benomyl or thiophanate methyl are given and then the entire area is defoliated using n-butyl 2,4,5-T, folex, cacodylic acid or ethephon, so that the trees remain leafless for about two months (Abdul Aziz, 1976; Lim and Hashim, 1977).

Several plant protection operations are being carried out for controlling this disease. Aerial spraying (8 - 10 rounds) is done using benomyl 300 g, thiophanate methyl 200 g or mancozeb 2 kg in 30 L water per ha at intervals of 7 to 10 days. For fogging 200 g thiophanate methyl or 1 kg mancozeb are being used in 6 to 8 L of agricultural spray oil per ha at intervals of four to seven days (Martins and Silva, 1979; Chee and Wastie, 1980). Systemic fungicides like chlorothalonil (Daconil), triforine (Saprol) and triadimefon (Bayleton) are found promising in small-scale trials (Chee and Wastie, 1980; Santos *et al.*, 1984).

10.5.2 Biological control

Biological control of *M. ulei* using *Hansfordia pulvinata*, a hyperparasite which grows well on conidial lesions, has been attempted (Lieberei *et al.*, 1989). It was reported by Feldman (1990) that mycorrhizal fungi can cause an increase of resistance of the rubber tree against *M. ulei*. The generation period of spores was increased and the sporulation of the pathogenic fungus was decreased. The diameter of lesions was also decreased.

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