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DISEASES OF BAMBOOS AND RATTANS IN KERALA

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Abstract

Disease survey revealed a total of 64 pathogenic diseases including one of unknown etiology, possibly a virus, affecting different species of bamboos and rattans in nurseries, plantations and natural stands. Altogether 56 pathogens were associated with these diseases, of which 31 are new pathogen records for bamboos and 16 for rattans, including 13 hitherto undescribed species; 24 species are first record from India.

In bamboos, thirteen seedling diseases affect both bareroot as well as container seedlings at different growth phases. With these diseases, altogether 14 fungi belonging to 11 genera were found associated. One disease, seedling foliage striping and stunting was of unknown etiology and respected possibly caused by a virus. Of the 14 fungi found associated with various diseases in bamboo nurseries, *Rhizoctonia solani* emerged as the most dominant nursery pathogen, causing four diseases viz. damping-off, seedling spear rot, seedling wilt and web blight.

Among the foliage diseases affecting nursery seedlings, leaf rust caused by *Dasturella divina* was widespread in occurrence as it was recorded on seedlings of almost all the bamboo species raised in nurseries in the State. Both uredinial and telial stages were observed on bamboo seedlings. *Bipolaris maydis*, *B. urochloae* and *Bipolaris* sp. caused leaf blight; *Exserohilum holmii* and *E. rostratum* caused leaf spots on various species of bamboos. Some of the leaf spot diseases of minor importance were caused by *Dactylaria* sp., *Colletotrichum gloeosporioides*, *Alternaria alternata* and *Curvularia pallescens*. Seedling rhizome rot of *B. bambos* caused by *Rhizostilbella hibisci* state of *Nectria mauritiicola* was recorded in container seedlings. Leaf striping and stunting disease, the symptoms of which were found characteristic of those produced by a virus, occurred in *B. bambos* seedlings.

In bamboo plantations and natural stands, a total of 28 pathogenic diseases caused by 35 fungi and one mycoplasma-like organism (MLO) were recorded. Of these, only rhizome bud rot caused by *Pythium middletonii* occurred exclusively in young plantations, while witches' broom caused by Balansia linearis and little leaf disease caused by MLO were recorded only in natural stands. Rest of the diseases were found both in plantations as well as natural stands.

Rot of emerging culms caused by *Fusarium moniliforme* var. *intermedium* and rot of growing culms caused by *F. equiseti* occurred both in plantations and natural stands and was widespread in the State. Both the disease affected the culm production in plantations and natural stands. Die-back of branches caused by *Fusarium pallidoroseum*, thread blight caused by *Botryobasidium salmonicolor* affecting foliage, culms and branches, foliage blight caused by *Bipolaris maydis* and *Bipolaris* sp. and *Dasturella divina*, causing leaf rust, were recorded in bamboo plantations as well as natural stands. Seventeen foliar diseases of minor significance with which twenty two species of fungi belonging to 17 genera were also recorded on different species of bamboos in plantations and natural stands. Basal culm decay and withering caused by *Ganoderma lucidum* and *Amylosporus campbelli*, and culm staining and die-back caused by *Apiospra* sp. occurred in old clumps in natural stands and plantations.

In rattans, altogether 11 seedling diseases were recorded both in bareroot as well as container nurseries with which 13 fungi were associated. Seedling collar rot caused by *R. solani*, *Sclerotium rolfsii*, *F. longipes* and seedling blight caused by *Guignardia calami* were the economically important nursery diseases. Among the seven leaf spot diseases caused by *C. gloeosporioides*, *B. ellisii*, *Corynespora cassicola*, *A. alternata*, *Pestalotiosis thew*, *Curvularia lunuta* and *Phomopsis* sp., leaf infection caused by *C. gloeosporioides* was widespread and occurred in most of the rattan species.

In rattan plantations and natural stands, altogether 12 diseases were recorded. Of these eight foliage diseases were caused by 11 fungi of which six were also associated with the seedling diseases in rattan nurseries. Among the foliage diseases, leaf blight caused by a hither to undescribed *Sphaerodothis* sp. was the most widespread in occurrence. *C. crassipes*, *F. pallidoroseum* and *Phyllachora calamigena* were also caused leaf spots of minor significance. *Corynespora* sp. and *Phomopsis* sp. were the other two hitherto undescribed species which caused leaf infection. In rattan plantations, fruit rot caused by *F. moniiforme* appeared to has potential to become a serious disease. Thread blight caused by *P. filamentosa*, which occurred in high humid areas during the wet period, and staining and stem rot caused by *B. theobromae*, occurred in rattan clumps affected by ground fire, were of minor significance.

1. INTRODUCTION

Bamboos and rattans are non-timber forest products which have gained considerable importance in the recent past. Bamboos, encompassing 75 genera and about 1250 species, are versatile group of plants of multiple end uses; they play an important role in the rural economy of many developing countries. It is estimated that about 21 million hectares of the earth surface is covered by bamboo forests. They are widely distributed in the tropical to temperate zones, from sea level to alpine elevation (3000-4000 m). In India, there are about 128 species of bamboos belonging to 23 genera covering an area of 10.03 million hectares, which constitute around 12.8% of the total area of forest cover in the country (Tiwari, 1991). More than 50 % of the recorded bamboos occur in eastern India. Other areas rich in bamboo resources are the Western Ghats, Andaman and Nicobar Islands, Bastar region of Madhya Pradesh and Siwalik hills of Uttar Pradesh. In addition to the natural occurrence of bamboos in forests, they have been planted on a large scale in many States. *Bambusa bambos* (L.) Voss *(=B. arundinacea* (Retz.) Willd.), *B. nutans* Wall., *B. vulgaris* Schrad. *Dendrocalamus hamiltoniii* Nees and *D. strictus* Nees are the common species raised in plantations.

In Kerala, bamboos form a significant component of the natural vegetation and occur in tropical evergreen, semievergreen and moist deciduous forests, sub-tropical hills, and also as southern moist bamboo brakes. About 17 bamboo species belonging to five genera have been recorded in Kerala (Gamble, 1896; Mukteshkumar, 1990). Of these, *B. bambos*, D. strictus, *Pseudoxytenanthera bourdillonii* (Gam.) Naithani, *P. ritcheyi* (Mum) Naithani *(=Oxytenanthera* monostigma Bedd.), *Schizostachyum beddomei* (Fisch.) Majumdar (= *Teniostachyum* wightii Bedd.), *Ochlandra travancorica* (Bedd.) Benth. ex Gam., *O. scriptoria* (Dennst.) Fisch., *O. beddomei* Gam., *O. ebracteata* Raizada & Chatterji and *O. wightii* Fisch. occur naturally. In addition, a large number of bamboo species have been introduced and cultivated. In Kerala, B. *bambos, D. strictus* and *Ochlandra* spp. are the commercially exploited bamboos. B. *bambos* prefers rich moist soil and grows on banks of perennial river and streams and moist valleys. It also occurs as extensive patches or as undergrowth in mixed forests. *D. strictus* grows naturally in tracts receiving as low as 750 mm of rainfall, mostly in dry areas of Palakkad, Mannarkkad and Munnar Forest Divisions; sporadic occurrence is also noticed in moist deciduous and dry deciduous forests. *Ochlandra species,* popularly known as reed bamboos, occur as undergrowth in tropical evergreen, semi-evergreen and moist deciduous forests, and also as pure reed brakes. Reed bamboos often form pure patches where the canopy has been opened up by shifting cultivation or felling of tree species (Basha, 1992).

Bamboos have also been raised in pure or mixed plantations. So far, an area of 3,400 ha has been brought under bamboo cultivation (Anon., 1990). Apart from this, bamboos are grown traditionally in homesteads and farmlands, accounting for a total of 310 ha in homesteads (Krishnankutty, 1991) alone. As 'poor man's timber' bamboos play an important role in the rural economy of the State. They are used in traditional cottage industries for making mats and baskets and about 30,000 people are directly or indirectly dependent on this for their livelihood (Nair, 1986; Muraleedharan and Rugmini, 1990).

Apart from the traditional uses, bamboos form an important raw material for paper, pulp and rayon industries in the state.

Rattans (canes), comprising of 14 genera and about 600 species are widely distributed in the Paleotropics. In India, rattans are represented by four genera viz. *Calamus*, *Daemonorops*, *Plectocomia* and *Korthalsia* with 51 species, occurring in the Western Ghats of Peninsular India, Eastern and North-eastern States and Andaman and Nicobar Islands. They are generally found in the evergreen, semi-evergreen and moist deciduous forests. Only the genus *Calamus* occurs in Peninsular India and more than 10 species have been located in different forest areas of the Kerala State (Renuka et al, 1986; Mohanan and Muraleedharan 1988, Renuka, 1992). Recently, small-scale trial planting of rattan has been initiated in the State. Among the various rattan species occuring in Kerala, *Calamus thwaitesii* Becc., *C. gambleii* Becc. *C. hookerianus* Becc., *C. rotang* L. and *C. travancoricus* Bedd. are the commercially exploited ones. Rattan industry in the State consists of cottage type small and medium sized units and more than 60 such units are functioning in the State (Mohanan, 1992). This cotage industry is highly labour intensive and a large number of people, especially belonging to the economically weaker sections, are engaged in the collection and processing of rattans.

The natural forests form the main source of bamboos and rattans. The productive potential of bamboo and rattan stands in the State is greatly affected by various climatic, biotic and abiotic factors viz., erratic rainfall, fire, grazing, unscientific harvesting, and pests and diseases. Bamboos and rattans are also vulnerable to various diseases which affect them in nurseries, plantations as well as in natural stands. Limited experience in raising bamboo and rattan seedlings together with lack of information on diseases affecting them and their control measures have often resulted in partial to complete failure of several nurseries. In the recent past, over-exploitation of these two important natural resources without considerration of sustainable management, has also resulted in resource depletion in many areas. The dwindling supply of bamboos and rattans has affected the traditional cottage industries as well as those in modern sector. It has now become essentia1 to conserve and manage the existing bamboo and rattan resource bases and also to bring more area under intensive management as well as effective utilization of the harvested material. In this context, survey of diseases of bamboos and rattans is of crucial importance. So far, no systematic attempt has been made to study the diseases affecting bamboos and rattans in nurseries, plantations and natural stands in the state. Hence, the present investigation was taken up to conduct a systematic survey of the diseases affecting bamboos and rattans in Kerala.

2 MATERIALS AND METHODS

2.1. Selection of study areas and sampling procedures

Initially, a reconnaissance survey was made in various bamboo and rattan growing areas in the State to ascertain their geographic distribution and disease potential. Based on this, representative plots were selected in different localities for detailed investigations. Three plots each of 50x50 m were selected for bamboos at random in each of the 17 localities;

for reed bamboos 20 x20m plots were selected in each of the five areas (Appendix 1). In addition, bamboo preservation plots, trial plots, botanical gardens, Bambusetum, bamboo brakes, etc. were also identified and selected for the study. For rattans, three plots each of 20 x 20 m were selected at random in each of the 16 localities (Appendix 2). The selected plots were visited at least twice a year, during June to September and December to May, and observations recorded on Disease Data Sheets. Information on the location of bamboo and rattan nurseries raised in the State from 1987 onwards was also gathered from various Forest Divisions. As far as possible most of the nurseries were (Appendix 3) visited frequently between December to June, when the seedlings were at different stages of growth. Experimental bamboo and rattan nurseries raised at KFRI, Peechi during 1988-1991 and bamboo nursery at Chandhanathodu, Wynad raised during 1991-1992 were also surveyed intensively for seedling diseases. Bamboo and rattan species surveyed in nurseries, plantations, natural stands, preservation plots, etc. are given in Appendix 4.

2.2. Disease indexing

Observations on disease incidence, severity, spread, symptoms and nature of damage caused to seedlings, etc. were recorded in bamboo and rattan nurseries. The incidence of a disease was recorded either by counting the number of disease patches and the approximate area covered by them or percent seedlings affected for a given density of seedlings in a seedbed (Sharma and Mohanan, 1991a). Infected seedlings were counted separately in transplant and container beds. A disease scoring scale (Appendix 5) was used for assessing the severity of seedling diseases.

Severity of foliage diseases, branch infection, culm necrosis, etc. was rated on a numerical scale (0-3) of disease rating index. The average severity index of a disease (DSI) in a plantation/natural stand was calculated using the following formula (Sharma et al., 1985).

$$DSI = \frac{nLx1 + nMx2 + nSx3}{N}$$

Where, nL, nM, nS represent total number of clumps with low, medium and severe disease severity; 1, 2, 3 disease severity index (DSI) for low, medium and severe respectively and N, the total number of clumps assessed in all the observation plots.

For emerging and growing culm diseases, number of healthy, diseased, deformed and emerged culms died each year, were counted separately for each clump from the plot and percent incidence calculated. The percent incidence of a particular disease in an area/ plantation was calculated using the following formula:

$$\text{Percent incidence} = \frac{nd}{N} \times 100$$

where, nd is the total number of culms/clumps affected and N is the total number of culms/clumps observed in all the plots.

2.3. collection of infected materials and isolation of causal organism

Infected materials viz., seedlings, foliage, stem, culm, culm sheath, branch, rhizome,

roots, etc., collected from nurseries and field, were brought to the laboratory in separate polythene bags and stored in a refrigerator. Isolation of causal organisms from the disease specimens was carried out within one to two days of collection.

2.3.1. Culture media used for isolation and maintenance of isolates

Potato dextrose agar (PDA) and malt extract agar (MEA) were used as general media for isolation and maintenance of fungi. Oat meal agar (OMA), Lima bean agar (LBA), Rose bengal agar (RBA), Potato sucrose agar (PSA) were also used for selective isolation of various fungi. SMC medium (Saglio *et al.*, 1971) was used for isolation of MLO. Nutrient agar medium (NAM) was used for isolating and maintaining bacteria. All the culture media (dehydrated) used in the study were supplied by Himedia, Bombay.

2.3.2. Identification of causal organism

Identification of pure culture of microorganisms isolated from various disease specimens was attempted up to species level wherever possible, on the basis of their cultural and morphological characters. For authentic identification or confirmation, the cultures and herbarium specimens bearing fructifications were referred to IMI, U.K. The colour standard of Kornerup and Wanscher (1978) was used for describing the fungus. The identified cultures were subcultured regularly and stored at 25 ± 2^0C

2.4. Microtomy and histopathology

To study the histopathology of little leaf disease of D. *strictus* and also to gather morphological details of fructifications of various fungi such as pycnidia, perithecia and rust sori, appropriate specimens were selected and their sections (2-8mm) cut using Minotome cryomicrotome (IEC, USA). Samples of internodal region from young shoots affected with little leaf diseased as well as those of healthy D. *strictus* plants were selected for histopathological studies. Samples were fixed in formalin -acetic acid-alcohol (FAA) (Johnston and Booth, 1989). Sections were cut using cryomicrotome, mounted in distilled water and viewed under Leitz Dialux 20 microscope. Phloem tissues were examined for any deformities.

2.4.1. Dienes' staining reaction

Free hand-cut sections of internodal region from young shoots of little leaf diseased and healthy D. *strictus* were taken. The sections were stained with 0.2% solution of freshly prepared and filtered Dienes' stain (methylene blue, 2.5 g; azure II, 1.25 g; maltose, 10.0 g; sodium carbonate, 0.25g; distilled water, 100 ml) (Deeley et al., 1979) for ten minutes, then washed and mounted in distilled water and viewed under Leitz Dialux 21 microscope.

2.4.2. Fluorescence microscopy

Aniline blue, a fluorochrome used for detecting callose in the phloem of mycoplasma infected plant tissues (Hiruki and Shukla, 1973) was used in fluorescence microscopy. Free hand-cut D. sections of little leaf diseased as well as healthy tissues of strictus, immediately heat-killed in boiling water for 10 minutes, were stained in 0.01% aniline blue prepared in

1/15M phosphate buffer(Ghoshetal., 1985a,b).Stained sections were viewed under Leitz Dialux 20Fluorescence microscopeand photomicrographs taken.

Hoechst 33258,a DNA binding fluorochrome (Russel etal., 1975) was also used in fluorescence microscoy. Free hand-cut sectionswere fixed in 3%glutaraldehyde in cacodylatebufferat40Cfor6 h.Sections were washed in0.1 Mphosphatebufferand stained in Hoechst 33258prepared in 0.1 M phosphate buffer containing 100ugml^{-1} for 15 to 20 min and viewed under Leitz Dialux 20 Fluorescence microscope.

2.43. Transmissionelectron microscopy

Two millimetre bits of juvenile shoot and petiole from little leaf diseased and healthy D. *strictus* plants were fixed in2.5%glutaraldehydebuffered with0.1 Msodium cacodylate, pH 7.0, for 24 h at 4° C Sections were washed thoroughly in the same buffer and post fixed in2%osmium tetroxidein0.1 Mcacodylate buffer for5-6h. After washing with cacodylate buffer (30 min.), and distilled water, the sections were dehydrated in acetone series and embedded in Epon 812 (Morris, 1965).

Ultra-thin sections werecut with LKBIII Microtome using glass knife and differentiated with aquousuranyl acetate (0.5%)and lead citratefor 10to 15min.ineachstain (Reynolds, 1963); sections were viewed under Zeiss transmission electron microscope (TEM) and photomicrographs taken.

2.4.4. Staining

Lactophenolcotton blue 0.l%, glycerolanilineblue0.2%(glycerol (50%), 100ml; aniline blue, 0.2 g)were used for staining the fungal specimens. Pyridoxin (50%)was used for clearing the whole mount (Sharma and Mohanan, 1991a).

2.5. Pathogenicity test

Pathogenicity of various fungi associated with diseases of bamboos and rattans was confirmed in artificial inoculation trials by employingstandard procedures. Forsoil-borne diseases, the soil was infested with appropriate quantity of inoculum of test fungus,raised in corn-meal-sand medium and seeds of bamboo or rattan were sown at appropriate rate in the infested soil in Aluminium trays; the trays were maintained in a humidity chamber, watered regularly and observed for the development of disease. For foliage diseases of bamboos, 10-to 60days old B. bambos and D. *strictus* bareroot seedlings raised in sterilized forest soil in metallic trays (30x 30 x 5cm;90 x60 x 25 cm), over the polyurethane foam(20 x 10x lcm) or 10-to 11 month-old container seedlings were used. For culm and branch infection, 3-year-old B. *bambos* clumps maintained in large metallic trays were used. New culms produced from the clump were monitored and used for inoculation trial. For confirming the pathogenicity of fungi causing various diseases of rattans, l0-day to 4-month-old bareroot as well as container seedlings of *C. thwaitesii,C. gamblei,C. hookerianus,* C. *pseudotenuis* and C. *rotang* were used.

2.5.1. Field trial

A field trial was carried out at Thenkodum (Kaliyar Forest Range) in a 1979 teak

plantation where bamboo was raised at an espacement of 10x10m during 1986 and large-scale mortality of outplanted bamboos was recorded during 1987. The pathogen associated with the disease was identified as *Pythium* middletonii. For assessing the natural infection of rhizome caused by *Pythium middletonii*, one hectare area was planted with 18-month-old *B. bambos* container seedlings during June 1988, in pits of 30x 30x 30cm at an espacement of 10x 10m.

2.52. Screening of tetracycline for little leaf disease recovery

Twelve clumps of *Dendrocalamus strictus* affected with little leaf disease were selected in natural stands at Thakarapady (Mannarkkad Forest Divn.) for tetracycline therapy. Tetracycline-hydrochloride tree injection formula (Pfizer Ltd., Thane) (1.0 g 500 ml^{-1}) (Ghosh ***et al.***,1985a) was applied as foliar spray (50ml shoot-1) on the selected culms. The treated portion, nodes including nodal shoots was covered with a polythene sheet for a day and later removed. Observations on the remission of symptoms, if any, were recorded at fortnightly intervals for six months.

2.6. Evaluation of fungicides for disease control

Various fungicides were evaluated (Appendix 6) for their efficacy against different pathogens following poison-food technique and or modified soil fungicide screening method (Sharma and Mohanan,1991a).

3. RESULTS AND DISCUSSION

3.1. DISEASES OF BAMBOOS

3.1.1.Diseases in nurseries

In Kerala, usually 12 to 18-month-old bareroot or container seedlings are used for outplanting. Bamboo seedlings are raised by the Forest Department following the usual forest nursery prescriptions. Generally, bamboo nurseries are raised during the month of December-January. Bamboo seeds collected during the current seeding year or properly stored seeds having high germinability are sown at the rate of 500g to 1.5Kg per standard seedbed (12x 1.2x0.25 m). In many localities, seeds soaked overnight in water are used for sowing. Shade regulation over the nursery beds and watering are done as in the case of other forestry species. After 40 to 50 days of growth, the seedlings are either transplanted into polythene containers (18 x 12 cm) filled with forest soil or in the newly raised transplanting beds, at 15 x 15 cm spacing. Outplanting of one-year-old bareroot or container seedlings is carried out after the onset of South-West monsoon i.e., during the month of June-July.

A total of 27 bamboo nurseries comprising of 10 to 100 standard beds, raised at 18 different localities in Kerala, were surveyed for the occurrence of diseases during 1987-1992. Altogether 13 seedling diseases were recorded in bamboo nurseries with which 14 fungi were found associated consistently (Table 1). Most of these diseases were prevalent

in almost all the bamboo nurseries surveyed, while only a few were restricted to certain nurseries. However, the severity of each disease varied from nursery to nursery depending on the local climatic factors, bamboo species raised, seedling density, nursery practices adopted, etc.

Table I: ***Checklist of nursery diseases of bamboos recorded in Kerala during 1987-1992***

Sl. No.	Disease	Pathogen(s)	Bamboo species affected‘
1.	Damping-off		
	i. Pre-emergence damping-off	*Rhizoctonia* solani Fusarium *moniliforme* *F. oxysporum*	BB,DS,DB,TS
	ii. Post-emergence damping-off	*R . solani*	BB,DS,DB,TS
2.	Seedling spear rot	R. solani	BB,DS
3.	Seedling wilt	*R.* solani	BB,DS
4.	Web blight	*R. solani*	BB,DS,DB,TS
5.	Leaf rust	Dasturella divina	BB,DS,DB,OT,TS
6.	Bipolaris leaf blight	*Bipolaris maydis* *B. urochloae* *Bipolaris* sp.	BB,DS,DB,DM,TS,O W PP BB
7.	Exserohilum leaf spot	Exserohilum rostratum E. holmii	BB,DS BB,P’P
8.	Dactylaria leaf spot	*Dactylaria* sp.	BB,DS,DB,OW,TS
9.	Colletotrichum leaf spot	*Colletotrichum gloeosporioides*	BB,DS
10.	Curvularia leaf spot	*Curvularia pallescens*	BB,BV,DL,TO,OS
11.	Alternaria leaf tip blight	Alternaria alternata	BB,DS
12.	Seedling rhizome rot	Rhizostilbella hibisci state of *Nectria* mauritiicola	BB
13.	Leaf striping and stunting	Unknown etiology (possibly a virus)	BB

‘BBB.*bambos;* DS: D. *strictus* DB:D.*brandisii;* DLD.*longispathus;* DMD.*membranaceus;* TST.*siamensis;* 0S:O.*scriptoria;* 0T:O.*travancorica;* OW: O.*wightii;* PP:P.*pubescens.*

1. DAMPING-OFF

Occurrence

The disease, both pre- and post-emergence damping-off was recorded in B. *bambos* nurseries raised at Periya (South Wynad Forest Divn.), Chandhanathodu (Cannanore Forest Divn,), Paneli (Malayattoor Forest Divn.), Pattikad and Peechi (Trichur Forest Divn.), Nilambur (Nilambur Forest Divn.), Kulanjithodu (Ranni Forest Divn.) and in *D. strictus* nursery at Dhoni (Palakkad Forest Divn.) during 1987-1992. In these nurseries, different seed rates ranging from 750 g to 1.5 Kg per standard seedbed were used. In

addition, the seedbeds were provided shade with thatched coconut leaves or with 'jungle leaves' and over watered. Pre-treatment of seeds was done in all the nurseries except in a nursery at Kulanjithodu where severe damping-off was recorded (Table 2). Disease incidence was found to be low in all the nurseries except at Dhoni (during 1987-'88)' and at Kulanjithodu (during 1989-'90), where medium and severe infections were recorded respectively. Damping-off was also recorded in seedlings of D. *strictus,* D. brandisii and ***T. siamensis*** in a nursery at Chandhanathodu during 1991-'92.

Symptoms

In bamboo nurseries, sown with good quality seeds but provided with either excessive or thick shade and frequent watering, often poor seedling emergence was recorded even after 7 to 12 days of sowing. The disease occurred in patches in the seedbeds. The size and number of the patches and the seedling emergence depended upon the severity of the infection. When a thin layer of top soil over the patch was removed gently, a large number of well-filled seeds covered with fungal mycelium and powdery fungal spore mass were observed. The seed decay and pre-emergence damping-off were characterized by the rotting of the well-filled viable seeds and also the just emerged radicle. In nurseries situated at Dhoni and Kulanjithodu, partial failure of nursery was recorded due to the poor seedling emergence on account of damping-off. Post emergence damping aff was characterized by the development of water-soaked greyish brown lesions on the emerging plumule near the soil level. The lesions spread and became necrotic which resulted in collapse of the affected plumule.

Table 2: Severity of damping-off in bamboo nurseries *at* dfferen t localities in Kerala surveyed during *1987-1992*

		Disease severity'									
		1987-'88		1988-'89		1989-'90		1990-'91		1991-'92	
Sl. No.	Locality	Bamboo species	DSI	DSR	DSI	DSR	DSI	DSR	DSI	DSR	DSI	DSR
1.	Periya	BB	-	-				-	0.80	L	0.64	L
2.	Chandhanathodu	BB	-	-						-	0.95	L
3.	Pattikad	BB	-	-	0.40	L						
4	Paneli	BB	-	-				-	0.50	L	0.40	L
5.	Peechi	BB	-	-	0.50	L	0.40	L	036	L		
6.	Dhoni	DS	1.13	M	0.75	L						
7.	Nilambur	BB	-	-	055	L	0.22	L				
8.	Kulanjithodu	BB	-	-		-	2.10	S				

DSI : Disease severity index; DSR : Disease severity rating L: low; M: medium; S: severe; BB B. *bambos;* Ds: D. *strictus*

causal organisms

Three fungi were found causing damping-off of bamboo seedlings.

1. *Rhizoctonia solani* Kuhn state of *Thanatephorus cucumeris* (Frank) Donk (IMI No.350658).
2. *Fusarium moniliforme* Sheld(IMI No.322571).
3. *Fusarium oxysporum* Schlecht.

Rhizoctonia solani was isolated mostly from the damped-off seedlings which caused radicle and plumule rot, while *Fusarium moniliforme* and *F. oxysporum* caused mainly pre-emergence damping-off and seed decay.

Pathogenicity test

Seeds of *B.bambos* sown in *R.solani* infested soil showed comparatively poor emergence (57%) than those in control (96%). Though, seedling emergence occurred after four days of sowing in both control and *R. solani* infested soil, germination completed in control within seven days of sowing, while it took 12 days in treated soil. Infection of radicle and just emerged plumule was observed in *R. solani* infested soil which consequently resulted in post-emergence damping-off. Post-emergence damping-off occurred within one to two days of emergence as water-soaked greyish brown lesions on the plumule at the soil level. Severe infection on the emerging radicle and plumule often led to the development of abnormal incurved seedlings which later succumbed. When a thin top layer of the seedbed soil was removed gently, the ungerminated well-filled decayed seeds were found covered with the mycelium of *R. solani*. *R. solani* was reisolated from the infected radicle, decayed seeds and damped-off seedlings.

B. bambos seeds coated with conidia of *Fusarium moniliforme* and *F. oxysporum* separately and sown in Aluminium culture trays showed slightly low percent of seedling emergence (89%) as compared to controls (96%). Seedling emergence occurred after four days of sowing and completed within seven days in *Fusarium* treated seeds as well as in controls. Only pre-emergence damping-off occurred in both the Fusarium infested soils as evidenced by the low per cent seedling emergence. Upon a closer examination, ungerminated well-filled seeds treated with both *F. moniliforme* and *F.oxysporum* found decayed. The decayed seeds were recovered with white cottony fungal mycelium bearing powdery spore mass over the whole seed surface. Infection of the just emerged radicle and plumule as greyish brown lesions was observed less frequently in seedlings infested with *F. monilforme* and *F. oxysporum*. *F. moniliforme* and *F. oxysporum* were reisolated from the decayed seeds, and decayed radicle and plumule.

Discussion

Damping-off, the first disease to appear in the seedbed nurseries affects seedlings both before emergence (pre-emergence damping-off) and after emergence (post-emergence damping-off) within 2 to 15 days after sowing; the development of the disease mainly depends upon the micro climatic conditions prevailing in the nursery. Though, almost all the nursery-grown forestry species are susceptible to damping-off fungi, the seeds of species which germinate quickly and seedlings which grow fast possibly sustain

damage from damping-off than slow emerging and slow growing species (Duryea, 1984). This is also true in the case of bamboos as the seed germinates quickly and the seedling grows rapidly. The overall incidence and damage caused by damping-off are comparatively less in bamboo seedlings than those recorded for other forestry species. (Bakshi *et al* 1972; Sharma *etal* 1985; Mehrotra, 1990). Pre-sowing seed treatment is also known to play an important role in minimizing the incidence and development of damping-off (Bakshi, 1976). In the case of bamboo seeds, overnight soaking in water which possibly reduces the spermoplane microflora, and subterranean exposure of seeds prior to germination, facilitate to minimize the incidence of damping-off. This explanation holds good for the severe damping-off during the year 1989 recorded in a nursery at Kulanjithodu, sown without pretreating the seeds.

Fusariurn moniliforme and *F. oxysporum* are associated only with the pre-emergence damping-off, while R. *solani* causes mainly post-emergence damping-off of bamboo seedlings. The only indication of pre-emergence damping-off in nursery beds is the presence of sparse and patchy emerging seedlings. But it is confirmed by digging up seeds that have not emerged and observing them for decay. A possible evidence of seedborne nature of Fusarium pre-emergence damping-off has been provided by the seed pathological studies on stored seeds of *B. bambos* and *D. strictus,* which reveal occurrence of *Fusarium* spp. in high frequency affecting seed germination and seedling growth (Mohanan, 1990a).

Fusarium spp. and *R. solani* have been recognized as the important damping-off pathogens in forest nurseries throughout the world (Brown and Wylie, 1991; Ferreira and Muchovej, l991; Sutherland, 1991; Ray, 1991; Borja and Austara, 1991; Arentz, 1991; Perrin, 1991). In India, R. solani has emerged as the most important damping-off pathogen in forest nurseries, especially in high rainfall areas (Bakshi *et* d., 1972 Sharma et d., 1985; Mehrotra, 1990). However, *Fusarium* spp. were recorded less frequently in forest nurseries in India (Bakshi, 1976; Sharma *et al.,* 1985). The present findings are in conformity with the earlier observation, i.e. in bamboo nurseries R. *solani* has become the principal dampingoff fungus, whereas *F. moniliforme* and F. *oxysporum* are of minor importance and cause only seed decay and pre-emergence damping-off.

Excessive soil moisture due to over watering, thick shade, high seedling density and high organic soil contents are the main factors contributing to initiation and spread of damping-off (vaartaja, 1952; Gibson, 1956, Sharma and Mohanan J99la). Some of these factors are also found to be responsible for the high incidence of damping-off in bamboo seedlings. Though, this disease cannot be considered as a potential one, for raising disease-free nursery stock pre-sowing seed treatment and regulation of shade and moisture in the seedbeds should form part of the nursery management.

2. SEEDLING SPEAR ROT

Occurrence

The disease was observed in *B. bambos* nurseries at Kulanjithodu during 1989-'90, Periya and Niravilpuzha (Wynad Forest Divn.) during 1990-'91, Chandhanathodu during 1991-

'92 and in D.*stricuts* nursery at Dhoni during 1988-1989. Infection of emerging spear-like plumule occurred within two to five days of emergence. The overall disease inadence was found low in all the nurseries. However, in B. *bambos* nursery at Chandhanathodu, the disease incidence was were in seedbeds without any shade, sown with high seed rate of 3Kg per standard bed and watered insufficiently. In seedbeds where the seeds were covered with a thick layer (>0.5cm) of soil, generally, the disease incidence was very high.

Symptoms

The disease is manifested as small irregular water-soaked lesions on emerging spear-like plumule near the soil level or at the pointed apical portion. The lesions coalesced and spread ,rapidly from base to the apex or from tip downwards covering the entire spear which subsequently became necrotic. The infected spears failed to grow further and expand to form leaves and dry up in due course. The disease occurred in patches in seedbeds and the advanced stage of infection could easily be detected as the infected seedlings in patches gave a burnt-up appearance.

Causal organism

Rhizoctonia solani Kuhn state of *Thanatephorus cucumeris* (Frank) Donk (IMI No.350658).

Pathogenicity test

In artificial inoculation trials, seedlings of B. *bambos* merged on the fourth day of sowing in both R. *solani* treated soil as well as control. Characteristic spear rot was observed in the infested soil on the emerging seedling plumule near the soil level as greyish brown water-soaked lesions with dark brown margin. The lesions spread very quickly in a linear fashion towards the tip of the elongating spear and within three days the entire infected spear became necrotic. Infection at the tip of the spear emerging through the soil was also observed, where, downward spread of the infection was noticed. In the control no infection was recorded. R. *solani* was reisolated from the infected seedlings.

Discussion

Seedling spear rot caused by R. *solani* is the disease which affects emerging plumule. It is a disease recorded for the first time on bamboos. Symptomwise, the disease appears to be an extension of the damping-off which was probably delayed by the unfavourable soil conditions. The disease was recorded only in five out of the 27 nurseries surveyed, where a thick layer of soil was spread over the seeds and the seed beds received less water. Longer period of subterranean condition of the emerging plumule due to thick layer of soil, high soil temperature and water stress may have possibly enhanced the chance of infection by R. *solani*. This circumstantial evidence clearly suggests that the development of spear rot depends mainly on the nursery management practices. Occurrence of this disease in bamboos confirms the earlier observation that R. *solani* is highly diverse in its characteristics, producing different disease symptoms under different microclimatic conditions (Baker, 1970).

3. *SEEDLING WILT*

Occurence

The disease was recorded in 20 to 40day-old *B. bambos* and *D. strictus* seedlings at Chandhanathodu nursery during 1991-'92and in 40 to 50-day-oldmntainer seedlingsof *B. bambos* in a Social Forestrynursery at Kalamassery (Emakulam Social Forestry Divn.) during 1987-1988. At Chandhanathodu, seedling wilt was observed in seedbeds with or without shade, having highseedlingdensity (3.0Kg seeds per standard bed) and watered copiously. In both the nurseries, disease incidence was found to be low.

Symptoms

Initially, the infection occurred as water-soaked, greyish brown lesions on the seedling stem near the ground level. The infection spread upwards and caused lesions on leaf sheath, basal leaves and stem; the juvenile leaves were free from the infection. The infected areas on the stem became dark brown in colour and necrotic, which later coalesced and became constricted. Affected seedlings showed symptoms of physiological wilting. Due to loss in turgidity, the seedlings showed rolling up of the entire foliage from 11 AM onwards, especially those in seedbeds under direct sun light and less frequently watered. Bending and breaking up of the seedling stem often occurred at the constricted area and epicormic roots developed from the lower portion of this cankered area. The wilted seedlings rarely showed browning and decay of feeder roots. Production of small yellowish brown sclerotial bodies on the affected basal part under high humidity was also noticed. Severe infection usually resulted in high mortality of seedlings, either in distinct patches or scattered all over the seedbed. The infection continued for 30to 40 days in seedbedsdependingon the microclimatic conditionsprevailingin thenursery. Inseedbeds provided with shade, the infected seedlingscouldbedetected easily during early morning hours. However, by the middle of the day in theshadedseedbedsand from 11AM onwards in the seedbeds without shade, the symptoms of physiological wilting and rolling up of the leaves was evident.

Causal organism

Rhizoctonia solani Kuhn state of *Thanatephorus cucumeris* (Frank) Donk (IMI No.350659); anastomosis group - AG2-2IV.

Discussion

seedling wilt of bamboos caused by *R. solani* is recorded in bareroot and container seedlingsaffectingyoung 20to 40-day-old seedlings. The pathogen affects the conducting tissues of root and stem and rarely the foliage is affected. This indicates the specificity of the fungus on host tissues. *R. solani* is already known for its complex nature due to the presence of different strains which can affect all the tissues of seedlings. Specificity among the pathogen strains in the population or even within the strain, has been reported to cause infection of aerial parts and underground tissues (Baker, 1970). The *R. solani* strain, which caused seedling wilt, was found to be belonging to the anastomosis group AG2-2IV.

Isolates of *R. solani* AG-2-2 are generally considered to cause root and crown rots of sugar beet and corn (Anderson, 1982; Ogoshi, 1987); they also have been reported to cause foliar diseases and seedling decay of soybean, and sheath blight of mat rush (Ogoshi, 1987; Liu and Sinclair, 1992). In Kerala, *R. solani* has been recorded to cause seedling wilt and mot rot of *Eucalyptus grandis* Hills ex Maiden, *E. tereticornis* Sm. and *Casuarina equisetifolia* Forst (Sharma et *al.* 1984b; Mohanan and Sharma, 1989, 1993).

4. WEB BLIGHT

Occurrence

Web blight of bamboo, a widespread seedling disease in Kerala, was recorded from 23 seedbed nurseries in 15 localities in the State during 1987-1992 (Table 3). Disease was also recorded in *B. bambos*, D. *stricuts, D. brandisii*, and *T. siamensis* seedlings in a experimental nursery raised at Chandhanathodu during 1991-'92. Severity and spread of infection largely depended on the microclimatic conditions prevailing at the nursery site and also the cultural practices adopted in the nursery. In all the nurseries surveyed, disease severity was found to be low except at Niravilpuza, Kulanjithodu, Periya, Begur, Paneli and Pezhad, where disease severity index (DSI) ranged between 1.04-1.25 and disease severity rating (DSR) was medium. The disease affected 20 to 30-day-old bamboo seedlings and continued further depending on the favourable microclimatic conditions prevailing in the nursery.

Symptoms

Infection appeared in 20 to 30 day-old bamboo seedlings as water-soaked lesions on the stem near the soil level. Later, the infection spread rapidly affecting the entire shoot, except one to two juvenile leaves. Infected stem and foliage became discoloured, greyish brown to dark brown, within two to five days of infection. Leaf necrosis was initiated either from the leaf tip and proceeded towards the base of the leaf or from the leaf margins towards the midrib.

The disease spread very rapidly within seedling through the fast growing mycelial strands of the fungus. Incitation and spread of disease between seedlings was mainly through the physical contact of the diseased foliage with the healthy neighbouring seedlings. The disease usually occurred as small patches comprising of 5 to 10 seedlings in the seedbed which increased in size as more and more seedlings got affected gradually under favourable microclimatic conditions. The individual infection focus in the seedbed spread and merge with other foci leading to formation of large disease patches of upto 30 cm dia. The disease was recorded in seedbeds provided with or without shade. However, high disease incidence and its rapid spread was usually observed in seedbeds having high seedling density and those watered copiously. Infected foliage showed shades of greyish brown, purplish grey, and pastel green discolouration which later turned into necrotic areas. Complete necrosis often led to withering of the foliage. Under high humidity, especially during the early morning hours fungal mycelium, which arose from the soil epiphytically, grew over the affected seedlings entangling their foliage and stem. Yellow-ish brown sclerotia of the fungus developed on the decayed basal foliage and stem. The

Table3: Severety of web blight in bamboo nurseries at different localities in kerala surveyed during 1987-1992

Sl NO.	Locality	Bamboo species"	Disease severity' DSI	DSR	Year
1.	Vadavukodu	BH	033	L	1987-1988
2.	Kalamassery	BB	0.30	L	1987-1988
3.	Dhoni	DS	0.40	L	1987-1988
			0.30	L	1988-1989
4.	Peechi	BB	0.50	L	1988-1989
			0.60	L	1989-1990
			0.54	L	1990-1991
5.	Nilambur	BB	0.40	L	1988-1989
			0.63	L	1989-1990
6.	Pattikad	BB	0.93	L	1987-1988
7.	Pariyaram	BB	0.75	L	1989-1990
8.	Kulanjithodu	BB	1.04	M	1989-1990
9.	Vadasserikkara	BB	0.76	L	1990-1991
10.	Niravilpuzha	BB	1.05	M	1990-1991
			1.16	M	1991-1992
11.	Thettamala	BB	0.82	L	1991-1992
12.	Pcriya	BB	1.25	M	1990-1991
			1.24	M	1991-1992
13.	Begur	BB	1.04	M	1990-1991
14.	Paneli	BB	1.12	M	1990-1991
			1.18	M	1991-1992
15.	Pezhad	BB	0.93	L	1990-1991
			1.20	M	1991-1992

'DSI: Disease severity index; DSR: Disease severity rating; L: low; M: medium.
'BB: *B.bambos;* DS: D.strictus

affected seedlings were killed outright within 10 to 20 days of infection, leaving large circular to irregular patches of dried up seedlings in seedbeds (Plate 1).

Causal organism

Rhizoctonia solani (IMINos. 350660,350661,350662,350659); anastomosis groups - AGI-IA, AGI-IC, AG2-2IV.

Discussion

Among the nursery diseases of bamboos recorded, web blight caused by R. *solani* is the most wide spread and potential one. The disease occurs in almost all the bamboo nurseries

surveyed and the severity varies considerably depending on the microclimatic conditions prevailing in the nursery. Though, web blight affects 20 to 30 day-old seedlings, the disease continued (90 to 120 days) till the microclimatic conditions in the nursery favoured the growth and development of the fungus. Heavy and incessant rain for a couple of days followed by an overcast weather for 5 to 6-days form the ideal condition for the disease to become severe. High density of seedlings, thick shading over the seedbeds and free water on seedlings also influenced greatly the development and spread of the disease.

In forest nurseries in India, web blight caused by *R. solani* has earlier been recorded in Khasi pines *(Pinus kesiya* Royle ex Gord. (Mehrotra, 1989), *Cusuarina equisetifolia* Forst in Kerala (Mohanan and Sharma, 1989, 1993), and a large number of broad leaved forest species viz., *Ailanthus triphysa* (Dennst.) Alston, *Azadirachta indica* A. Juss., *Bombax ceiba* L., *Cassia nodosa* Ham., *Ceiba pentandra* (L.) Gaertn., *Derruis robusta* Benth, *Eucalyptus* spp., *Gmelina arborea L., Melia azedarach L., Michelia champaka,* (L.) Piers., *Paraserianthes falcataria* (L.) Nielson in different parts of the country (Sharma and Sankaran, 1984; Sharma *et al.*, 1984b, 1985; Florence *et al.,* 1985; Mehrotra, 1989; 1990; Mohanan and Sharma, 1993; Ali, 1993). In bamboos, R. solani causing web blight belong to AG1-IA, AGI-IC, and AG2-2IV.

Management of web blight has been suggested in other forestry species which include sanitation, modification of cultural practices and use of fungicides. Sanitary measures recommended were disposal of leaf litter in the nursery and seggregation of diseased seedlings, soon after their detection for preventing the lateral spread of the disease which occurs through contact of the overlapping foliage of the adjoining seedlings (Mehrotra, 1989; Sharma and Mohanan, 1991a). Regulation of the shade over the nursery beds (no shade) and watering can check the disease; reducing the seedling density in the seedbeds was also suggested (Mohanan, 1994a). Application of carboxin (0.l%a.l.) after 7 and 21 days of seedling emergence has been suggested for controlling the disease (Mohanan, 1994a).

5. LEAF RUST

Occurrence

Leaf rust of bamboo seedlings was recorded from almost all the nurseries surveyed during the study. Rust appeared during the month of August affecting 4 to 8-month-old bareroot as well as container seed1ings; infection continued till late May. Rust was recorded on seedlings of B. *bambos,* D. *strictus* D. *brandisii, Oxytenanthera monostigma, Ochlandru travancorica, 0. scriptoria* and *T. siamensis,* Of these B. bumbos and D. strictus were the most susceptible species. Though, rust occurred in all the nurseries surveyed, the severity of infection was found low to medium except in a B. *bambos* nursery at Chandhanathodu during 1991-'92 Severe infection occurred in 8-month-old seedlings and 14 seedbeds were completely devastated by the disease. Medium infection was recorded in B. bambos nursery at Pezhad and Paneli during 1990-91, Nilambur during 1989-'90 and Periyaand during 1991-'92.

Symptoms

Infection usually appeared during the month of August on the mature leaves in the form of greyish brown minute flecks; usually, the juvenile leaves did not get any infection. These small flecks coalesced and formed spindle shaped dark brown pustules with pale halo around. Mature leaves were found more susceptible to infection than younger ones; higher density of uredinia was observed on the former than the latter. Uredinia, yellowish brown in colour, developed in the flecks on the adaxial surface of leaves. Development of uredinial sori was observed rarely on the abaxial surface. In severe cases, the adaxial surface of the entire leaf lamina became completely covered with uredinia imparting yellowish brown colour. The rust infection continued till late May. Dark brown teliosori developed either in mature uredinial sori or separately on the adaxial surface in linear rows during January. Necrosis and withering of mature leaves occurred due to severe rust infection.

Causal organism

Dasturella divina (Syd.) Mundk. & Khesw. (IMI Nos. 322078, 322081).

Discussion

Dasturella divina causing leaf rust is widespread in bamboo nurseries in the State. Seedling mortality due to rust infection was recorded only in a nursery at chandhanathodu, Wynad during 1991-'92, where cent percent rust incidence occurred. Seedlings completely died due to heavy infection in 14 out of 80 seedbeds. This clearly indicates the potential of the leaf rust in causing mortality of bamboo seedlings. It is interesting to note that bamboo seedlings were raised for the first time in Chandhanathodu nursery and during the past 20 years no bamboo was raised in that locality. Also, there are no bamboo stands in nearby areas which may have served as the reservoir of the inoculum. *D divina* is recorded as a heteroecious rust having an alternate host *Randia* spp. (=*Catunaregum* spp.) on which it produces pycnia and aecia (Bakshi *et al.*, 1972). However, no alternate host of the bamboo rust could be detected in the natural forest which surrounded the nursery. Under these conditions it is not clear that how such a severe rust infection occurred at Chandhanathodu. From India, so far, two species of *Dasturella* viz., D. *divina* (=D. *oxytenantherae* Sathe) and *D. bambusina* have been recorded on different bamboos (Mundkur and Kheswala, 1943; Sathe, 1965; Bakshi and Singh, 1967; Rangaswami et al ., 1970). *D* bambusina differs from D. divina mainly in the number of teliospores per chain and depth of telial coloumn. Though, rusts collected from different bamboo species in the State also showed variation in morphological characters of urediniospores and teliospores, these characters were not reliable in diffferentiating them into separate species. *D. divina* has also been recorded from Australia, Japan and Taiwan (Cummins, 1971; Hsieh, 1984; Johnson, 1985). This is the first record of the rust on bamboos in Kerala as well as first record of D. *divina* on T. *siamensis* in India. Since, the leaf rust can cause considerable loss to the nursery stock, detailed studies on epidemiology, disease cycle and possible control measures are warranted.

6. BIPOLARIS LEAF BLIGHT

Occurrence

Leaf blight, affecting both young and mature leaves of 2 to 18-monthaid bamboo seedlings, was found widespread in the nurseries surveyed. The infection appeared in young seedlings during the months of March-April and it continued till outplanting of seedlings. The disease was recorded in bareroot as well as container seedlings of B. *bambos* at Pattikad during 1987-'38, Nilambur during 1988-1990, Peechi during 1988-'91, Kulanjithodu during 1989-'90, Pariyaram during 1989-90, Paneli, Pezhad and Periya during 1990-'92, Vadasserikkara during 1990-'91, Thettamala, Niravilpuzha, Vattapoyil and Chandhanathodu during 1991-92 In addition, various other species of bamboos were also found affected by the disease: D. *strictus* at Dhoni during 1987-'89, *Phyllostuchys pubescens* at Peechi during 1989-'90, *D. brandisii*, D. *strictus* and *T siamensis* at Chandhanathodu during 1991-'92, D. *membranaceus* and *O. wightii* at Palappilly during 1991-'92. In all the nurseries, disease severeity was found low. However, in Chandhanathodu nursery, during the month.. of December to January, when cool nights alternate with hot days, severe infection was encountered. The disease incidence was higher in beds exposed to direct sunlight than those provided with shade. In thickly shaded beds seedlings located in the extreme end of the beds, which were exposed to direct sunlight, had higher disease incidence.

Symptoms

The disease manifested as minute, spindIe-shaped water-soaked lesions on both young and mature leaves, which later turned into dark bmwn to dull violet lesions with greyish brown centres. Lesions coalesced and formed large necrotic areas. Necrosis of leaf tissues started from the leaf tip downwards or from the leaf margins towards the midrib. Usually, darkbrown cross bands occurred in the necroticarea. The colour of thelesions, spread, etc. depended on the bamboo species affected, leaf maturity, and the pathogen species associated. Under high humidity, sporulation of the fungus was observed and spores were produced as dark greyish black mass in the necrotic tissues on the adaxial surface of the leaf (Plate 2).

Causal organisms

Three species of *Bipolaris* were found causing the leaf blight:

1. Bipolaris *maydis* (Nisikado & Miyake) Shoem. anamorph of *Cochliobolus heterostrophus* (Drech.) Drech. (IMl No. 326944).
2. *Bipolaris urochloae* (Putterill) Shoem. (IMI No. 326947)
3. *Bipolaris* sp. (IMI Nos. 326946, 326947).

Since, the symptoms varied depending upon the species of *Bipolaris* involved, details of symptoms produced by each species are given below.

B. *maydis* was isolated from B. bambos seedlings in nurseries at Paneli, Pezhad, Periya, Thettamala, Niravilpuzha, Chandhanathodu and Peechi; from D. *membranaceus* and *O. wightii* seedlings in nursery at Palappilly and from D. *brandisii*, D. *strictus* and *T. siamensis*

seedlings in a nursery at Chandhanathodu. *B. maydis* produced dark brown lesions with greyish brown centre.

B. urochloae was isolated from 8-month-old *Phyllostachys pubescens* seedlings in a nursery at Peechi. *B. urochloae* produced dark brown to blackish brown linear to irregular lesions which spread rapidly to the entire surface of the leaf lamina of both young and mature leaves under high humidity. *Bipolaris* sp. was isolated from *B. bambos* seedlings in nurseries at Nilambur, Peechi, Chandhanathodu, Kulanjithodu, where it occurred intermixed with *B. maydis*. The symptoms produced by this species were similar to those of *B. maydis*.

Pathogenicity test

Pathogenicity of isolates of *Bipolaris* sp. and *B. maydis* was tested on 2-month-old *B. bambos* seedlings raised on polyurethane sheet. *B. urochloae* was tested on 11-month-old *P. pubescens* container seedlings. Foliage infection developed on young and mature leaves as tiny water-soaked specks after two days of incubation. In *B. urochloae* inoculated seedlings, infection developed as minute greyish brown to dark brown lesions on young as well as mature leaves after 36 h of incubation. The infection spread rapidly when the inoculated seedlings removed from the humidity chamber and exposed to direct sunlight. No significant difference was observed in the initial symptoms produced by different *Bipolaris* spp. However, in *B. urochloae* inoculated *P. pubescens* seedlings, the infection spread very fast and the entire seedling became infected and defoliation occurred within one month of inoculation.

Discussion

Information on seedling disease caused by *Bipolaris* spp. in forest nurseries is very meagre, although many species are known to attack graminaceous agricultural crops. Recently, a severe outbreak of foliage disease of *Populus deltoides* Marsh. caused by *B. maydis* has been recorded in nursery and plantation in Punjab (Chauhan and Pandey, 1992). *Bipolaris* spp, causing foliage infection in *Eucalyptus tereticornis* and *Calamus thwaitesii* has also been recorded recently from Kerala (Mohanan and Sharma, 1986; Mohanan, 1990b). *B. urochloae* (= *Helminthosporium urochloae* (Putterill) Subram.) has not been recorded earlier on any forest tree seedlings in India, although, on other graminaceous agricultural hosts it is well established. All the three fungi viz., *B. maydis*, *R. urochloae* and *Bipolaris* sp. which caused seedling leaf blight are new pathogen record for bamboos. *Bipolaris* sp. (IMI Nos. 326946, 326947) recorded on bamboos differs from the earlier reported *Bipolaris* spp. in cultural and morphological characters (Sivanesan, IMI, pers. commun.). It represents new species of the genus and hence will be validly published elsewhere. In the pathogenicity trial, the development and spread of infection in inoculated seedlings was rapid when the seedlings were removed from the incubation chamber and kept in direct sunlight. The high incidence of disease in seedbeds in direct sunlight than those under shade also confirms this observation. This clearly shows the role of light and high temperature for the disease development. Even though, the disease is widespread in bamboo nurseries in the State, it did not cause any potential damage to the seedling stock.

7. EXSEROHILUM LEAF SPOT

Occurrence

Infection was observed in 2 to 8-month-old bare root as well as container seedlings of *B. bambos*, *D. strictus* and 8-month-old container seedlings of *P. pubescens* in a nursery at Peechi during April-May, 1989-90. Disease incidence in 6-month-old D. strictus seedlings was found to be low, while in *B. bambos* and *P. pubescens* infection varied from medium to severe causing defoliation. Infection spread rapidly during the wet periods, (June-July), affecting the entire foliage of the seedlings.

Symptoms

Leaf spots were observed as minute greyish brown watersoaked lesions on the mature leaves. Under warm-humid condition, the individual lesions coalesced to form large spindle-shaped to irregular lesions with greyish white centre and dark brown to chocolate brown margin (Plate 3). The diseased areas became necrotic and under high humidity sporulation of the fungus occurred as greyish black spore mass on the adaxial surface of the necrotic lesions. Severe infection led to the spread of lesions to the entire leaf lamina followed by withering of the affected leaves and premature defoliation.

Causal organisms

1. *Exserohilum rostratum* (Drech.) Leonard & Suggs anamorph of *Setosphaeria rostrata* Leonard (IMI No. 326945).
2. *Exserohilum holmii* (Luttr.) v. Am. anamorph of *Setosphaeria holmii* (Luttr.) Leonard & Suggs (IMI No. 327737).

E. rostratum was isolated from *B. bambos* and *D. strictus* seedlings and *E. holmii* from seedlings of *B. bambos* and *P. pubescens*. *E. holmii* produced greyish brown to greyish black water-soaked lesions on *P. pubescens* which coalesced and spread to the entire leaf under warm humid condition. While on *B. bambos* the pathogen produced greyish brown irregular lesions with greyish white centres. Heavy sporulation of the fungus occurred on the adaxial surface of the affected leaves of both the bamboo species.

pathogenicity test

Pathogenicity of isolates of *Exserohilum rostratum* and *E. holmii* tested on 2-month-old *B. bambos* seedlings gave positive results. Infection occurred in inoculated seedlings of *E. rostratum* and *E. holrnii* within two days of incubation as tiny water-soaked specks. The disease developed rapidly when the inoculated seedlings were removed from the humidity chamber and kept outdoor. *E. rostrutum* and *E. holmii* were reisolated from the 'infected tissues which confirmed pathogenicity of the isolates.

Discussion

Exserohilum leaf spot, affecting both bareroot and container seedlings, was recorded only from a nursery at Peechi. This is the first record of *E. holmii* on bamboos as well as first pathogen record from India. Similarly, *E. rostratum* causing leaf spot of *B. bambos* and

Phyllostachys pubescens is the first pathogen record. Earlier, *E. halodes* (Dresch.) Leonard and Suggs was reported to cause leaf blight of *B. arundinacea* (Retz.) Willd *(= B. bambos)* in forest nursery at Dhanvard, Karnataka (Bhat et *al.*, 1989). *E. rostratum* has also been recorded to cause seedling foliage infection of *Eucalyptus grandis* and *E. tereticornis* in southern India (Mohanan and Sharma, 1986). The rapid development of Exserohilum infection in inoculated seedlings kept outdoor clearly indicates that for expression of disease symptoms high humidity is not a limiting factor. Since, the pathogens cause withering and premature defoliation only under conducive microclimatic conditions, the disease seems may not pose problems in raising bamboo seedlings. Hence, Exserohilum leaf spot may be rated as economically insignificant disease.

8. DACTYLARIA LEAF SPOT

Occurrence

Dactylaria leaf spot was widespread in bamboo nurseries in Kerala and usually occurred in 1 to 10-month-old bareroot and container seedlings of *B. bambos* and *D. strictus* in most of the nurseries surveyed during 1987-'92, and seedlings of *D. brandisii* and T. *siamensis* at Chandhanathoduand *0. wightii* at Palappilly during 1991-'92. Incidence of the disease was generally low in all these nurseries; *B. bambos* and *D. strictus* were the most affected species.

Symptoms

The disease manifested as minute watersoaked lesions near the leaf tips. The lesions coalesced and spread to form large circular to irregular greyish brown lesions with greyish white centres and dark brown margins. In seedbeds provided with thick shade and profuse watering which led to severe infection, withering of leaf tips was noticed; leaf sheath and petioles were also got affected with the disease. Under high humidity, heavy sporulation of the fungus was observed on the necrotic leaf spots.

Causal organism

Dactylaria sp. (IMI Nos. 327745, 327746)

Pathogenicity test

Pathogenicity of *Dactylaria* sp. was tested on 1-month-old *B. bambos* seedlings. Infection appeared as water-soaked specks after 48 h of inoculation. The specks developed into characteristic greyish brown circular to irregular lesions with dark brown margins within 15 days of incubation. *Dactylaria* sp. was reisolated from the infected tissues.

Discussion

Dactylaria Sacc. is a genus consisting of plant pathogenic, saprophytic as well as nematode trapping species. So far, nearly 35 species of *Dactylaria* have been reported (Das Gupta et al., 1964; Ellis, 1976; Choudhry, 1982). Recently, *D. chysosperma* (Sacc.) Bhatt & Kendrick and *D. arundica* Choudhry have been recorded on fallen twigs of bamboos viz.,

Ochlandra travancorica and *Arundinaria* spp. respectively from Kerala and Uttar Pradesh (Mani Varghese and Rao, 1979; Choudhry, 1982). Since,the *Dactylaria isolate*from bamboo seedlings vary in cultural and morphological characteristics from the *Dactylaria* species recorded so far, it is possibly a new species. The disease is economically insignificant.

9. COLLETOTRICHUM LEAFSPOT

Occurrence

Disease was recorded in 15-day-old to 10-month-old bare root as well as container seedlings of B. *bambos* in nurseries at Kulanjithodu, Vadasserikkara, Palappilly, Peechi, Niravilpuzha,Begur and Pariyaram during 1988-92and D. *strictus* nursery at Dhoni during l988-'89; disease severity was found low in all the nurseries. Colletotrichum leaf spots were often found intermixed with other leafspots such as those caused by *Bipolaris maydis* and species of *Dactylaria* and *Bipolaris*.However, pure infection was also observed in many nurseries.

Symptoms

Disease appeared as minute water-soaked lesions on the abaxial surface of the mature leaves. The lesions spread and formed large reddish brown areas linear to irregular in shape which often concentrated either at the leaf base or at the margins and tips. The discoloured areas later became necrotic. Merging of lesions with those of other leaf infecting fungi was observed. Infection was also recorded on leaf sheath and petioles of bamboo seedlings.

Causal organism

Collectotrichum gloeosporioides(Penz.)Penz.&Sacc.and its teleomorph*Glomerella cingulata* (Stonem.)Spauld.& Schrenk (IMI Nos. 331635,331798).

Pathogenicity test

Pathogenicity was tested employing 25-day-old B. *bambos* seedlings raised over polyurethane sheet. The seedlings inoculated by spraying conidial suspension of the fungus were kept in the humidity chamber. Infection developed only on mature leaves as minute lesions after 48h of inoculation. The lesions developed into necrotic areas within 12days of inoculation. C. *gloesporioides* was reisolated from the infected tissues.

Discussion

C. *gloeosporioides* is a common leaf infecting fungus in forest nurseries which has been reported from a large number of forestry species viz., *Ailantus triphysa, Bombax ceiba, Dalbergia latifolia* Roxb., *Eucalyptus* spp., *Gmelina arborea, Lagerstroemia speciosa* (L.) Pers., etc. (Bakshi *et al,* 1972; Sharma *et al.*, 1985; Ali, 1993).Earlier the fungus has been recorded on bamboos from U.S.A. (Anon.,1960) and from Malaysia (Azmy and Maziah, 1990). Recently, C. *gloeosporioides* has been recorded on different species of bamboos from Meghalaya (Deka *et al.*, 1990).Though, in bamboos, Colletotrichum leaf spot is not very

serious; along with other foliage pathogens viz, *Bipolaris* spp.; *Exserohilum* spp. and *Dactylaria* sp. it may cause severe infection and withering of leaves.

10. CURVULARIA LEAF SPOT

Occurrence

Curvularia leaf spot was recorded to infect 1 to 2-month-old bareroot seedlings of B. *bambos* at Nilambur and leaves of 40-day-old vegetatively propagated *D. longispathus*, T. oliveri and O. *scriptoria* in a nursery at KFRI Campus, Peechi during 1988-'89. Disease seventy was found low in B. *bambos*, *T. oliveri* and 0. *scriptoria*. Severe infection was recorded only in vegetatively propagated shoots of D. *longispathus*.

symptoms

Infection appeared as watersoaked lesions with yellow halo on young and mature 1eaves. The lesions coalesced and formed circular to irregular greyish black spots with dark yellow halo. The lesions developed near the leaf tips and margins coalesced fast and formed large necrotic areas. The affected leaf tips rolled in and dried up.

Causal organism

Curvularia pallescens anamorph of cochliobolus pullems (Tsuda & Veyama) Sivan. (IMI Nos. 320689, 327773).

Pathogenicity test

Pathogenicity of the isolate was confirmed by spraying conidial suspension of C. pallescens on the leaves of I-month-old B. *bambos* seedlings raised over polyurethane sheets. Infection developed as minute greyish brown to dark brown watersoaked lesions on both young and mature leaves after 72 h of incubation in the humidity chamber which later coalesced and formed irregular greyish black lesions within one week of incubation. C. *pallescens* was reisolated from the infected tissues.

Discussion

The leaf spot caused by C. *pallescens* is of minor importance. *C. pallescens* is a weak pathogen and has been recorded as causing foliage infections of minor significance on many forestry crops in Kerala (Sharma *et al.*, 1985). Recently, C. *andropogonis* (Zim.) Boed. has been reported as causing leaf spot of *O. scriptoria* and *O. travancorica* in Kerala (Balakrishnan *et al.*, 1990). *C. pallescens* is a new record on bamboos.

11. ALTERNARIA LEAF TIP BLIGHT

Occurrence

The disease was recoded in 1 to 3-month-old bare root seedlings of D. strictus at Dhoni, B. *bambos* bareroot as well as container seedlings at Nilambur, Pariyaram, Kalamassery;

Vadasserikkara, Begur, Vadavukodu, Thettamala and Kulanjithodu nurseries during the months of April-May. Severe foliage infection led to seedling leaf tip blight.

Symptoms

Infection manifested as minute greyish brown linear to spindle-shaped lesions near margin, base and tip of both young and mature leaves. The lesions coalesced and caused necrosis of the affected leaf tissues. Infection spread downward under warm-humid conditions. Usually, leaf tips were found severely affected which led to seedling leaf tip blight.

Causal organism

Alternaria alternata (Fr.) Keissler (IMI Nos. 331799,327736).

Pathogenicity test

Pathogenicity of *A. alternata* was tested on 1-month-old D. *strictus* and B. *bambos* seedlings. Infection developed as minute greyish brown lesions mostly at the tips and leaf margins on young and mature leaves of both the species within three days of incubation in humidity chamber. The lesions later turned into dark brown linear to irregular necrotic areas with pale to dark yellow halo around. *A. alternata* was reisolated from the infected tissues.

Discussion

A. alternata causing leaf tip blight of B. *bambos* and D. *strictus* seedlings during hot season (April-May) occurs in nurseries under water stress. *A. alternata* is a weak pathogen and causes foliage infection on many forestry species. In Kerala, the fungus causes infection on *Eucalyptus grandis* and *E. tereticornis* (Sharma, *et al.*, 1985). *A. alternata* is a new pathogen record on bamboos.

12. SEEDLING RHIZOME ROT

Occurrence

Seedling rhizome rot was recorded in 11-month-old container seedlings of B. bambos in a nursery at Pattikad during 1987-'88 and Peechi during 1988-'89. In both the nurseries, the disease observed during May-June, which caused four percent seedling mortality at Peechi and five percent at Pattikad.

Symptoms

The above ground symptoms of disease were manifested as general wilting of seedlings, rolling up of foliage, yellowing of mature leaves and finally premature defo1iation. The affected seedlings when uprooted carefully showed dark yellowish brown discolouration and decay of growing portion of the rhizome, especially around the rhizome buds. Usually, the fleshy rhizome buds become discoloured and decayed. Later the

infection spread to the entire rhizome of seedlings. The diseased seedlings were killed outright.

Causal organism

Rhizostilbella hibisci (pat.) Seifert state of *Nectria mauritiicola* (Henn.) Seifert & Samuels (IMI No. 326955).

Pathogenicity test

Pathogenicity test was conducted with 12-day-old PDA-grown culture of R. *hibisci*. Container-grown 10-month-old B. *bambos* seedlings were inoculated by injuring the rhizome buds and young growing tip of the rhizome using sterile scalpel blade. Above ground symptoms developed after 30 days of inoculation. Discolouration and decay of the rhizome led to outright killing of the shoots and also decay of the rhizome. Yellowish brown, branched, large rhizomorphs and slimy spore heads of the fungus developed on the decayed rhizome buds. Seedlings inoculated without injury, developed no symptoms even after two months' of incubation.

Discussion

Rhizome rot of container seedlings of B. *bambos* caused by R. *hibisci* state of *Nectria mauritiicolais* a new disease record on bamboos as well as new pathogen record from India. Earlier, two closely related fungi viz., *Sphaerostilbe bambusae* Pat. and S. *hypococoides* Kalchbr. & Cke. have been recorded to cause root rot of bamboos from India (Mathur, 1936). Recently, *Amylosporus campbelli* (Berk) Ryv. has been reported as causing root and rhizome rot of D. *strictus* seedlings in nursery at Jabalpur (Tahir *et al.*, 1992).

R. hibisci causes browning and rot of the entire rhizome resulting in outright killing of current shoots as well as rhizome buds. The rot of rhizome buds hinders the production of new shoots, and also rhizome growth and its proliferation. In container nurseries, where rhizome rot was recorded, possibly the infection is manifested through mechanical wounds to the rhizome caused during transplanting operation. Pathogenicity trial confirms the role of injury in the manifestation of the disease as the infection developed only in wound inoculated seedlings. Since, the rhizome rot is not common in bamboo nurseries it is of minor importance. The disease can be managed by adopting proper nursery management practices and also care during transplanting to avoid injuries to the seedling rhizome.

13. LEAF STRIPING AND SEEDLING STUNTING

Occurrence

The disease occurred in 14-month-old container seedlings of B. *bambos* at Pezhad and Kulanjithodu and 4-month-old B. *bambos* bareroot seedlings at Paneli and Periya during 1990-'91; disease incidence was low in all the nurseries. In the Pezhad nursery 5.6% of seedlings were found infected due to which a large number of otherwise plantable seedlings had to be discarded.

Symptoms

Disease manifested as pale yellowish white to greenish white stripes on both young and mature leaves. Striping of leaves was also observed in the new shoots developed from the rhizome. The affected leaves become leathery and often the individual stripes merged together and the leaves become greenish white in colour. Affected seedlings showed stunted growth and thin, fragile, pendulous stem which snapped easily. Fifteen 10-month-old diseased container seedlings brought from the nursery to the laboratory and maintained for two years for close observation revealed the systemic nature of infection. All the new shoots developed from the rhizome also showed similar symptoms.

Causal organism

Unknown etiology. Leaf stripping, mottling, stunting and mosaic diseases of plants were earlier reported to be caused by a virus. The symptomatology of the leaf striping and stunting disease of bamboo seedlings showed the possibility of viral pathogen.

Discussion

Leaf striping and stunting of B. *bambos* seedlings is a new disease record from India. Symptomatically, the disease appears to be caused by a virus. However, further studies on etiology of the disease need to be undertaken to confirm the causative organism. A similar disease has earlier been reported on cultivated species of bamboos in plantations in Taiwan (Lin *et al.*, 1979). The disease was reported to be caused by Bamboo mosaic virus (BoMV) belonging to the group of potex virus (Lin *et al.*, 1993).

3.1.2. Diseases in plantations and natural stands

In Kerala, planting of commercially important bamboos viz., B. *bambos* and D. ***strictus*** in degraded forests, poorly stocked softwood plantations and old teak plantations has been taken up recently. Small-scale trials of *D. longispathus*, **O.** *travancorica*, T. oliveri, etc. have also been initiated recently. Usually, 12 to 18-month-old bareroot as well as container seedlings are utilized for planting. For large-scale planting, bareroot seedlings maintained in the transplanting beds at an espacement of 15x 15cm are used. Seedlings with intact rhizomes are collected by dismantling the beds carefully. Pruning of shoots about 30-40 cm from the base of the seedlings is often practised in certain localities. Planting is done in pits taken at an espacement of 8 x 8 m or 10x 10m after the onset of south-west monsoon during the month of June-July.

Disease survey, conducted in 22 selected representative areas in eight bamboo plantations and 14 natural stands and various trial plots and a Bambusetum, in the State during 1987-'91 recorded a total of 29 diseases affecting bamboo culm, rhizome, branch, foliage, culm sheath, etc. (Table 4). Among these a few were found economically important which affected the stand productivity considerably, while others were of minor importance.

Table 4: Checklist of diseases m bamboo plantations and natural stands in Kerala recorded during 1987-1991

sl. No.	Disease	Pathogen(s)	Bamboo species affected'
1.	Rhizome bud rot	*Pythium middletonii*	BB
2.	Rot of emerging culm	F. *moniliforme* var. *intermedium*	BB,DS,TO,BB A,DL,BP,BV
3.	Rot of growing culm	F. *equiseti*	BB,BBA,BP,DB,DS,DL,TO
4.	Branch die-back	F. *pallidoroseum*	BB,BV,DS
5.	Necrosis of culm internode	*Curvularia lunata*	TO
6.	Witches' broom	*Balansia linearis*	OE,OS,OT,OTH
7.	Littleleaf	MLO	DS
8.	Thread blight	*Botryobasidium salmonicolor*	BB,BBA,BP,BV,DB,DL,DS,OT, OS,OE,TS,BG,BP,BT,BVE
9.	Foliage blight	*Bipolaris maydis*	BB,DB,DL,DS,BP,OM
		Bipolaris sp.	BB,DS,DL
10.	Leaf rust	*Dasturella divina*	BBA,BB,BG,BP,BT,BVE,BV, DB,DH,DL,DS,OM,TO,TS
11.	Exserohilum leaf spot	*Exserohilum holmii*	BB,BP,DL
		E. rostratum	BB,DS
12.	Zonate spot	*Dactylaria* sp.	BB,DS,DL,BP,OE,OS,OT,TS,Ts
13.	Colletotrichum leaf spot	*C. gloeosporioides*	As,BB,DS,OE,OS,OT
14.	Ascochyta leaf spot	Ascochyta sp.	BB,DS,TS
15.	Tar spot	*Phyllachora ischaemi*	BB
		P. longinaviculata	BB,DS,OM
		P. shiraiana	BB,BV,DS,OT,OS
16.	Petrakomyces leaf spot	*Petrakomyces indicus*	As,BB,DS,OE,OS,Ts
17.	Phoma leaf spot	*Phoma herbarum*	BB,DS
		P. sorghina, Phoma sp.	BB,DS
18.	Phomopsis leaf spot	*Phomopsis* sp.	BB,DS,Ts
19.	Stagonospora leaf spot	*Stagonospora* sp.	BB,DS
20.	Septoria leaf spot	*Septoria* sp.	Ts
21.	Chaetospermum leaf spot	*Chaetospermum carneum*	BB
22.	Curvularia leaf spot	*Curvularia lunata*	As,OE,OS,OT,Ts
23.	Altemaria leaf tip blight	*Alternaria* alternata	BB,DS
24.	Rosenscheldiella leaf spot	*Rosensheldiella* sp.	OT
25.	Coccodiella leaf spot	*Coccodiella* sp.	OT
26.	Cerodothis leaf spot	*Ceridothis aurea*	DS
27.	Culm sheath spot	*Pestalozziella* sp.	BB,BP,BV,DB,DS,
28.	Culm staining and die-back	*Apiospora* sp.	BV,DL
29.	Basal culm decay	*Ganoderma lucidum*	BB,DL,DS
		Amylosporus campbelli	

'As: *Arundinaria* sp.; BBA: B *balcooa;* BB: B. *bambos;* BG: B. *glaucescens;* BP: *B. polymorpha;* BV B. *vulgaris;* BVE: *B. ventricosa;* BT B. *tulda;* DH D. *hamiltonii;* Ds: D. *strictus;* DB: D. *brandisii;* DL: D. *longispathus;* OE 0. *ebracteata;* OS: 0. *scriptoria;* OT: *0. travancorica;* 0TH: 0. *travancorica* var. *hirsuta;* OW: 0. *wightii;* PP: *P. pubescens;* TO: T. *oliveri;* TS: T. *siamensis;* Ts: *Thyrsostachys* sp.

1. RHIZOME BUD ROT

Occurrence

The disease was recorded in 1-year-old B.bambos plantations at Kaliyar (Kothamangalam Forest Divn.), Ezhattumugam (Vazhachal Forest Divn.) and Irumpupalam (Trichur Forest Divn.) during 1987. Infection was observed during the months of september-October in the low lying and water-logged areas in the plantations. Though, the disease severity in Ezhattumugam and Irumpupalam plantations was low, 35.6% and 15.6% of the outplanted seedlings respectively were affected. While at Kaliyar, the disease severity was found to be medium and 71.4% of the outplanted seedlings were diseased. (Table 5).

Table 5: Incidence and severity of rhizome bud rot of B. bambos *caused by* Pythium middletonii *in plantations at different localities in Kerala during 1987*

SI. No.	Locality	Percent incidence	Disease severity. DSI	DSR
1.	Kaliyar	71.42	1.71	M
2.	Ezhattumugam	35.59	0.88	L
3.	Irumpupalam	15.62	0.40	L

DSI:Disease severity index; DSR Disease severity rating; L: low; M: medium.

Symptoms

Above ground symptoms of the disease manifested as yellowing of the entire foliage of shoots resulting in completed defoliation. Since pruning of shoots was done at Kaliyar and Ezhattumugam plantations, defoliation of the affected plants was very fast and within 15 to 20 days complete defoliation occurred. The affected plants showed browning and rot of the rhizome buds and tender tissues around the buds (Plate 4); both pointed scaly buds which gave rise to new shoots in the growing season and flat buds which promoted rhizome proliferation, were affected by the disease. As rhizomes of even the young, l-year-old plant was very hard and woody, the discolouration and rot were usually found restricted to the fleshy buds and tender tissues at the growing points. However, the infection spread through the hard and woody rhizome tissues very slowly, often reaching up to the base of the shoots resulting in the symptom expression of disease. Since, the scaly buds, flat buds, and the tender portions were also infected, the new shoot production as well as rhizome proliferation were greatly affected, thus, resulting in stunted growth and mortality of the plants. Mechanical wounds caused to the seedling rhizome during collection, transportation, planting, etc. and also injury caused by rodents, porcupines and pigs in the field were the other entry points for the infection.

Causal organism

Pythium middletonii Sparrow (IMI No.327739).

Pathogenicity test

Pathogenicity of P.*middletonii* isolate,grown onOMA,was tested employing 1-year-old seedlings of B.*bambos* grown in large metallic trays (90 x 60 x 20 cm). Infection developed only in seedlings inoculated by injuring the rhizome with sterile scalpel blade. Typical above gmund symptoms and rhizome bud rot developed after 30 days of inoculation. P. *middletonii* was reisolated from the decayed rhizome buds. The seedlings inoculated without injury did not develop infection even after three months' of inoculation.

Field trial

Observations on disease incidence and survival showed about 96percent survival of the planted out seedlings with 12percent disease incidence. Infection was observed only in water-logged seedlings and also in those which had the rhizomes injured.

Discussion

In young bamboo plantations, rot of fleshy rhizome buds and subsequent death of outplanted seedlings caused by *Pythium middletonii* is a new disease record on bamboos. *P. middletonii* has earlier been recorded from India as the causal agent of damping-off and other seedling diseases of different agricultural as well as forestry crops (Singhand Pavgi, 1974;Rajagopalan and Ramakrishnan, 1967; Ali, 1993). Since, the pathogen causes rot of scaly and flat buds of rhizome, it hinders the production of new shoots in the growing season as well as the subterranean proliferation of the rhizome. The pathogen seemsto enter through the injury caused during either planting operation or the injury caused by rodents, porcupine, etc. after the planting in the field. Pathogenicity and field trials also confirm the entry of the pathogen through the wounds as the infection develops only in injured rhizomes. Since the disease could be recorded only from newly raised bamboo plantations, it can be managed by improving the cultural and management practices in the plantations.

2. *WlTCHES' BROOM*

Occurrence

Witches' broom disease is wide-spread in reed bamboo growing areas of the State. It affected all the commercially important reed bamboos viz., *Ochlandra travancorica, 0.* scriptoria and 0. *ebracteata;* the disease was recorded from all the plots of reed bamboos selected for the study. The incidence of disease varied depending upon the locality; the maximum incidence (2.65%) was recorded at Periya during 1989-90 and the minimum (5.98%) at Kottoor during1988 (Table 6). In addition, infection was also recorded in 0. *travancorica* and *0.travancorica* var.*hirsuta* in reedcatchment areas at Kulathupuzha,Palode (Trivandrum Forest Divn.); Chalakkayam,Nilakkal, Kakki and Muzhiyar (Ranni Forest Divn.); Adimaly, Devikulam, Bhoothathankettu, Pooyamkutty, Edamalayarand Kappayam

(Munnar Forest Divn.); Adirappally, Epra and Sholayar (Vazhachal Forest Divn.); Nelliampathy and Pothumala (Nenmara Forest Divn.) and on **O.** *scriptoria* at Alat (South Wynad Forest Divn.) and Kottiyoor (Cannanore Forest Divn.). The disease was also recorded on a grass, *Pennisetum polystachyon* (L.) Schultes, which might have served as an alternate host, as it was seen growing in the vicinity of the affected reed bamboos. Usually, brooming symptoms became prominent during the months of December-January with the production of incurved, black shining fructifications of the fungus on the affected shoots.

Table 6: Incidence and severity of witches' broom disease in nutural stands of reed bamboos surveyed during 1988-1991

Sl. No.	Locality	Bamboo Species	Disease Severity 1988			3989			1990			1991		
			% incidence	DSI	DSR	% incidence	DSI	DSR	% incidence	DSI	DSR	%incidence	DSI	DSR
1.	Periya	OS	21.91	0.23	L	24.65	0.26	L	24.65	0.26	L		-	. .
2.	Watchumaram	OT	8.57	0.08	L	9.28	0.11	L	10.00	0.12	L	10.71	0.14	L
3.	Vazhachal	OS	9.83	0.11	L	11.47	0.13	L	11.47	0.13	L	14.75	0.19	L
4.	Pachakkanam	OT	7.69	0.08	L	8.33	0.10	L	8.97	0.12	L	9.61	0.16	L
5.	Kottoor	OE	5.98	0.05	L	7.69	0.08	L	8.54	0.11	L	9.40	0.13	L

[a]DSI Disease severity index; DSR: Disease severity rating.
.OE: **O.** *embracteata*, OS 0. *scriptoria*, OT: 0. *travancorica;* - Observations not recorded due to flowering.

Symptoms

Manifestation of the disease was indicated by the development of numerous stunted shoots at the nodes of the mature culms which had normal branches and foliage. These abnormal **shoots** did not develop into normal branches and produced successively only highly reduced shoots from their nodes. The stunted internodes of these shoots varied from 0.5 to 5.0 cm in length; culm sheaths which covered the internodes also became highly shortened in size and became boat-shaped often with a prominent ligule. Foliage developed from the abnormal shoots was yellowish green and highly reduced in size. The leaf size varied from 1.5-8.5 x 0.5-1.0 cm as against 35-40 x 8.0-21.5 cm of healthy normal leaf of *0. travancorica.* The internodes showed purplish pink to purple discolouration with highly reduced pale green foliage. Successive development of a large number of highly shortened thin shoots in tuft from the nodes of the infected culms gave rise to the appearance of witches' broom. New shoots emerged from the rhizome during the growing season also showed pronounced brooming symptoms. From an infected rhizome, a large number of abnormal, highly shortened shoots, often ranging from 30 to *800* in number, developed. The shoots grew only up to 10 to 50 cm in height showing typical symptoms of the disease. Often one or two normal culms also developed from the infected rhizome which gave rise to apparently healthy branches and foliage. Possibly due to these healthy

culms, the diseased clumps were not killed outright.

Fungal fructification developed on the affected shoots after five to six months of infection. Initially, shining white fungal mycelial weft appeared on the infected shoot, culm sheath, and foliage. The internodes covered by the boat shaped small culm sheaths became purplish pink to deep magenta in colour with closely adhering white fungal mycelium over them. The distal end of the abnormal shoot as well as the shoot developed immediately from each node of the abnormal shoot became modified into fungal fructification bearing structures. White powdery fungal stroma developed at the base of their nodes and spread to the proximal end which later developed into greyish white to pale yellow, uniformly raised ascomata. The ascomatal stroma extended from the base of the nodes to the distal end except 1 to 2 cm at the terminal portion. As the development of the fructification progressed, the whole structure turned to shining brown to greyish brown in colour with a white basal portion. At this stage, the shoot portion bearing the developing fungal fructification became free from culm sheath and formed an incurved sickle-shaped structure. The fructification further matured and became shining black in colour (Plate 4). Development of the fructification started during September-October and it usually matured during January-February. After the discharge of the ascospores, the fructification got degenerated during the month of May-June. As new shoots were produced successively from the infected abnormal shoots, the disease also spread to the new shoots. The fungus also produced long, hair-like black rhizomorphs on the affected withered shoots, foliage, and culm sheaths during the dry period.

Causal organism

Balansia linearis (Rehm.) Diehl (IMI Nos. 322086, 322087, 326955).

Pathogenicity test

Mycelial disks of 15-day-old cultures of the fungus, raised from infected tissues as well as the mature ascocarps were inoculated on culm nodes of developing shoots of 2-year-old 0. *scrptoria* clump. The infection developed on the branch buds only in three out of twelve inoculated culms after two months of inoculation. Silvery white mycelial strands, which closely stuck over the shoots, were produced from the inoculated node. The nodal shoots showed reduction in their internodal length and foliage size; however, fructification of the fungus did not develop in the infected shoots even after one year of inoculation.

Discussion

Witches' broom disease caused by *B. linearis*, affecting commercially important reed bamboos, is widespread in the reed catchment areas of the State. Since, the macroconidial Ephelidia state of the fungus could not be detected either in naturally / artificially infected host tissues or in culture medium, ascospores produced in large quantity are suspected to be the source of infection in the natural stand, as also reported by Zhu (1989a) in the case of B. take in china. Witches' broom disease of bamboo has earlier been recorded from china, Indonesia, Japan, Taiwan and Vietnam (Shinohara, 1965; Chen, 1970; Zin *et al.*, 1981; Mao, 1993). *Balansia take* causing witches' broom of *Phyllostachys* viridis and P. *glauca* has been

recorded from China. The disease is found widespread in Hunan Province causing 95 to 100 percent infection (Lin and Wu, 1987). The pathogen over-winters in infected bamboo branches and produces conidia in the spring sprouts of infected bamboos, which form the source of infection. Other fungi identified to cause witches' broom of bamboos are *Epichloe bambusae* on *B. vulgaris, D. asper, Gigantochloa* spp. in Indonesia and *Loculistroma bambusae* on *Pkyllostachys* and *Aciculosporium take* on *Bambusa* sp. in China (Shinohara, 1965; Chen, 1971; Nozu and Yamamoto, 1972; Kao ad Leu, 1976. Lin *et al.,* 1981). Lin and Wu (1987) reported association of a bacteria-like organism and *B. take* with the witches' broom of *Phyllostachys aurea.*

The underground rhizome was reported as free from infection (Zhu, 1989a,b). However, production of large number of wiry shoots with brooming symptoms from the underground rhizome of the witches' broom diseased bamboo clumps in Kerala, indicates the spread of infection to the rhizome as well as systemic nature of the disease. *B. linearis* is a new pathogen record on bamboos as well as a new record of fungus from India.

3. *LITTLE LEAF DISEASE*

Occurrence

The disease was recorded in *D. strictus* clumps in natural stands at Agaly, Thakarapady, Goolikadavu (Mannarkade Forest Divn.) and Chinnar (Wild Life Divn. Idukki). Little leaf disease also affected *D. strictus* clumps in sandal reserves at Marayoor (Munnar Forest Divn.), where sandal spike disease also occurred. The disease incidence varied from locality to locality, the highest being at Thakarapady followed by Agaly and Goolikadavu (Table 7). In Chinnar, percent incidence of disease was comparatively low than in the areas of Mannarkkad Forest Division. Clump to clump spread of infection was found to be slow and an increase of 6% was recorded at Agaly, 12.50% at Thakarapady, 9.38% at Goolikadavu, and 2.32% in Chinnar over a period of four years. The disease severity rating (DSR) at Thakarapady was recorded to be medium (M) from 1989 onwards and at Goolikadavu during 1991.

Table 7: Incidence and severity of little leaf disease of D. strictus in natural stands in Kerala during 1988-1991

Sl. No.	Locality	1988			1989			1990			1991		
		% incidence	DSI	DSR	% incidence	DSI	DSR	% incidence	DSI	DSR	% incidence	DSI	DSR
1.	Agaly	64.00	0.76	L	64.00	0.76	L	67.16	0.85	L	70.14	1.14	L
2	Thakarapady	77.50	1.00	L	87.50	1.20	M	85.50	1.28	M	90.00	1.55	M
3.	Goolikadavu	59.37	0.62	L	59.37	0.68	L	59.37	0.71	L	68.75	1.16	M
4.	chinnar	9.30	0.09	L	9.30	0.90	L	9.30	0.11	L	11.62	0.18	L

DSI: Disease severity index; DSR: Disease severity rating; L: low; M: medium.

Symptoms

The disease was characterized by the development of numerous highly reduced abnormal bushy shoots from the nodes of the newly emerged culms and also from culm branches. The internodes of these abnormal shoots were highly reduced in size and the branchesdeveloped from their respetive nodes also became highly shortened. The fo1iage developed from theseshoots, which showed prominent reduction in size, was needle-like. Profusedevelopment of theseabnormalshoots from eachnode of thedevelopingculmand their successive growth gave rise to a massive bushy structure around each node. The disease also affected the culm elongation; infected culms showed stunted growth and became incurved mainly due to the weight of the abnormal shoots at the nodes (Plate 5). From low to moderately infected clumps, healthy looking, straight growing culms were also produced. In this case development of abnormal shoots occurred from the culm branch nodes. Even though, the growth of the culm was completed within *six* months of emergence, the abnormal shoots continued to develop from the culm nodes and branch nodes year after year and formed a massive structure of highly reduced and branched nodal shoots. In a severely affected clump, all the culms produced from the rhizome in a growingseason became infected. The wholeclumpbecame bushy with a few diseased and highly deformed culms.

Histopathology

Transverse sections of diseased as well as healthy tissues of *D. strictus* prepared by cryomicrotome and observed under Leitz Dialux 20 Microscope showed necrosis in the phloem tissues of the diseased specimens; phloem necrosis or any deformity was not observed in the healthy tissues. Generally, phloem tissues in the diseased nodal and internodal tissues were found more than those of healthy tissues.

Dienes' stain reaction

Dienes' stain (0.2%) gave excellent differentiation of the little leaf diseased tissues of D. strictus Dark blue stained distinct areas could be detected in the phloem tissues, while no such distinct blue stained areas were observed in healthy tissues. This indicated the presence of MLOs in the phloem of the diseased tissues (Plate 5a).

Fluorescence microscopy

Transverse sections taken from diseased and healthy shoots of *D.strictus* when stained with Aniline blue (0.01%) gave excellent differentiation under fluorescence microscope. Bright yellow green fluorescent spots were observed throughout the phloem tissues of diseased specimens. Transverse sections of a comparable tissues from healthy shoots showed no such fluorescent spots in the phloem (Plate 8b). This indirectly indicated the presence of MLOs in the phloem of the diseased tissues. Cell walls of xylem and their sclerenchymatous tissues, from both diseased as well as healthy shoots, also showed pale yellow fluorescence (Plate 6).

Hoechst 33258, a fluorochrome stain (0.01%) did not give any positive fluorescence in the phloem tissues of the diseased as well as healthy shoots.

Transmission electron microscopy

Ultra-thin sections of little leaf diseased *D. strictus* shoots revealed pleomorphic bodies inside the sieve elements. These bodies were not observed in comparable sections taken from healthy shoots. The abundance of these bodies varied from cell to cell. However, over

all concentration of these bodies in the phloem cells was low. In size and morphology, these bodies were similar to mycoplasma-like organisms (MLOs) reported to occur in phloem cells of plants affected by yellows type of diseases. Other microorganisms like bacteria, virus-like particles or fungi were not detected from any of the sections examined (Plate 6).

Causal Organism

Mycoplasma - like organism (MLO).

Isolation and culture of MLOs

In the inoculated tubes containing the SMC culture medium, no colour change was noticed even after 10 days of incubation which indicated the absence of MLO multiplication. Samples of inoculated medium were periodically examined under dark field microscope for any microbial growth. However, no such growth was observed.

Screening of tetracycline for disease recovery

The developing young bamboo culms showing advanced symptoms of little leaf disease, applied with Tetracycline hydrochloride (0.5g/250 ml) as foliar spray showed disease remission symptoms; seven out of 12 treated culms showed the remission symptoms within one month of treatment. Development of few medium-sized to normal foliage from the abnormal treated shoots was observed; elongation of internodes was also observed in Tetracycline hydrochloride treated shoots. However, in most of the treated bunches of the nodal shoots, after the development of few normal leaves, the disease symptoms reappeared after three months of treatment.

Discussion

Little leaf disease caused by MLO was recorded only in *D. strictus* growing in natural stands, situated in the dry tracts of the State. Disease was also observed in bamboo clumps growing in sandal reserves at Marayoor and Chinnar, where severe sandal spike disease also occurred. Earlier, *D. strictus* has been identified as a collateral host of the sandal spike pathogen (Nayar and Ananthapadmanabha, 1977). However, in Attapady Forest Reserve, where 90% disease incidence was recorded, no sandal trees could be found in the vicinity. This probably implies that *D. strictus* is doubtful as a collateral host of sandal spike pathogen.

In Kerala, MLO associated diseases recorded on forest tree species include sandal spike and little leaf of eucalypts (Sharma *et al.*, 1983; Ghosh *et al.*, 1984, 1985a,b). In the present study, Aniline blue (0.01%) gave positive bright yellow green fuorescence indicating the presence of MLO in the phloem sieve cells. Hoechst 33258, a benzimidole derivative DNA binding fluorochrome gave negative result. Negative result with Hoechst 33258 has also been reported in the detection of little leaf of eucalypts by Ghosh *et al.*, (1985b). Dienes' staining reaction gave excellent differentiation of the diseased bamboo tissues. Deep blue staining occurred in the phloem of little leaf diseased tissues whereas such staining was not found in healthy tissues. Electron microscopy proved the presence of MLOs in the sieve cells of the diseased tissues, though their concentration in the phloem cells is low.

Attempts to culture the MLO associated with bamboo little leaf using SMC medium were unsuccessful. Although, culturing of MLOs has been attempted by various workers using several media (Nayar and Ananthapadmanabha, 1970; Muniappa *et al.*, 1980; Ghosh *et al.*, 1985a), except for the genus *Spiroplasma* all attempts have been unsuccessful. Though, several claims on cultivation of MLO have been reported, none of them have been

confirmed.

Antibiotictreatment tocontrol plant diseases associated with MLO has been attempted after the discovery of suppressive effect of tetracycline group of antibiotics on symptom development of mulberry dwarf disease (Ishiie *et al.,* 1967) and tetracycline and chloramphenicol against aster yellows disease (Davis *et al.,* 1968). Since, in bamboos, the process of culm production, elongation and development is completed within six months and after that only abiological consolidation takes place,it is not worth tocontrol thedisease ofemerged culmsbychemicalsorantibiotics. Foliarapplicationoftetracyclineistried only to prove the etiology by the production of positive remission symptoms. For practical control measures, the rhizome of the diseased clumps should be treated with theantibiotics much before the production of new shoots.

4. ROT OF EMERGING CULM

Occurrence

Most of the bamboo plots selected in plantations and natural stands for the survey recorded the disease.The incidence and seventy of thediseasevaried with the localityand the bamboo species. In *B. bambos* plantations at Nilambur, Kollathirumedu, Ezhattumugam, Palappilly, and Irumpupalam, the incidence was low and varied from 5.5% to 15.1% during 3988-91 (Table 8).

In D. *strictus,* the disease incidence was 25.5% recorded at Nadukani during 1988; however, during the following years comparatively low percent incidence was observed. Of the bamboo plantations surveyed, T. *oliveri* at Mundoor, recorded the lowest disease incidence which ranged from 3.2 to 4.4%.

Table8: Incidence of rot of emerging culms in bamboo plantations in Kerala during 1988-1991

Sl. No.	Locality	Bamboo species affected	No.of clumps observed	Percent incidence 1988	1989	1990	1991
1.	Nilambur	BB	102		5.50 (109)	4.03 (124)	6.04 (149)*
2.	Kollathirumedu	BB	67		12.59 (127)	13.46 (156)	8.57 (140)
3.	Ezhattumugam	BB	59		12.60 (119)	12.32 (146)	14.86 (148)
4.	Palappilly	BB	60		10.40 (125)	11.11 (144)	10.18 (167)
5.	Irumpupalam	BB	64	6.80 (132)	11.92 (151)	15.11 (172)	14.00 (200)
6.	Nadukani	Ds	43	25.49 (153)	18.23 (159)	14.70 (136)	17.96 (128)
7.	Mundoor	TO	96	3.78 (317)	3.24 (340)	4.14 (362)	4.42 (294)

'Figures in parenthesis are total number of newly emerged culms.

BB B. *bambos;* Ds: D. *strictus;*TO :T *oliveri;* - Observations not recorded.

In a Bambusetum at Nilambur, rot of emerging culm was recorded on B. *balcooa* ,B. *bambos, B. polymorpha, B. vulgaris,* D. *longispathus,* D. *strictus* and T. oliveri. The disease incidenceamong the seven species of bamboos varied considerably.B. *bambos,D.longispathus* and D. *strictus* recordedcomparativelyhigh percent infection during years 1988-'91 (Table 9); B. *bambos* recorded highest disease incidence (20%) during 1988.

Rot of emerging culm was recorded in natural stands at Thirunelly, Noolpuzha, Muthanga, Anamari, Marayoor, and Chinnar during 1987-'91. Disease incidence varied from 14.5% to 24.8% during 1987 to 1991 in *B. bambos* plots at Thirunelly. In Noolpuzha, percent disease incidence ranged from 17.1 to 26.8 during 1988-'90 (Table 10). Among the B. *bambos* plots in natural stands, highest percent disease incidence was recorded in Anamari (33.7) during 1991. Plots at Muthanga and Marayoor recorded comparatively low incidence throughout the survey period. Percent disease incidence was also low in D. *strictus* stands at Chinnar.

Table 9: Incidence of rot of emerging culms in a Bambusetum at Nilambur during 1988-1991

Sl. No.	Bamboo species affected	No. of clumps observed	Percent incidence 1988	1989	1990	1991
1.	*B. balcooa*	4	6.66 (15)	5.26 (19)	4.54 (22)	8.69 (23)
2.	*B. bambos*	5	20.00 (20)	17.64 (17)	15.78 (19)	19.04 (21)
3.	B. plymorpha	4	10.00 (20)	13.04 (23)	12.00 (25)	9.52 (21)
4.	*B. vulgaris*	19	5.26 (76)	2.94 (102)	2.06 (97)	2.43 (82)
5.	*D. longispathus*	12	7.29 (96)	8.08 (99)	11.60 (112)	16.66 (74)
6.	*D. strictus*	18	15.78 (38)	17.50 (40)	16.21 (37)	17.77 (45)
7.	*T. oliveri*	3	0	0	0	5.88 (12)

'Figure in parenthesis is total number of newly emerged culms.

Table 10 : Incidence of rot of emerging culms in bamboo natural stands in Kerala surveyed during 1987-1991

Sl. No.	Locality	Bamboo species affected'	No.of clumps observed	Percent incidence				
				1987	1988	1989	1990	1991
1.	Thirunelly	BB	114	1451 (317)	14.65 (423)	18.39 (397)	24.75 (412)	24.68 (316)'
2	Noolpuzha	BB	98	17.12 (368)	25.00 (268)	27.58 (116)	26.76 (116)	
3.	Muthanga	BB	68	8.02 (212)	5.38 (260)	16.73 (257)	19.45 (293)	19.12 (272)
4.	Anamari	BB	120	22.81 (228)	13.99 (286)	18.85 (382)	22.82 (447)	33.69 (558)
5.	Marayoor	BB	55	11.11 (117)	13.33 (135)	8.07 (161)	10.30 (165)	
6.	Chinnar	DS	43		10.62 (113)	12.40 (121)	7.95 (88)	6.12 (98)

'Figure in parenthesis is total number of newly emerged culms.
BB: B. *bambos;* DS: D. *strictus;* - Observations not recorded.

Symptoms

Rot of emerging culms manifested as greyish brown lesions surrounded by dark brown margin on the outermost culm sheath of emerging bamboo culms, belonging to 'komali' stage (15-to 30cm in height), near the ground level. Lesions were also formed on tips and margins of culm sheaths. These lesions spread rapidly, became necrotic and covered the entire area of the external culm sheath. Since, at this stage, the culm sheaths of emerging shoots were telescopically arranged tightly one over the other, the infection spread very fast from the outer most culm sheath, which was in contact with the soil, to the inner culm sheaths. As the tissues of the emerging shoots at this stage were very tender and succulent, the infections spread rapidly, and the tissues became discoloured and decayed with a strong smell of molasses. Since, growth of the emerging culm at this stage was extremely slow lasting for 10to 15days after emergence, the disease spread to the entire emerged culm and hindered its further growth and development. Usually, severe infection and mortality were observed at this phase of growth. When the intact culm sheaths of the diseased shoots were removed one by one, the discolouration and spread of rot was observed from outermost sheath to the innermost one and also to the undifferentiated portion of the shoot. Severely infected emerging culms ceased their further growth and became completely decayed (Plate 7). The diseased and later decayed emerging culms came off easily when pulled.

Histopathology

Longitudinal median (LMS) and transverse sections (TS) of the diseased shoots showed that infection developed on the outermost culm sheath and spread towards the innermost undifferentiated tissues. Browning and rot were found severe on the outermost four to seven culm sheaths only. The fungal mycelium was detected in the affected vascular tissues and intercellular spaces. In LMS, the spread of discolouration was seen from shoot tip downwards. However, this type of infection did not spread to the inner tissues but caused browning and necrosis on the margins and tips of two to three outer culm sheaths. In many cases apical portions of the sheaths remained free from discolouration. Mining insect larvae were frequently detected in the decayed tissues of the outer culm sheaths.

Causal organism

Fusarium moniliforme Sheldon var. *intermedium* Neish & Legget (IMI No.350751)

Pathogenicity test

Pathogenicity of F. *moniliforme* var. *intermedium* was tested employing 3-year-old B. *bambos* maintained in large metallic trays (90 x 60 x 25 cm). The emerging shoots were inoculated with conidial suspension of the fungus with and without injuries on the culm sheath at the ground level during June 1991 and May 1992. During 1991 a *Sarocladium* like fungus (IMI Nos. 350747, 350748, 350749, 350750) associated with the rot of the emerging culms in many localities was also included in the infection studies. However, the infection developed only in Fusarium inoculated shoots in treatment with injuries; of the ten shoots inoculated, infection developed only in seven shoots. Severe infection and death of the infected shoots was observed during 1992 tests which occurred within 35 days of inoculation. F. *moniliforme* var. *intermedium* was reisolated from the infected tissues.

Discussion

Rot of emerging culms, occurring both in plantations and natural stands, is widespread in bamboo growing areas of Kerala affecting most of the species. Comparatively, the disease incidence is more in the natural stands than plantations. In natural stands, where water logging is observed, the disease incidence is usually found high. Among the bamboos surveyed, B. *bambos*, D. *longispathus* and D. *strictus* are the most affected species. Very high disease incidence and mortality occur in emerging culms of 15 to 30cm height; this growth stage of the culm is usually referred to as 'Komali' stage (Kondas, 1982). The emerging shoots at this phase showed a period of very slow growth or remained without any elongation for about 10 to 15 days. This gestation period facilitates the incitation and spread of the infection into the innermost tissues. *Fusarium moniliforme* var. *intermedium* associated with the disease is a soil-borne pathogen and the mechanical injuries on the culms sheath caused either during the process of penetration through the soil, or by the mining insect may possibly serve as the avenues for infection. Though, Sarocladium sp. was also isolated from the decayed culm sheath, inoculation trials with the same failed to

produce any infection. *Sacrocladium oryzae* causing sheath rot of paddy has recently been recorded as the casual agent of bamboo blight in Bangladesh (Boa, 1987). The pathogen has also been recorded from India causing blight of B. *nutans* in coastal belts of Orissa (Jamaluddin *et al*.,1992). The bamboo blight affects the developed culms and and it spreads from culm tip downwards. However, the culm rot in Kerala affects only the just emerging culms. Five years' data on disease incidence in natural stands, plantations and Bambusetum reveal that large-scale mortality of the emerging culms due to this disease, along with the damage and destruction by the cattle and wild animals may pose serious threat to the stand productivity. Detailed investigation on epidemiology of the disease and control measures are needed. *Fusarium moniliforme* var. *intermedium* is a new pathogen record on bamboos.

5. ROT OF GROWING CULM

Occurrence

Rot of growing bamboo culms was observed both in plantations and natural stands surveyed in the State during 1987-1991. Disease was observed in plantations at Nilambur, Kollathirumedu, Ezhattumugam, Palappilly, Irumpupalam, Nadukani and Mundoor. In Irumpupalam, 12.1% disease incidence was recorded in B. *bumbos* clumps during 1988; however, in the following years, disease incidence was comparatively low and it was only 3% during 1991 (Table 11). During 1989, in B. *bumbos* plantations at Ezhattumugam, Palappilly, Nilambur and Kollathirumedu, the percent incidence was 10.4, 11.2, 11 and 8.7, respectively which decreased subsequently during the following years in all these localities (Table 11). Percent incidence was found low in D. *strictus* at Nadukani, and T. *oliveri* at Mundoor during the five years of survey from 1987 to '91.

In natural stands at Noolpuzha, Muthanga and Anamari, comparatively low percent disease incidence was recorded during the survey. Of these, highest percent disease incidence of 14.65 was recorded in Noolpuzha during 1989.

In a Bambusetum at Nilambur, five species of bamboos viz., B. *balcooa*, B. *bumbos*, B. *polymorha*, D. *longispathus* and D. *stridus* were found affected with the disease. Of these, B. *bambos*, B. *polymorpha* and D. *stridus*, were severely affected during 1987 and 1988. In B. *bumbos*, B. *polymorpha* and D. strictus which recorded high incidence of the disease during 1987 and 1988, there was a gradual decline in the disease incidence reaching the lowest incidence during 1991. On the contrary in *D. longispathus*, the incidence steadily increased from 4.2 to 17.6% during 1987 to 1991 (Table 11).

Symptoms

Infection appeared as water-soaked greyish brown spindle-shaped lesions usually at the base of the culm sheaths attached to the nodes. In growing culms of 1m and above in length, the culm sheaths covered the expanding internodes more or less completely and also protected.

Table 11 : lncidence of rot of growing culms in bamboo plantations, natural stands and Bambusetum surveyed during 1987-1991

sl. No.	Locality	Bamboo species affected''	Percent incidence 1987	1988	1989	1990	1991
1.	Nilambur	BB	-	-	11.00 (109)	6.45 (124)	335 (149)'
2	Kollathirumedu	BB	-	-	8.66 (127)	7.69 (156)	6.42 (140)
3.	Ezhattumugm	BB	-	-	10.43 (119)	7.27 (146)	5.93 (148)
4.	Palappilly	BB	-	-	11.20 (125)	11.80 (144)	7.18 (167)
5.	Irumpupalam	BB	-	12.12 (132)	7.28 (151)	5.23 (172)	3.00
6.	Nadukani	Ds	8.53 (164)	5.88 (153)	4.40 (159)	4.41 (136)	6.25 (128)
7.	Mundoor	TO	3.82 (366)	3.78 (317)	2.35 (340)	2.49 (362)	2.39 (294)
8.	Noolpuzha''	BB	11.41 (368)	8.21 (268)	14.65 (116)	10.34 (116)	
9.	Muthanga''	BB	9.91 (212)	5.76 (260)	4.28 (257)	2.38 (293)	0.73 (272)
10.	Anamari''	BB	5.26 (228)	2.79 (286)	1.57 (382)	1.56 (447)	1.61 (558)
11.	Nilambur (Bambusetum)	BB	16.66 (18)	25.00 (20)	17.64 (17)	10.52 (19)	4.76 (21)
		BBA	O (18)	0 (15)	4.54 (19)	0 (22)	8.69 (23)
		BP	18.18 (22)	25.00 (20)	13.04 (17)	8.00 (19)	4.76 (21)
		DL	4.22 (71)	5.20 (96)	6.25 (99)	15.17 (112)	17.56 (74)
		Ds	14.70 (34)	18.42 (38)	20.00 (40)	18.91 (37)	8.88 (45)

'Figures in parenthesis are total number of newly emerged culms. ''Natural stands,@ BB: B. *bambos;* BBA: B. *balcooa* ;BP: B. *polymorpha;* Ds: *D. strictus;* DL *D. longispathus;* TO: T. *oliveri;*- Observations not recorded.

the buds at the nodes from mechanical injuries. Infection was predisposed by the injuries made by a sap sucking insect, *Purohitha cervina* Distant (Fulgoridae) on culm sheath at the nodal region. Oozing of sap from the pin-prick like injuries made by the insect occurred and the infection developed in and around the wounds. The lesions coalesced and spread

to form dark greyish brown irregular necrotic areas with dark brown margins; theinfection often spread to the entire culm sheath covering the internode. Subsequently, the infection also spread to the tissues beneath the sheath i.e., branch buds, culm node and internodal tissues. Since, the culms at this stage were tender and succulent in nature and grew rapidly, the rot of the affected tissues progressed from one internode to another at a faster pace. Severely infected culm ceased its growth, became shriveled, decayed and fell off. In many instances, diseased culms fell off before they complete their elongation phase. Medium to severe infection caused various deformities to the culm including shriveling and necrosis of culm internodes, twisting and bending of culms due to severe necrosis on one side of the culm, partial development of branches, breaking of culm at the point of infection, etc (Plate 8). The infected culm sheaths became closely attached to the internodes and did not fall off even at the time of development of branches. Infection on branch buds hindered the development of normal branches from the nodes.

The causal fungus sporulated profusely on the necrotic tissues of the culm internode and culm sheath. Build up of the insect (P. cervina) population at the culm elongation phase was found responsible for the spread of the disease within the individual culm or among the culms and clumps by way of dispersal of fungal spores mechanically.

Causal organism

Fusarium equiseti (Corda) Sacc. (IMI No. 322572)

Pathogenicity test

Pathogenicity of *Fusarium equiseti* was tested during July 1992 by employing young growing culms from 3-year-old clumps of *B. bambos*. Infection developed only in the injured and inoculated culms; uninjured inoculated culms did not develop any infection. Infection occurred as discrete necrotic lesions around the wounds after three days of inoculation which coalesced and spread to the base of the culm sheath. When the infected culm sheath was removed, discolouration and necrosis could be seen on the nodes and expanding internodes. Since, the inoculation was done at the base of the unexpanded internode of the growing culm, the infection reached upto three to five internodes above the inoculated node. F. *equiseti* was reisolated from the infected tissues.

Discussion

Rot of growing culms, caused by *Fusarium equiseti* occurs in most of the bamboo species surveyed both in plantations and natural stands. Young 2 to 4-year-old clumps of *B. bambos*, D. *longispathus*, and D. *strictus* in plantations and Bambusetum were found to be severely affected and succumbed to infection. After the initial period of slow growth, the culm elongation takes place in spurts of increasing rates and the whole process of culm elongation is completed within 70 to 90 days of culm emergence as in the case of *B. bambos*. Since, the bamboo culms lack terminal growth and all the culm internodes are arranged telescopically one above the other, injuries made by the sap sucking insect, Purohitha cervina on the outermost culm sheath, also affect a few inner culm sheaths and the unexpanded culm internodes. Later, the infection also spreads to the tissues of culm internodes. The

wounds made by the sap sucking insect serve as the avenue for the infection by F. *equiseti*. The pathogenicity test also confirms that the infection occurs only through the injuries made on the culm sheaths or culm internodes. F. *equiseti* has earlier been recorded as the causal agent of various diseases in forestry as well as agricultural crops in India (Shukla and Bhargava, 1975; Singh and Joshi, 1972). Symptomatically, the disease is different from culm blight of village bamboos caused by *Sarocladium oryzae*, reported from Bangladesh (Boa and Rahman, 1987), and those reported from coastal belts of Orissa (Jamaluddin *et al.*, 1992). Though, often a *Sarocladium* like fungus could be isolated from the diseased culms, in pathogenicity trials it failed to produce any disease symptoms. Five years' data on the disease from selected plots in plantations, natural stands and Bambu setum reveal that, high incidence of disease which occurred during 1987-1988 can be well correlated with the heavy build up of the insect population which was observed during these years. In the following years, as the insect population, which usually builds up during the months of June-July, was found diminishing in the bamboo plots (Bambusetum), the disease incidence also showed a decreasing trend. Since, the disease may pose practical problems in bamboo stands, especially those in the establishing phase, close monitoring of the disease and sap sucking insect is required.

6. BRANCH DIE-BACK

Occurrence

Branch die-back was found widespread in B. *bambos* and D. *strictus* plantations and natural stands surveyed. The disease was common in new culms. Branch die-back was recorded in B. bambos plantations a t Nilambur, Kollathirumedu, Ezhattumugam, Palappilly, Irumpupalam and *D. strictus* plantation at Nadukani and natural stands at Thirunelly, Noolpuzha, Muthanga, Anamari, Marayoor and Chinnar during 1989-'91. The disease was also recorded in clumps of B. *vulgaris* and D. *strictus* in a Bambusetum at Nilambur during 1989-'91. Though, the disease severity was low in all the plots surveyed, percent disease incidence was found comparatively high in plantations than natural stands (Table 12). Culms in young developing clumps in plantations were found severely affected by the disease. The disease occurred during the months of September-Odober and became severe during December-January causing die-back of branches at the top and culm tips.

Symptoms

Infection was recorded on the branches and top three to five internodes of young culm in the form of small greyish magenta coloured linear lesions which later developed into necrotic streaks. Infection was observed on the foliage as pale yellowish linear lesions, later spreading to the entire leaf lamina, which results in leaf necrosis, withering and subsequent premature defoliation. The necrotic streaks on the branches and culm internodes coalesced to form large streaks; often the entire length of apical three to five culm internodes as well as the affected branches became discoloured. As the leaves of the infected branches defoliated prematurely, discolouration and necrosis on the branches and culm tip became very prominent. Infection spread from branches to the culm node and from there to the

internode downwards. Under high humidity, causal fungus sporulated on the infected necrotic areas of the culm internodes and branches. Infection caused premature defoliation and die-back of branches and culm tip.

Table 12: Severity of branch die-back caused by Fusarium pallidoroseum *in bamboo plantations, natural stands and Bambosetum in Kerala surveyed during 1989-1991*

Sl. No.	Locality	Bamboo species affected@	Disease Severity‘ 1989			1990			1991		
			%incidence	DSI	DSR	% incidence	DSI	DSR	%incidence	DSI	DSR
Plantation											
1.	Nilambur	BB	44.11	0.80	L	3333	0.65	L	3333	055	L
2.	Kollathirumedu	BB	47.76	0.67	L	46%	0.59	L	47.76	0.59	L
3.	Ezhattumugam	BB	0	0	0	3438	0.44	L	39.06	0.50	L
4.	Palappilly	BB	0	0	0	37.66	0.46	L	51.66	0.52	L
5.	lrumpupalam	BB	34.37	0.34	L	14.06	0.15	L	2031	0.21	L
6.	Nadukani	DS	30.23	0.32	L	25.58	0.25	L	30.23	0.34	L
Natural stands											
1.	Thirunelly	BB	10.52	0.11	L	6.14	0.07	L	3.51	0.03	L
2.	Noolpuzha	BB	4.08	0.04	L	6.12	0.07	L	3.06	0.03	L
3.	Muthanga	BB	10.59	0.12	L	8.82	0.08	L	735	0.07	L
4.	Anamari	BB	5.83	0.05	L	2.50	0.03	L	1.66	0.02	L
5.	Marayoor	BB	9.09	0.09	L	3.64	0.04	L	10.10	0.13	L
6.	Chinnar	Ds	13.95	0.13	L	930	0.12	L	6.98	0.07	L
7.	Nilambur	BV	21.00	0.26	L	31.57	0.42	L	36.84	0.42	L
	(Bambusetum)	DS	50.00	0.57	L	55.55	0.83	L	66.66	094	L

‘DS1:Disease severity index; DSR: Diseaseseverityrating; L: low; M: medium;@BB: B. *bambos;* BV: *B. vulgaris;* DS: *D strictus.*

Causal organism

Fusarium pallidoroseum (Cooke) Sacc. (IMI No. 320686)

Pathogenicity test

Pathogenicity of F. *pallidoroseum* was tested on fully developed new shoots of 3-year-old B. bambos clump. Infection developed within four days of inoculation both on injured and uninjured culm tips and branches as well as the foliage which were sprayed with a conidial suspension of the fungus. Characteristic linear greyish magenta coloured lesions developed on the culm internodes and branches, which later spread and became necrotic. Infedional so developed on petiole, leaf sheath and leaves as pale yellow lesions which later

spread and became necrotic. Foliage blight, withering and premature defoliation were observed within 40 days of inoculation. *F. pallidoroseum* was reisolated from the diseased tissues.

Discussion

Recently, foliage infections caused by F. *pallidoroseum* on bamboos in North Eastern states (Deka *etal.*, 1990) and by F. *semitectum* in Kerala (Balakrishnan *etal.*, 1990) have been recorded. A similar disease affecting the foliage of basket bamboo (*Phyllostachys* sp.), caused by Fusarium sp., has been recorded from Yontai County, Fujian Province, China (Kuai, 1987). The disease caused more than 30% infection; the leaf tips and outer margin of the leaves begin to wither which are finally defoliated. F. *semitectum* causing wilt of D. *latiflorus* has also been reported from the same area (Xie *et al.*, 1987). The cold injury was found to be the predisposing factor for the infection. In Kerala, *F. pollidoroseurn* has been recorded *on Acacia auriculiformus, A. melanoxylon* causing foliage and twig blight (Mohanan and Sharma, 1988), and on *Calamus thwaitesii* and C. *hookerinus* causing foliage infection (Mohanan, 1990b).

7. NECROSIS OF CULM ITERNODE

Occurrence

The disease was recorded only in a *Thyrsostachys oliveri* plantation at Mundoor (Palakkad Forest Divn.) during 1988-1990. The infection occurred in new culms which were produced late in the growing Season i.e., in the months of August-September. Severity of the disease was low and the percent incidence of the disease during 1988, '89, '90 was 2.8, 1.5 and 1.1, respectively. Possibly, mechanical injury caused by the cattle on the new developing culms predisposed the infection.

Symptoms

The disease manifested as small dark brown to black lesions, invariably associated with a small longitudinal split or crack, at the culm node. The internodal lesions spread rapidly in the upward and downward direction, causing infection of both the internodes forming a large necrotic area with pale yellow halo. Under high humidity the pathogen produced spores on the necrotic tissues. The infection resulted in formation of numerous abnormal shoots from the affected nodes. The internal tissues of the node and internodes showed pronounced discolouration. Such affected culms got snapped easily by wind or animals at the point of infection.

Causal organism

Curvularia lunata (Wakker) Boedijn, anamorph of *Cochliobolus lunatus* Nelson & (IMI No. 326949)

Pathogenicity test

Pathogenicity of *Curvularia lunata* was tested on new culms of T. *oliveri* during June 1991. The shook were inoculated with conidial suspension of the fungus after making small injury at the node by sterile scalpel blade. Infection developed as water soaked greyish brown to dark brown lesion around the injury within seven days of inoculation. Later, the infection spread and the entire internode became necrotic within one month of inoculation. The inoculated uninjured shoots did not develop any infection. C. *lunata* was reisolated from the necrotic tissues of the infected shoots.

Discussion

Among the bamboo species surveyed, only very few diseases have been recorded on *Thyrsostachys oliveri*. C. *lunata* causes necrosis of culm internodes, on the late emerged culms of T. *oliveri*. Since, the disease affects mostly the late emerged and otherwise slow growing culms, which are usually very few in number, it is not considered to be economically important. C. *lunata* is a weak pathogen and usually causes infection on fleshy tissues; the infection of supple bamboo culm is predisposed by the mechanical injury caused on the culm; pathogenicity trial also confirms the mode of infection.

8. THREAD BLIGHT

Occurrence

Disease was recorded in B. *bambos* plantations at Nilambur, Kollathirumedu, Ezhattumugam, Palappilly and Irumpupalam, in D. *strictus* plantation at Nadukani, and in *T. oliveri* plantation at Mundoor during 1989-1991; in natural stands, the disease was recorded in **O.** scriptoria at Periya and Vazhachal, in 0. *travancorica* at Watchumaram and Pachakkanam, in **O.***ebracteata* in Kottoor, in B. bambosa t Thirunelly, Noolpuzha, Muthanga and Anamari. Disease severity was low in all the localities surveyed (Table 13). In a Bambusetum at Nilambur, a total of eleven species of bamboos were found affected with the disease (Table 14). Disease severity was low in all the bamboo species in the Bambusetum except in B. vulgaris which showed medium seventy with 94.7% and 94.9% disease incidence during 1990 and 1991 (Table 13). The disease was also observed in all the reed bamboo catchment areas of the State, surveyed. Since, free water on the host surface and high atmospheric humidity were the favouring factors for the development and spread of the infection, disease appeared during the monsoons, subsided and almost disappeared during the dry period. Usually, infection occurred after the onset of South-West monsoon during June and continued till the end of North-East monsoon i.e., during September-October. Infection on the new foliage developed either from the mycelial threads which perennated on the culms and branches or from the air-borne asexual or sexual spores of the fungus. In high elevated areas, the disease affected reed bamboos during the months of June-July and it continued till December-January, often affecting the entire shoots of the clump depending on the prevailing climatic conditions.

Table 13: Incidence andseverityofthread blight in bamboo plantations and natural stands at different localities in Kerala surveyed during 1989-1991

Sl. No.	Locality	Bamboo species affected@	Disease Severity' 1989 % incidence	1989 DSI	1989 DSR	1990 %incidence	1990 DSI	1990 DSR	1991 % incidence	1991 DSI	1991 DSR
Plantation											
1.	Nilambur	BB	35.29	0.38	L	25.49	0.25	L	29.41	032	L
2.	Kollathirumedu	BB	35.82	0.40	L	46.26	0.49	L	11.94	0.16	L
3.	Ezhattumugam	BB	38.77	0.35	L	33.89	0.40	L	18.64	0.20	L
4.	Palappilly	BB	41.66	0.41	L	19.40	0.25	L	35.82	0.45	L
5.	Irumpupalam	BB	3437	0.37	L	3281	0.32	L	14.06	0.14	L
6.	Nadukani	DS	6.79	0.06	L	16.27	0.16	L	13.95	0.14	L
7.	Mundoor	TO	0	0	-	3.13	0.31	L	2.08	0.02	L
Natural stand											
1.	Thirunelly	BB	14.03	0.14	L	9.65	0.09	L	6.14	0.06	L
2.	Noolpuzha	BB	5.10	0.05	L	14.28	0.14	L	14.28	0.14	L
3.	Muthanga	BB	14.70	0.15	L	14.70	0.15	L	19.12	0.19	L
4.	Anamari	BB	6.66	0.67	L	9.16	0.09	L	5.00	0.05	L
5.	Periya	0S	15.03	0.15	L	30.13	032	L	19.17	0.21	L
6.	Watchumararn	OT	17.85	0.22	L	1214	0.17	L	1285	0.19	L
7.	Vazhachal	OS	14.75	0.15	L	1639	0.20	L	26.22	039	L
8.	Pachakkanam	OT	1858	0.23	L	8.97	0.10	L	14.10	0.04	L
9.	Kottoor	OE	9.40	0.10	L	12.82	0.14	L	14.52	0.18	L

'DSI : Disease severity index; DSR : Disease severity rating; L: low; M medium; @BB: B. *bambos;* DS *D. strictus;* TO: *T. olivevi;* OE: *0. ebracteata;* OS: *0. scriptoria;* OT: *O. travancorica.*

Symptoms

Infectionon the foliage manifested as large water-soaked irregular lesions with greyish green centre and greyish white margin. Usually, the lesions appeared at the base of the leaf and advanced towards the leaf tip or at any place on the foliage and subsequently spread throughout the lamina. Fine silvery white fungal mycelial strands appeared on the lower surfaceof the corresponding lesions on the foliage (Plate 9).

Spread of the disease was mainly through the physical contact of the advancing fungal hyphae on the diseased foliage with the healthy neighbouring foliage. Free water on the foliage surface and high ambient humidity favoured the mycelial growth of the fungus on the host and also thespreadof the disease. Rapid spread of thediseasecouldbejudged from a linear hyphal growth of 80 mm recorded on infected intact leaf of B. *vulgaris* within 48 hours. Diseased foliage stuck together closely due to the mycelial weft of the fungus at the leaf margins, leaf tips and leaf bases where they came into contact with each other. The whole foliage of the affected shoot became greyish white, and often appeared as affected

withchemical toxicity.Infection caused browning and necrosis leading toblightoftheculm and branches,especially of foliage.White to paleorange pustules developed on the affected plant parts. During the dry period the blighted foliage dried up, withered and defoliated; but many leaves remained stuck together on the dried up twigs because of the mycelial strands.The mycelia1 threads on the dried up and partly killed branches perennated during the dry period and formed the source of infection during the wet period.

Table 14: Incidence and severity of thread blight in Bambusetum at Nilambur during 1989-1991

Sl. No.	Bamboo species affected	No.of clumps observed	Disease Severity' 1989			1990			1991		
			% incidence	DSI	DSR	%incidence	DSI	DSR	%incidence	DSI	DSR
1.	*B. balcooa*	4	50.00	0.50	L	50.00	0.50	L	25.00	0.25	L
2.	*B. bambos*	5	40.00	0.40	L	40.00	0.40	L	20.00	0.20	L
3.	*B. glaucescens*	1	0	0	-	0	0	-	100.00	1.00	L
4.	*B. polymorpha*	3	3333	0.33	L	66.66	0.66	L	33.33	033	L
5.	*B.tulda*	1	0	0	-	100.00	1.00	L	0	0	-
6.	*B.* ventricosa	2	0	0	-	50.00	050	L	50.00	0.50	L
7.	*B. vulgaris*	19	63.15	1.05	L	94.73	137	M	94.93	132	M
8.	*D. brandisii*	1	0	0	-	0	0	-	100.00	1.00	L
9.	*D. longispathus*	12	50.00	0.58	L	41.66	0.42	L	3333	0.42	L
10.	*D.strictus*	18	38.88	0.50	L	50.00	0.66	L	44.44	0.72	L
11.	*T. siamensis*	1	0	0	-	0	0	-	100.00	1.00	L

'DSI : Disease severity index; DSR : Disease severity rating; L low; M medium; - Nil.

Causal organism

Botryobasidium salmonicolor (Berk &Br.) Venkatanarayanan (IMI N0.327740).

Discussion

Thread blight of bamboos caused by B. salmonicolor was recorded in plantations and natural stands; severe infection is observed on B. *bambos*, B. *vulgaris* and D. *strictus* in plantations and Ochlandra species in natural stands. Thread blight is a common disease in natural forest and it has been recorded on many plantation crops as well as other species growing in natural forests (Butler and Bisby, 1931; Anon., 1951). Thread blight was recorded in bamboos as early as in 1943 by Rogers from Karnataka and recently by Balakrishnan *et el.* (1990) from Kerala. Among the bamboo species surveyed, B. *vulgaris* is the severely affected species which showed 94.7% infection during 1990 and 1991. Even though, the disease is widespread, especially in tracts of high rainfall areas, and caused large-scale defoliation, it seems to be economically unimportant.

9. FOLLAGE BLIGHT

Occurrence

Most of the bamboo species were found affected with the foliage blight; B. *bambos* and D. *longispathus* were the most affected ones. The disease was recorded in plantations and natural stands of B. *bambos* and D. *strictus* during 1988-1991 (Table 15). Disease severity was low in all the areas except in a plantation at Nilambur where severity was found to be medium in 1990 and 1991, the disease incidence being 97% and 80.4% respectively. Foliage blight was also recorded in B. *brandisii*, *D. longispathus* and D. *strictus* in a Bambusetum at Nilambur. In addition to the selected plots, the disease was also recorded in natural stands of *B. bambos* and *D. strictus* at Thudukky, Kadukuman and Anavay during 1988-1990.

Table 15: Incidence and severity of foliage bligh f in plantations and natural stands of bamboos in different localities in Kerala surveyed during 1988-1991

Sl. No.	Locality	Bamboo Species affected@	Disease Severity' 1988 % incidence	1988 DSI	1988 DSR	1989 % incidence	1989 DSI	1989 DSR	1990 % incidence	1990 DSI	1990 DSR	1991 % incidence	1991 DSI	1991 DSR
Plantation														
1.	Nilambur	BB	61.76	0.75	L	71.56	0.87	L	97.05	1.13	M	80.39	1.18	M
2.	Kollathirumedu	BB	79.10	0.86	L	53.73	0.56	L	59.70	0.72	L	82.08	0.98	L
3.	Ezhattumugam	BB	40.67	0.47	L	44.06	0.47	L	35.59	0.42	L	47.45	0.61	L
4.	Palappilly	BB	91.66	0.98	L	95.00	0.98	L	100.00	1.08	L	95.00	10.33	L
5.	Irumpupalam	BB	42.19	0.45	L	46.88	0.44	L	25.00	0.25	L	45.31	0.53	L
6.	Nadukani	DS	30.23	0.33	L	27.90	0.30	L	-	-	-	34.88	0.37	L
Natural stand														
1.	Thirunelly	BB	14.91	0.15	L	18.42	0.18	L	21.92	0.24	L	21.05	0.24	L
2.	Noolpuzha	BB	23.47	0.23	L	21.42	0.23	L	21.43	0.24	L	27.55	0.32	L
3.	Muthanga	BB	35.29	0.43	L	45.58	*0.50*	L	55.88	0.62	L	27.94	0.32	L
4.	Anamari	BB	18.33	0.23	L	30.83	0.34	L	35.83	0.48	L	22.50	0.28	L
5.	Marayoor	BB	23.66	0.25	L	32.72	0.36	L	29.09	0.35	L	21.81	0.25	L
6.	Chinnar	DS	18.60	0.23	L	34.88	0.39	L	37.20	0.44	L	16.28	0.19	L
7.	Agaly	DS		-	-	8.95	0.08	L	17.91	0.18	L	13.42	0.13	L
8.	Goolikadavu	DS		-	-	34.37	0.37	L	28.12	0.28	L	56.25	0.69	L
9.	Thakarapady	DS		-	-	47.50	0.43	L	22.50	0.25	L	45.00	0.53	L

'DSI : Disease severity index; DSR : Disease severity rating; - Observations not recorded; L: low; M: medium; @BB: *B. bambos;* DS: *D. strictus.*

Symptoms

Infection appeared as small water-soaked greyish brown spindle-shaped lesions on

both young and mature leaves during August-September. Around the small lesions, pale yellow to yellowish orange halo developed. These lesions coalesced and formed large spreading greyish brown to yellowish brown irregular lesions with dark brown border, often covering theentireleaf lamina. Suchleavesbecame nercrotic and blighted. The colour of the lesion,its size and natureofspread variedslightlydependingonthebamboospecies, leaf maturity, fungal species associated and microclimatic conditions. Generally, in D. *longispathus,* water-soaked, spindle-shaped lesions became circular to irregular, fast spreading necrotic spots with dark brown concentric area alternate with pale brown area. The necrotic spots spread to the entire foliage and caused foliage blight. In B. *bambos* and *D. strictus,* infection appeared mainly at the foliage tips and spread towards the base of the foliage. Severe infection caused yellowing of the foliage followed by leaf blight and later withering. Oftengreyish black to blackfungalsporemassdevelopedonthe abaxial surface of the necrotic areas on the blighted foliage.

Causal organisms

1. *Bipolaris maydis* (Nisikado &Miyake) Shoem., anamorph of *Cochliobolus heterostrophus* (Dresch.) Dresch.(IMI N0.326944).
2. *Bipolaris* sp. (IMI No. 326947).

Usually, B. *maydis* produced dark brown lesions with greyish brown centre. In **O.** *monostigma,* the disease symptoms were the production of greyish yellow water-soaked irregular lesions, usually near the leaf tip, while in D. *longispathus* the lesions were water-soaked and spindle-shaped which later spread fast and became irregular necrotic spots with dark brown margin. The fungus sporulated heavily on the adaxial surface of the necrotic lesions. The cultural and morphological characters of the two pathogens were identical to those of *B. maydis* and *Bipolaris* sp.(IMI No.326946) causing leaf spot in bamboo seedlings.

Pathogenicity test

The pathogenicity test of *Bipolaris* sp. and B. *maydis* is provided under the Nursery diseases.

Discussion

Bipolaris spp., the common foliage pathogens of agricultural crops belonging to Gramineae have also been recorded on forestry crops viz., *Populus deltoides, Eucalyptus tereticornis, Acacia auriculiformis* A. Cunn., A. *melanoxylon* R. Br., etc., causing foliage blight (Mohanan and Sharma, 1986,1988; Chauhan and Pandey, 1992).Earlier, Drechslera rostrata and *Exserohilum* halodes, two closely related fungi were recorded as causing foliage blight in bamboo nurseries and plantations from Madhya Pradesh (Harsh *et al.,* 1989) and

Karnataka (Bhat *et al.*, 1989). In the present study, young (2 to 4-year-old) bamboo plantations of *B. bambos* and *D. longispathus* are found to be severely infected in successive years which in turn affect the clump vigour. Since, the new culms produced from such infected clumps become stunted in height and show low vigour, appropriate control measures for the disease have to be worked out. Harsh *et al.* (1989) suggested application of Difolatan (0.2% a.i.) or Fytolan (0.4% a.i.) for controlling the foliage infection caused by *D. rostrata*. *B. maydis*, *B. urochloae* and hitherto undescribed *Bipolaris* sp. are also recorded from bamboo nurseries during this study. Foliage blight of bamboos caused by *Bipolaris* spp. is a new disease record.

10. LEAF RUST

Occurrence

Foliage rust of bamboos is widespread in Kerala. The disease was recorded in *B. bumbos* and *D. strictus* in plantations and natural stands. In plantations at Nilambur, cent percent disease incidence was recorded during 1988-'91 with medium disease severity (Table 16). In natural stands at Marayoor cent percent disease incidence was observed only during 1988 and 1991 and the disease severity was rated as medium. In *D. strictus*, disease incidence as well as disease severity were low in plantations as well as natural stands. In a Bambusetum at Nilambur, among the 14 species of bamboos affected by rust, the maximum disease severity was only moderate in *B. bumbos*, *B. vulgaris*, *B. ventricosa*, *D. strictus* and *0. monostigma;* in other species the severity was low (Table 16). Rust infection was also recorded in *B. ventricosa* in the Botanical Garden, Calicut University and in *0. travancorica* at Kakki and Pamba.

Symptoms

Initially, infection appeared as minute pin-head, water-soaked flecks on the adaxial surface of the foliage where yellowish orange to rust brown linearly arranged urediniosori developed. On the corresponding abaxial surface of the flecks greyish brown to dark brown lesions with yellowish orange halo formed. Often, numerous such lesions developed on a single leaf lamina which later coalesced and spread to the entire leaf. Severe infection caused yellowing and necrosis of the leaf tissues between the spots. Uredinia developed during August-September and continued to produce bright yellowish orange coloured urediniospores till April-May. Development of uredinia on the abaxial surface of the leaves was rarely observed (Plate 10). Teliosori developed linearly on the adaxial surface of the foliage either in the degenerating urediniosori or separately during December-January. Severe uredinial infection caused abnormal defoliation even before the development of

Table 16: lncidence and severity of leaf rust caused by Dasturella divina in bamboo plantations and natural stands in different localities in Kerala surveyed during 1988-1991

Sl. No.	Locality	Bamboo species affected	Disease Severity' 1988 % incidence	1988 DSI	1988 DSR	1989 % incidence	1989 DSI	1989 DSR	1990 % incidence	1990 DSI	1990 DSR	1991 % incidence	1991 DSI	1991 DSR
Plantation														
1.	Nilambur	BB	100.00	1.15	M	100.00	1.30	M	100.00	1.19	M	100.00	1.28	M
2.	Kollathirumedu	BB	95.52	1.00	M	98.50	1.18	M	97.01	1.13	L	97.01	1.18	M
3.	Ezhattumugam	BB	84.75	1.20	M	86.44	1.00	L	89.83	1.01	L	96.61	1.03	L
4.	Palappilly	BB	83.33	0.87	L	75.00	**0.77**	L	100.00	1.07	L	100.00	1.22	M
5.	Irumpupalam	BB	87.50	0.92	L	92.19	1.00	L	96.88	0.98	L	93.75	0.97	L
6.	Nadukani	DS		-	-	55.81	0.60	L	55.81	0.60	L	55.81	0.58	L
Natural stand														
1.	Thirunell	BB	36.84	0.40	L	33.33	0.36	L	28.07	0.30	L	52.63	0.54	L
2.	Noolpuz	BB	69.39	0.74	L	62.24	0.67	L	73.47	0.91	L	45.92	0.49	L
3.	Muthanga	BB	38.23	0.41	L	72.05	0.81	L	54.41	0.63	L	51.47	0.69	L
4.	Anamari	BB	90.83	0.93	L	59.17	0.66	L	50.00	0.57	L	56.67	0.59	L
5.	Marayoor	BB	100.00	1.55	M	96.36	1.25	M	94.55	1.33	M	100.00	1.35	M
6.	Chinnar	DS	44.19	0.47	L	65.12	0.72	L	76.74	0.90	L	62.79	0.67	L
7.	Agaly	DS		-	-	64.18	0.69	L	52.23	*0.58*	L	40.30	0.45	L
8.	Goolikadavu	DS		-	-	53.13	0.53	L	59.38	0.59	L	59. 38	0.63	L
9.	Thakarapady	DS		-	-	42.50	0.43	L	45.00	0.48	L	47.50	0.50	L

· DSI: Disease severity index; DSR : Disease severity rating; @BB *B.bambos;* DS: *D.strictus*.
- : Observations not recorded; L: low; M medium.

Table 17: Incidence and severity of leaf rust caused by Dasturella divina in Bambusetum at Nilambur during 1989-1991

Sl. No.	Bamboo species affected	No.of clumps observed	Disease Severity' 1989 %incidence	1989 DSI	1989 DSR	1990 %incidence	1990 DSI	1990 DSR	1991 %incidence	1991 DSI	1991 DSR*
1.	*B.balcooa*	4	50.00	0.50	L	50.00	0.50	L	75.00	0.75	L
2.	*B.bambos*	5	100.00	1.20	M	100.00	1.40	M	100.00	1.20	M
3.	*B.glaucescens*	1		-	-	0	0	-	100.00	1.00	L
4.	*B.polymorpha*	3	100.00	1.00	L	100.00	1.00	L	100.00	1.00	L
5.	*B.tulda*	1		-	-	0	0	-	100.00	1.00	L
6.	*B.ventricosa*	2		-	-	100.00	2.00	M	100.00	2.00	M
7.	*B.vulgaris*	19	100.00	1.11	M	100.00	1.21	M	100.00	1.32	M
8.	*D.brandisii*	1	100.00	1.00	L	100.00	1.00	L	100.00	1.00	L
9.	*D.hamiltonii*	1		-	-	0	0	-	100.00	1.00	L
10.	*D. longispathus*	12	41.66	0.42	L	33.36	0.33	L	58.33	0.58	L
11.	*D.strictus*	18	100.00	1.17	M	100.00	1.33	M	100.00	1.44	M
12.	*0. monostigma*	1	100.00	1.00	L	100.00	2.00	M	100.00	2.00	M
13.	*T. oliveri*	3	0	0	-	0	0	-	100.00	1.00	L
14.	*T. siamensis*	1		-	-	0	0	-	3333	0.33	L

DSI : Disease severity index; DSR : Disease severity rating; - Observations not recorded; L: low; M: medium.

causal organism

Dasturella divinu (Syd.) Mundk & Khes. (IMI Nos. 322081,322078).

Discussion

Leaf rust caused by *D. divina* is found to be widespread affecting most of the bamboo species in Kerala; *B. bambos, B. Vulgaris, B. ventricosa, D. strictus and 0. monostigma* are observed to be the most affected species, whereas *T.* oliveri is the least. ***D.*** divinu has earlier been recorded as having 0 to IV stages and of these 0 to I stages occur on Ruadia spp. (= *Catunaregum* spp.) and other two stages on bamboos (Bakshi *et al.,* 1972). In the present study,no alternate host isobserved either in plantations or natural stands. Though,Randia spp. occur in bamboo natural stands in Kerala, rust infection was seldom observed. However, undergrowth belonging to Gramineaeis found affected with the same leaf rust. Among the rust fungi viz., D. divinu, D. bambusina, Puccinia spp., and Tunicospora bagchi, recorded on bamboos from India, D. divinu is the most widespread in the country (Sujan singh and Bakshi, 1964; Nema and Mishra, 1965; Sujan Singh and Pandey, 1971; Bakshi *et al.,* 1972).D.*divina* is a new pathogen record on B. *balcooa,* B. polymorpha, B. tulda, B. ventricosa, *B. vulgaris, D. brandisii, D. hamiltonii, D.longispathus, Oxytenanthera monostigma, T.oliveri* and *T. siamensis.*

11. *EXSEROHILUM LEAF SPOT*

Occurrence

Leaf spot was recorded in *B. bambos* plantations at Nilambur, Irumpupalam and Ezhattumugam during 1990 and 1991and also innaturalstandsat Marayoorduring 1989. In *D. strictus* the leaf spot was observed in natural stands at Agaly, Thakarapady and Chinnar. Disease was also recorded in *D. longispathus* and *B.polymorpha* in a Bambusetum at Nilambur and also few clumps in natural stands at Anavay and Kadukuman during 1988.The disease occurred on mature leaves during August-Septemberand was sporadic in distribution in the plots surveyed.

Symptoms

Infection manifested as small water-soaked greyish blacklinear to irregular lesions on mature leaves, which later coalesced and spread to the entire leaf lamina. The infection appeared in August-September; leaf necrosis, withering and premature defoliation recorded in October. The fungus sporulated profusely on the lower surface of the affected leaf.

Causal organisms

1. *Exserohilum rostratum* (Dresch.) Leonard & Suggs, anamorph of *Setosphaeria rostrata* Leonard (IMI No. 326945).
2. *Exserohilum holmii* (Luttr.) v. Arx., anamorph of *Setosphaeria holmii* (Luttr.) Leonard & Suggs (IMI No. 327737).

E.rostratum produced greyish blacklinear to irregular lesions on the foliage which later

spread to the entire leaf lamina. The fungus sporulated heavily under high humid conditions on the lower surface of the necrotic lesions on the affected foliage. *E. holmii* produced dark greyish brown to greyish black water soaked lesions which often spread to the entire leaf lamina. Generally, no marked difference in symptoms was observed in different bamboo species, except in juvenile leaves of *D. longispathus*, where the lesions were olive yellow, spindle-shaped and water-soaked, which later spread to the entire leaf lamina and became necrotic.

Discussion

E. holmii and *E. rostratum* are new pathogen record on bamboos. Recently, *E. halodes* and *Drechslera rostrata* have been recorded from Karnataka and Madhya Pradesh respectively as causing foliage blight on *Bambusa* sp. (Bhat *et al.*,, 1989; Harsh *et al.*, 1989). During this study, *E. holmii* and *E. rostratum* have also been recorded in bamboo nurseries in Kerala. Earlier, *Exserohilum* spp. causing foliage infection have been recorded in Eucalyptus *tereticornis, Acacia auriculiformis, A. melanoxylon, Calamus thwaitesii Becc.* and *C. psuedotenuis* Becc. ex Becc. & Hkf. in Kerala (Mohanan and Sharma, 1989; Mohanan, 1990b).

12. ZONATE LEAF SPOT

Occurrence

The disease was recorded in all the plots of *B. bambos, D. strictus, 0. travancorica, 0. scriptoria* and *0. ebracteata* surveyed during 1987-1991. However, the disease incidence as well as severity were very low in all the areas surveyed. Zonate leaf spot was also recorded in *B. polymorpha* and *D. longispathus, Oxytenanthera monostigma* and *T. siamensis* in a Bambusetum at Nilambur, and in *Thyrsostachys* sp. in Kulathupuzha during 1988-1991. Infection occurred usually on foliage in the lower branches. The development and spread of infection depended on the bamboo species as well as the local microclimatic conditions.

Symptoms

Infection appeared late in July as minute greyish brown spots of 2 to 3 mm across. The spots enlarged to 5 to 8 mm in dia and became yellowish brown with dark brown margins. The spots spread further and formed reniform semicircular to circular greyish brown areas of 5 to 10 mm in width with dark brown wavy margin around the light coloured central spot; later these developed into a large zonate leaf spots of 3 to 12 cm in dia depending on the host species and climatic conditions. In *O. travancorica* and *O. ebracteata*, a single spot often spread and developed into a large zonate spot of 10 to 12 cm dia extending the whole width of the fo1iage. In *B. bambos* and *D. strictus*, only two to three concentric rings developed around the central spot, In *Oxytenanther a monostigma* and *T. siamensis* after the development of one to two rings around the central spot, under high humidity the outer rings, deep magenta to dark brown in colour, spread to the entire leaf lamina (Plate 11).

Causal organism

Dactylaria sp. (IMI No 322576).

This fungusshowed similarcultural and morphologicalcharacters of *Dactylaria* sp. (IMI Nos. 327745,327746) causing leaf spot of bamboo seedlings.

Discussion

Zonate leaf spot caused by *Dactylaria* sp., which affects nine species of bamboos is a new pathogen record on bamboos. The disease is also observed on bamboo seedlings in nurseries in Kerala. The zonate leaf spot becomes very prominent on the foliage of reed bamboos, because of their large size.

13. COLLETOTRICHUM LEAF SPOT

Occurrence

In *B. bambos* plantations, the disease was recorded from Kollathiru medu, Irumpupalam, and Palappilly; in natural stands, it occurred at Thirunelly, Anamari and Marayoor. In *D. strictus* plantations, the leaf spot was observed at Nadukani and at Agaly and Chinnar in natural stands. The disease was also recorded in all the selected plots of reed bamboos. Besides, it was also recorded in *D. strictus* clumps at Thudukky and Anavay (Mannarkkad Forest Divn.) and in *Arundinaria* sp. at Munnar. Infection occurred on the foliage, especially those on the lower branches of the new culms, during the months of September-November.

Symptoms

The disease manifested as water-soaked small greyish brown spots on juvenile as well as mature leaves. These spots spread and coalesced to form large dark purple, linear to irregular areas which often covered the entire leaf lamina, as in *0. travancorica* and *0. ebracteata*. Infected foliage became pale yellowish green and leathery. Infection also spread to branches and caused discolouration and necrosis of the branches. Infection often led to leaf necrosis and premature defoliation. Usually, Colletotrichum leaf spot was found intermixed with Zonate leaf spot caused by *Dactylaria* sp.

Causal organism

Colletoh-ichum gloeosporioides (Penz.) Penz. & Sacc., anamorph of *Glomerella cingulata* (Stonem.) Spauld & Schrenk (IMI Nos. 331798,331801,331802,331803,331804).

Discussion

Colletotrichum gloeosporioides, a common foliage pathogen, has been recorded on a large number of forestry species causing various diseases symptoms such as leaf spot, shot-hole, leaf blight, leaf withering, etc. (Bakshi, 1976; Sharma *et al.*, 1985; Sankaran and Balasundaran, 1986, Mohanan, l988, 1990a,b). In the present study, the fungus is also recorded as causing seedling foliage infection. In India, the pathogen has earlier been recorded on bamboos in Meghalaya (Deka *et al,* 1990). Colletotrichum foliage infection has also been recorded on bamboos from Malaysia (Azmy and Maziah, 1990) and US.A. (Anon., 1960).

14. ASCOCHYTA LEAF SPOT

Occurrence

The disease was recorded in plantations as well as natural stands during November-December; *B. bambos, D. strictus* and *Thyrsostachys* sp. were the affected bamboos. In *D. strictus,* the disease was recorded at Agaly, Thudukky, Kadukuman, Marayoor and Chinnar; in *B.bambos* at Anavay, Kodanad and Kollathirumedu and in *Thyrsostachys* sp. at Kulathupuzha.

Symptoms

Infection appeared as minute spindle-shaped yellowish brown to brown watersoaked spots on the upper surface of the leaf. Both juvenile and mature leaves were found affected by the disease. The spot spread to form 3 to 5 mm in dia with greyish white centre. During December-January, dark brown to black pycnidia developed over the necrotic spots from which pinkish white spore mass oozed out under high humidity. In severe infection, necrosis of the affected leaf tissues and foliage blight occurred (Plate 12).

Causal organism

Ascochyta sp. (IMI No. 331647).

Discussion

Leaf spot caused by a hitherto undescribed species of Ascochyta is a new pathogen record on bamboos. Earlier, *A. bambusina* Rao has been recorded on *B. nana* from Maharashtra (Tilak and Rao, 1967) and *A .phaseolarum* Sacc. on *Bambusa* sp. from Kerala (Balakrishnan *et* al., 1990). The present isolate was quite near to *Ascochyta caryoticola* Punith. in taxonomic details, but differed in having conidia of variable shapes (B.C. Sutton, IMI, pers. communication). This *Ascochyta* sp. appears to be an undescribed species which will be validly published elsewhere.

15. TAR SPOT

Occurrence

Usually, the tar spot was observed on the foliage of the lower branches of the culms, affecting both the juvenile and mature leaves and also the leaf sheaths. *B. bambos, B. vulgaris, D. strictus, Oxytenanthera monostigma, Thyrsostachys* sp., *Ochlandra scriptoria, 0. travancorica* were the species found affected.

Symptoms

Infection appeared as pin-head pale to dark yellowish brown lesions on the abaxial surface. of the leaf. The lesions spread and developed into oval to circular spots with dark brown centre and pale yellow margin. Usually, four to six small spots (3-6 mm dia), appeared on the leaf lamina, as well as on the leaf sheath. Ascocarps developed as dark brown to black raised structures in the necrotic spots. Though, three species of *Phyllachora* were recorded, no difference was observed on symptoms produced.

causal organisms

1. *Phyllachora longinaviculuta* Parbery (IMINo. 3220777).
2. *P. shiraiana* Sydow. (IMI No. 322079).
3. *P. ischaemi* Sydow. (IMI No. 322807).

P. longinaviculata was recorded on *B. bambos* in plantations at Nilambur, Kollathirumedu, and Palappilly and also in natural stands at Muthanga, Noolpuzha and Marayoor. On D. *strictus* it was recorded from Agaly, Goolikkadavu and Chinnar. *P. shiraiana* was recorded on *B. bambos* in plantations at lrumpupalam and Ezhattumugam; on *D. stricuts* in natural stands at Thudukky and Anavay (Mannarkkad Forest Divn.); on *0. travancorica* and O. *scriptoria* at Vazhachal; on *B. vulgaris* in Nilambur; and on *Thyrsostachys* sp. at Kulathupuzha. *P. ischaemi* was recorded in a plantation of *B. bumbos* at Nilambur.

Discussion

Of the three species of *Phyllachora* causing tar spot on different species of bamboos, *P. longinaviculata* and *P. ischaemi* are new pathogen record on bamboos as well as new record of fungi from India. From Kerala, *P. bambusae* and *P. malabarensis* causing tar spot have earlier been recorded. *P. shiraina* already recorded on bamboos from Maharashtra (Sydow and Butler, 191I), is a new record on *Ochlandra travancorica, 0. scriptoria* and *D. stridus*.

16. PETRAKOMYCES LEAF SPOT

Occurrence

This leaf spot disease was recorded during July-September both in plantations and natural stands. The disease was observed in *B. bambos* plantations at Nilambur, Irumpupalam, Ezhattumugam and Kollathirumedu, and in natural stands at Muthanga, Thirunelly and Noolpuzha; *B. bambos* was also found affected in trial plots at Mallana and Kalady (Malayattoor Forest Divn.). In *D. strictus,* the leaf spots were observed in natural stands at Agaly and Chinnar and also isolated clumps at Thudukky and Kadukuman. The disease was also recorded on *Arundinaria* sp. (Munnar), *Thyrsostachys* sp. (Kulathupuzha), *0. scriptoria* (Periya) and *0. ebracteata* (Kottoor).

Symptoms

The disease manifested as pin-head sized brown water-soaked lesions on the foliage, especially the lower ones on the new culms. These lesions enlarged to form 3-5mm dia oval to elliptical dark violet spots with pale yellow halo. Later, the spots appeared as raised black structures bearing pycnidia of the fungus (Plate 13).

Causal organism

Petrakomyces indicus Subram. & Ramakr. (IMI No. 322075, 322084).

Discussion

Petrakomyces indicus causing leaf spot of *Arundinaria sp., B. bambos, D. strictus, Ochlandra ebracteata, 0. scriptoria* and *Thyrsostachys* is a new pathogen and host record. Earlier, *P. indicus*

has been recorded on *Bambusa* sp. from Tamil Nadu and Karnataka (Subramanian and Ramakrishnan, 1953; Rangaswami *et al.*, 1970).

17. PHOMA LEAF SPOT

Occurrence

In *D. strictus,* Phoma leaf spot was observed in natural stands at Agaly, Thakarapady, Goolikadavu (Mannarkkad Forest Divn.), Chinnar and in plantations at Nadukani. In *B. bambos,* the infection was observed in plantations at Nilambur, Palappilly and Kollathirumedu and also in clumps at Kumily (Kottayam Forest Divn.), and Kannavam (Cannanore Forest Divn.).

Symptoms

Infection occurred as small pin-head sized brown lesions on the adaxial surface of the leaves. Both juvenile and mature leaves were found affected. The spot turned spindle-shaped and later coalesced to form large irregular spot with greyish white centre and dark brown margin. The spot developed during August-September and pycnidia were formed in the necrotic lesions during November-December as erumpent structures. Under high humidity, cream to pink coloured gelatinous spore mass was produced in cirii from the pycnidia. Though, three species of *Phoma* were associated with the infection, no difference in symptoms produced on the host was observed.

Causal organisms

1. Phoma *sorghina* (Sacc.) Boerma, Dorenbosch & Van Kesteran (IMI NO. 331797).
2. *Phoma herbarum* Westend. (IMI NO. 331645).
3. *Phorna* sp. (IMI No.331646).

Discussion

Three species of *Phoma* viz., *P. herbarum, P. sorghina* and a hitherto undescribed *Phoma* sp. were found causing leaf spot on bamboos. So far, no Phoma species has been recorded on bamboos; all the three *Phoma* species recorded in the present study are new pathogen record. The isolates of *Phoma* sp. was found to be near to *P. macrostoma,* but differed in conidial characters (Punithalingam, IMI, pers. communication). Since, it appears to be an undescribed species, it will be validly published elsewhere.

18. PHOMOPSIS LEAF SPOT

Occurrence

In *B. bambos,* spot caused by *Phomopsis* sp. was recorded in plantation at Palappilly, natural stand at Kadukuman and in isolated clumps at Arippa (Trivandrum Forest Divn.). The disease was also recorded in natural stands of *D. strictus* at Anavay and Thudukky; in *Thyrsostachys* sp. the disease was observed at Kulathupuzha.

Symptoms

The infection occurred as minute greyish brown water-soaked lesions on the mature leaves which later spread to form circular to irregular spots with dark brown wavy margin. In *D. strictus,* the spots enlarged to form larger spots 5 to 8mm in dia with dark brown 2 to 3 concentric rings. Pycnidia developed in the necrotic tissues during November-December and the conidia oozed out in yellowish cirii (Plate 13).

Causal organism

Phomopsis sp. (IMI Nos. 331633,331641).

Discussion

The genus, Phomopsis consisting of a large number of species has been reported to cause foliage disease of various forestry tree species in the country (Bakshi *et al.,* 1972; Bakshi, 1976; Sharma *et al.*, 1985; Mohanan and Sharma, 1987a,b; Sankaran *et al.*, 1987, 1988). So far, no *Phomopsis* sp. has been recorded on bamboos. Since, this is the first record of *Phomosis* sp. on bamboos *(B. bambos, D. strictus* and *Thyrsostachys* sp.) and it appears to be an undescribed species, it will be validly published elsewhere.

19. STAGONOSPORA LEAF SPOT

Occurrence

The leaf spot was recorded in natural stands of *B. bambos* at Thirunelly, and Thudukky and in natural stands of *D. strictus* at Agaly and Chinnar. The disease affected mature leaves during the months of December-January.

Symptoms

The infection appeared as dark brown irregular lesions of 3 to 5 mm dia on mature leaves, which later enlarge and became brownish black necrotic spots. The spots usually developed along the leaf margins.

Causal organism

Stagonospora sp. (IMI No. 322076).

Discussion

A large number of *Stagonospora* spp. have been recorded on forestry tree species in India (Sydow and Butler, 1916; Sydow and Mitter, 1933; Thirumalachar, 1950; Singh and Khanna, 1970). So far, no *Stagonospora* has been recorded on bamboos. The present isolate of *Stagonospora* sp. is a new pathogen record on *B. bambos* and *D. strictus.* As the fungus appears to be an undescribed species, it will be validly published elsewhere.

20. SEPTORIA LEAFSPOT

Occurrence

The leaf spot was recorded on mature leaves of *Thyrsostachys* sp. in a trial plot at Kulathupuzha in the months of December-January, during 1987 to 1991.

Symptoms

Infection appeared as greyish brown to dark brown lesions of 2 to 4 mm dia on the upper surface of mature leaves. Pale to dark brown pycnidia developed in the centre of the lesion. Usually, leaf spots caused by *Phomopsis* sp., *Petrakomyces* sp., and *Septoria* sp. were found intermixed on the same leaf.

Causal organism

Septoria sp. (IMI No.322084).

Discussion

Septoria species causing foliage infection on forestry tree species have earlier been recorded from India (Patel *et al.*,1949; Tilak and Viswanathan, 1960). This is the first record of *Septoria* on bamboos. Since, the present fungus appears to be an undescribed species, it will be validly published elsewhere.

21. CHAETOSPERMUM LEAF SPOT

Occurrence

The leaf spot was recorded in plantations of *B. bambos* at Ezhattumugam during 1987-1988, at Kollathirumedu and trial plot at Mallana (Malayattoor Forest Divn.) during 1989. The disease was observed during the months of August-September, usually on the mature leaves of the lower branches of culms.

Symptoms

The disease manifested as numerous minute pale yellow lesions arranged linearly on the upper surface of the mature leaves. Free water on the leaf surface possibly helped in rapid spread of the lesions. Usually, development of a large number such lesions on the leaf imparted yellowish colour to the affected foliage. Yellowish brown minute pycnidia developed in the necrotic areas during October.

Causal organism

Chaetospermum carneum Tassi (IMI No. 331638).

Discussion

So far, four species of *Chaetospermum* have been recorded to cause plant diseases in India (Mukerji and Bhasin, 1986). *C. carneum* causing leaf spot is a new pathogen record on bamboos as well as a new fungus record from India.

22 CURVULARIA LEAF SPOT

Occurrence

The leaf spot was recorded in *Arundinaria* sp. at Munnar and *Thyrsostachys* sp. at Kulathupuzha during 1988 and in reed bamboos viz., *0. travancorica, 0. scriptoria* and *0.* ebracteata at Pachakkanam (Ranni Forest Divn.), Peruvannamuzhy (Calicut Forest Divn.) and Kottoor (Trivandrum Forest Divn.) respectively during the months of June-July in 1989 and 1990. The disease affected only the juvenlie foliage of new culms and the disease was found restricted only to a few clumps in each locality.

Symptoms

The leaf spots appeared as greyish black irregular lesions on the juvenile expanding foliage, especially those in the lower branches of new culms. Later, the lesions enlarged and covered the entire leaf lamina and became necrotic. The causal fungus sporulated profusely on the affected tissues.

Causal organism

Curvularia lunata (Wakker) Boedijn, anamorph of Cochliobolus *lunatus* Nelson & Haasis (IMI Nos. 326949, 326950, 326951).

Discussion

C. lunata, causing leaf spot, is a new pathogen record on bamboos. *C. lunata* is a weak pathogen and has also been recorded as causing foliage infection on many agricultural, horticultural and forestry species in India (Mukerji and Bhasin, 1986; Bilgrami *et al.,* 3991). In the present study. *C. lunata* has also been recorded as causing necrosis o f culm internodes of *T. oliveri,* Earlier, *C. andropogonis* has been recorded as causing foliage infection of *Bambusa* sp. from Kerala (Balakrishnan *et al.,* 1990).

23. ALTERNARIA LEAF TIP BLIGHT

Occurrence

The leaf tip blight was recorded in *B. bambos* plantations at Ezhattumugam, Kollathirumedu and Palappilly during 1990 and 1991. The leaf spot was also recorded in natural stands of *D. strictus* at Goolikadavu and Chinnar during 1989. Usually, the infection was also observed in mature leaves, especially those of the lower branches.

Symptoms

The disease manifested as small yellowish brown irregular lesions usually near the leaf tip, which later spread to form necrotic spots. The infection caused blight of the leaf tip.

Causal organism

Alternaria alternata (Fr.) Keissler (IMI No. 327736).

Discussion

A. alternata is a common leaf spot fungus and has been recorded on a large number of agricultural as well as forestry species in India (Bakshi, 1976; Bilgrami *etal.*, 1991).In *Eucalyptus* spp. it causes leaf tip blight (Sharma *et al.*, 1985); in *Albizia lebbeck* and *Melia azadirach* it causes leaf spots. In the present study, *A. alternata* is also found to be causing leaf tip blight of *B. bambos* and *D. strictus* nursery seedlings.

24.ROSENSCHELDIELLA LEAF SPOT

Occurrence

This leaf spot was recorded in *0. travancorica* in natural stands at Watchumaram and Pachakkanam, and in trial plot at Peruvannamuzhy and also in natural stands at Adirappally (Vazhachal Forest Divn.) during the months of September-October,

Symptoms

The infection appeared as minute yellowish brown linear lesions on the mature leaves during September-October. The lesions enlarged and formed 3 to 5 mm dia necrotic spots with yellow halo. The fungal fructifications developed in linear rows over the nerotic spots on the upper surface of the leaf (Plate 14).

Causal organism

Rosenscheldiella sp. (IMI No. 349072).

Discussion

Rosenscheldiella sp., recorded on leaves of *0. travancorica,* is a new pathogen record on bamboos. Earlier, *R. cinnamomi* Muthappa (Muthappa,1967), *R. eugeniae* Petch (Ananthanarayanan, 1962) and *R. indica* Anahosur (Anahosur, 1970) have been recorded on forestry tree species in India. Since, this isolate appears to be an undescribed species, it will be validly published elsewhere.

25. COCCODIELLA LEAF SPOT

Occurrence

The leaf spot was recorded in natural stands (Watchumaramand Pachakkanam) and in a trial plot (Peruvannamuzhy) of *0. travancorica.* The disease was observed on mature leaves during the months of September-October.

Symptoms

The infedionappeared as yellowish brown minute lesions which enlarged to form dark brown linear necrotic spot. Fructifications of the causal fungus developed in the necrotic spot on the lower surface of the leaf (Plate 14).

Causal organism

Coccodiella sp.(IMI No.349068).

Discussion

So far, only *C. quericifolia* Bose and Mueller has been recorded on leaves of *Quercus glauca* Thumb. from India (Bilgrami *et al.*, 1991). *Coccodiella* sp. is a new pathogen record on bamboos. The present isolate appears to be an undescribed species as all the currently known species of *Coccodiella* from monocots have smaller ascospores (B.C.Sutton,M, IMI pers. communication). The fungus will be validly published elsewhere.

26 CERODOTHIS LEAF SPOT

Occurrence

The leafspot was recorded in *D. strictus* and *B. bambos* natural stands at Attapady, Agaly and Wadakkanchery and in *Thyrsostachys* sp. plantation at Kulathupuzha. The disease occurred on both mature and juvenile leaves during December -January.

Symptoms

The infection manifested as tiny, pale yellow spots on the upper surface of the leaves. No necrotic spots were formed on the leaves as the disease progressed. The ascocarps of the causal fungus became erumpent through the ruptured epidermis. At maturity, the ascocarps appeared as tiny golden yellow streaks on the leaves and are arranged in linear rows. Hyaline to pale yellow microconidia of the fungus were also produced in the microconidial locules which developed close to the margin of the developing ascostroma or produced separately. The microconidia were extruded as pale to golden yellow masses to the leaf surface through a pore formed in the locule. Under conducive microclimatic conditions the entire leaf surface became covered with the spore masses. Severe infection caused, yellowing of the foliage which later dried up.

Causal organism

Cerodothis aurea Muthappa

Discussion

Earlier, *Cerodothis aurea* causing leaf spot has been reported in *B. bambos* stands in Karnataka State (Muthappa, 1969). In *D. strictus* stands, golden yellow fructification and sporemasses of *C. aurea* on the upper surface of the leaves as well as rust pustules of *D. divina* on the lower surface of the same leves were observed. The multiple infection causes premature defoliation.

27. CULM SHEATH SPOT

Occurrence

Culm sheath spot was recorded in *B. bambos* plantations at Irumpupalam, Ezhattumugam, Palappilly, and Kollathirumedu and in *D. strictus* plantation at Nadukani during 1987-1991. Infection was also recorded in *B. vulgaris* in trial plot at KFRI Campus, Peechi, and in

D. brandisii and *B. polymorpha* in a Bambusetum at Nilambur. The spots were observed in culm sheaths of expanding culm internodes during the months of June-July. The infection on the culm sheaths did not spread to the culm nodes or internodes.

Symptoms

The infection appeared as small brown spindle shaped to irregular lesions, usually at the margin and tip of the culm sheath. The lesion spread to form large 5-12 mm dia irregular necrotic spots with dark brown to purple margin. The infection caused browning and necrosis of margin and tip of the sheath. Sheath spot and necrosis were more pronounced in sheaths covering the lower 4 7 culm internodes.

Causal organism

Pestalozziella sp. (IMI No. 331637).

Discussion

The disease affected the culm sheaths protecting the developing culm internodes as well as nodal buds. Since, the culm sheath fall off after the development of the branches from the nodes, and the infection does not spread to the culm, such a spot disease is unlikely to become important. So far, only three species of *Pestalozziella* have been recorded from India, of which *P. artocarpi* Nag Raj & Kendrick caused leaf spot of trees (Nag Raj and Kendrick, 1972). *Pestalozziella* sp., a hitherto undescribed species causing spot disease of culm sheath of bamboos is a new pathogen record.

28. CULM STAINING AND DIE-BACK

Occurrence

The disease was recorded in 7-year-old clumps of *B. vulgaris* and *D. longispathus* in a Bambusetum at Nilambur. Disease occurred only in new culms during the months of July-August. Of the 19 clumps of *B. vulgaris* observed, infection was observed in two clumps during 1990, seven during 1991 which increased to 16 clumps during 1992. In *B. vulgaris* culm infection was 10%, 46% and 98%, respectively during these years. Disease incidence in *D. longispathus* was low and of the 12 clumps in the plot, only two were infected during 1992; about seven percent of the new culms were affected.

Symptoms

Infection was found to be predisposed by injury made by the bamboo hispine beetle, *Estigmena chinensis* Hope on the new culms. The culm borer attacked the juvenile culms and made bore holes of 1 to 2 mm dia usually at each node. The severity of the infestation depended on the insect population and their activities. Usually, bore holes were found made on almost all the nodes of the culm as well as branches. Pale purple to dark brown linear lesions developed around each bore hole which later spread to the entire culm internode and became necrotic. Raised black fructifications of the causal fungus developed on the affected internodes during. September-October. Infection also spread to the branches.

Usually, the discolourationof the culm internodes and later necrosis and die-backstarted from the distal end towards the base of the culm. Infection caused die-backof the branches and culm, which later became completely covered with the black fructifications of the fungus (Plate 15).

Causal organism

Apiospora sp. (IMI No.349066).

Discussion

Earlier, *A. indica* Theiss &Syd. has been recorded on twig and culms of *Bambusa* sp. from Kerala and elsewhere (Berkeley, 1856; Butler and Bisby, 1931). *A. montagnei* Sacc. and *Arthrinum* state of *A.camptospora* Penz. et Sacc. have also been recorded on dead bamboo culms (C. Mohanan, unpublished observation), however, they are notassociated with the die-back Since, the culm staining and die-backof *D. longispathus* and *B. vulgaris* caused by *Apiospora* sp. is predisposed by the infestation of the borer, the build up of the borer population has to be checked in order to avoid the infection by the *Apiospora,* especially in preservation plots and Bambusetum. This disease does not appear to become important as it was recorded only in a Bambusetum at Nilambur.

29. BASAL CULM DECAY

Occurrence

Basal culm decay was observed in *R. bambos* in natural stands at Anamari, Enjar, Thirunelli and in D. *strictus* stands at Chinnar. Basal culm decay was also observed in *D. lonspathus* and *B.* vulgaris clumps in a Bambusetum at Nilambur. Usually, decay was observed in old clumps affected by annual ground fire.

Symptoms

Injury caused at the basal part of the mature culms due to severe ground fire predisposed the infection by the decay fungi. Discolouration and decay occuurred around the fire scar and spread both downward and upward directions; rhizome and root system were also found affected. Sporophoresof the causal fungus developed from the basal part of the affected culms at the soil level. As the decay of the basal part of the culm progressed, yellowing of the leaves followed by complete defoliation of the affected culm. was observed; later shrinking and withering ofthe basal portionof the affected culms occurred.

Causal organisms

1. *Ganoderma lucidum* (Fr.) Karst.
2. *Amylosporus campbelli* (Berk) Ryv.

Discussion

Decay of basal culm, root and rhizome of B. *bambos* and other species of bamboos caused by various decay fungi has been recorded from different bamboo growing areas of the

country(Mitter and Tandon, 1932;Banerjee,1947;Bakshi, 197l).*G. lucidum* is aserious root rotpathogen and has earlierbeen recorded on many forestry species as well as on bamboo causing basal rot and rhizome decay (Sharma *et al.*, 1985; Balakrishnan *et al.*, 1990). Recently,*Amylospora campbelli* (Berk)Ryv.causing root and rhizome decay of *D. strictus* has been recorded fdrom Madhya Pradesh (Tahir *et al.,* 1992). Since, the basal culm decay was observed in fire-prone areas, the disease can be avoided by proper stand management.

3.2. DISEASES OF RATTANS

3.2.1 .Diseases in nurseries

Usually, rattan seeds are either sown directly in polythene containers filled with sawdust-soil mixture or in nursery beds; germination occurs about 10 to 15 days after sowing. After 2 to 3 months of growth in nursery beds, the bareroot seedlings are transplanted to polythene containers. The transplanted seedlings are retained in the containerbedsforabout oneyearbeforeoutplantingin the field.The survey revealed a total of 11diseases occurring both in bareroot as well as containerseedlingswith which 13fungal pathogens were found associated (Table 18).

Table 18. Checklist of nursery diseases of rattans and associated fungi

SI.No.	Disease	Fungi associated	Rattan species affected'
1.	**Damping-off**	***Fusarium oxysporum***	**CH,CP,CR,CT**
2.	**Seedling collar rot**	***F.longipes***	**CH,CT,CP,CT**
		Sclerotium rolfsii	**CP,CT**
		Rhizoctonia solani	**CH,CP,CT**
3.	**Seedling blight**	***Guignardia*** *calami*	**CH,CP.CT,CR,CTRA**
4.	**Seedling wilt**	***Fusarium solani***	**CH,CT**
5.	**Colletotrichum leaf spot**	*Coll.**gloeosporioides***	**CH,CP,CT,CR,CTR,CTRA**
6.	**Bipolaris leaf spot**	*Bipolaris **ellisii***	**CT,CP,CH**
7.	**Corynespora leaf spot**	***Corynespora cassicola***	**CP,CT,CH,CR,CTRA**
8	**Alternaria leaf spot**	***Alternaria alternata***	**CT,CC,CP**
9.	**Pestalotiopsis leaf spot**	***Pesatlotiopsis theae***	**CP**
10.	**Curvularia leaf spot**	***Curvularia lunata***	
11.	**Phomopsis leaf spot**	***Phomopsis sp.***	**CH,CP,CT,CTR**

'CG: *Calamus gamblei,* CH:*C.hookerianus,*CP *: C.pseudotenuis,* CR:*C.rotang* CT:*C.thwaitesii,* CTR:*C. travancoricus,* CTRA:*C. trachycoleus* CV *:C. vattayila*

1. DAMPING-OFF

Occurrence

Damping-off was recorded in *C. thwaitessi, C. travancoricus, C. rotang and C. pseudotenuis* nurseries raised at KFRI campus, Peechi during 1988-'91 and *C. pseudotenuis* nursery at

Peermedu during 1987, where the containers and seedbeds were over-watered. The disease often goes undetected because of misidentification as failure of germination of "poor seeds".

Symptoms

The disease, characterised by rotting of the emerging radicle and plumule, was observed within 3 to 5 days of sowing. Watersoaked necrotic lesions appeared on the emerging plumule at the soil level. The lesions spread and the affected areas became constricted and decayed. The affected plumule collapsed at the soil level. White fungal spore mass usually observed on the decayed plumule. Browning and necrosis were observed on the emerging radicle of the germlings (Plate 16).

Causal organism

Fusarium oxysporum Schlecht

Control measure

In a nursery at Peechi, damping-off was effectively controlled by application of thiram 75 WP as pre-sowing seed treatment (2 g/Kg of seeds). Captan 75WP was also found equally effective in controlling the disease. Application of fungicide (Captan 0.05%a.i.) as post-sowing soil drench also controlled the disease.

Discussion

Fusarium oxysporum is a common damping-off and collar rot pathogen capable of causing lafge-scale mortality of young seedlings under favourable nursery conditions (Sharma *etal.,* 1985).Immersing the rattan fruits in water for a longer period for depulping and separation of seeds, using contaminated sawdust as a sowing medium in the containers and overwatering the seedbed or container are the possible factors for the severe occurrene of the disease. Earlier, infection of tissue cultured rattan seedlings caused by *Fusarium* sp. has been recorded from Malaysia (Maziah, 1986). Damping-off of rattan seedlings caused by *F.oxysporum* is a new disease record.

2. SEEDLING COLLAR ROT

Occurrence

The disease was recorded in 2 to 5-month-old bareroot seedlings of *C. thwaitesii, C. hookerianus* and *C.pseudotenuis,* in a nursery at Peechi during 1988-'89. Disease occurred in small patches of five to ten seedlings in the seedbeds and caused 34 to 40% mortality of C. *pseudotenuis* and *C. hookerianus* seedlings during 1989. The infection was observed during the South-West monsoon i.e., June-July.

symptom

The infection occurred at the basal collar region of the seedling stem, as water-soaked greyish brown lessions which later became necrotic. Infection also spread to the petiole of

the lower leaves. Fungal mycelial strands were Seen spreading from the soil to the stem and petioles. The affected seedling stem at the collar region became constricted, and the tissues decayed. A large number of small white sclerotia of the causal agents (*Sclerotium rolfsii* or *R. solani)* were found produced on the decayed stem and petioles. Diseased seedlings also showed browning and decay of the roots. Severe infection often resulted in collapse of the seedlings.

Casual organisms

Three fungi were found associated with the disease.

1. *Sclerotium rolfsii* Sacc.
2. *Rhizoctonia solani* Kuhn state of *Thanatephorus cucumeris* (Frank) Donk
3. *Fusarium longipes* Wollenw. & Reinking (IMI NO. 322577)

Among these F. *longipes* was found associated with seedling collar rot of *C. hookerianus.* While *S. rolfsii* and *R. solani* were recorded on *C. thwaitesii* and *C. pseudotenuis.*

Control measure

Collar rot of rattan seedlings was controlled by drenching the seedbeds twice with MEMC (0.003% a.i.) or carboxin (0.2% a.i.) at an interval of ten days. Since, the disease is manifested under high soil moisture levels, the watering frequency as well as quantity should be reduced after the appearance of the disease in order to check its further spread.

Discussion

Sclerotium rolfsii and *R. solani,* the two sclerotial pathogens are world wide in distribution and are known to be pathogenic to a large number of crop plants in tropical and subtropical areas (Aycock, 1966; Bakshi, 1976; Sharma *et al.*, 1985). Both the pathogens have earlier been recorded on various forestry species causing seedling infection in Kerala (Sharma *et al.,* 1984b, 1985; Mohanan and Sharma, 1989). This is the first record of *S. rolfsii* causing seedling infection of rattans. Earlier, collar rot of *C. manan* seedlings caused by *F. oxysporum* has been recorded from Malaysia (Norani and Maziah, 1988). Though, *Fusarium* spp. are known to cause seedling infection of various agricultural and forestry species, collar rot of rattan caused by *F. longipes* is a new disease record as well as new pathogen record from India. In forest nurseries, seedling diseases caused by sclerotial pathogens like *R. solani* and S. *rolfsii* are effectively controlled by application of mercury based fungicide (MEMC) or systemic fungicide like carboxin. Carboxin is found equally effective against *F. longipes.*

3. SEEDLING BLIGHT

Occurrence

The disease was recorded in 2 to 6-month-old container as well as bareroot seedlings of *C. thwaitesii, C.trachycoleus, C hookerianus* and *C.rotang* in a nursery at Peechi and in 8-month-old *C. pseudotenuis* container seedlings at Peermedu. Disease incidence was very high (60-70%) in *C. pseudotenuis* container beds and caused 10 to 15% mortality.

The infection was observed during the months of January - February and it persisted till May.

Symptoms

The disease manifested as minute watersoaked lesions on the leaves, usually on the margins and tips of the lower fronds. The lesions later coalesced and spread to form dark brown to shining chocolate brown, spindleshaped lesions with pale yellowish brown margins. Later, the infection spread further, covering the entire leaf, the petiole and the seedling stem, which resulted in necrosis of the affected tissues and later seedling blight. Fructifications of the causal fungus were produced in concentric rings on the necrotic lesionsunder high humid conditions (Plate 16).

Causal organism

Guignardia calami (H. Sydow &Sydow)von Arx &E. Muller (M Nos. 319290,319291, 320692).

Control measure

In rattan nursery at Peechi, seedling blight was controlled by two application of carbendazim (0.02%a.i.) as foliar drench at ten days interval.

Discussion

Guignardia spp. haveearlierbeenrecorded on forestry seedlings as causal agents of foliar infections (Mohananand Sharma, 1989). *G.calami* causing seedling blight of rattans is a new diseaserecord from India.For ensuringhealthyseedlingstock,application of carbendazim (0.02% a.i.) as a prophylactic measure has to be carried out at proper time.

4. SEEDLING WILT

Occurrence

The disease was recorded in 6-month-old *C. thwaitesii* and *C. hookerianus* container seedlings in a nurserry at Peechi. Usually, the disease was observed in over-watered containers. Disease incidence was found very low in both the rattan species.

Symptoms

The initial symptom of thediseasemanifestedas yellowing and drooping of the foliage. Theaffected seedlingsshowed pronounced discolouration ofroots. Thediseased seedlings showed general symptoms of physiological wilting,

Causal organism

Fusarium solani (Mart.) Sacc. (IMI NO. 327741).

Discussion

Seedling wilt caused by *Fusarium solani* has earlierbeen recorded in various agricultural

as well as forestry species. *F. solani* is a soil-borne pathogen capable of causing root infection and thereby seedling wilt, especially in seedlings under physiological stress. Pathogenicity trial also proves that injury caused to the root system during the transplanting process may be the predisposing factor for the infection by *Fusarium* sp. Since, the disease incidence is very low and the disease only affects the seedlings in over-watered containers, it can be managed by proper nursery practices.

5. COLLETOTRICHUM LEAF SPOT

Occurrence

The disease is widespread in rattan nurseries and has been recorded in 3 to 10-month-old *C. thwaitesii, C. hookerianus, C. pseudotenuis, C. travancoricus, C. rotung* and *C. trachycoleus* seedlings. Infection was recorded throughout the year; disease severity depended largely on the microclimatic conditions prevailing in the nursery as well as the rattan species raised. Among the six rattan species, *C. thwaitesii* and *C. hookerianus* were found severely affected.

Symptom

The infection manifested as water-soaked, small pin-head to spindle shaped greyish brown lesions, which under conducive nursery environment coalesced and spread to form large angular to irregular necrotic areas. Small lesions near the leaf tip coalesced and caused necrosis of the leaf tips (Plate 16).

Causal organism

Colletotrichum gloeosporioides (Penz.) Penz. & Sacc. state of *Glomeralla cingulata* Stonem.

Discussion

In forest nurseries, foliage infection caused by *C. gloeosporioides* is very common and almost all the species grown in the State are affected by this pathogen. Since, the infection is found to be insignificant any control measures for the disease are not necessary. Earlier, *C. gloeosporioides* causing seedling infection of *C. trachycoleus* has been recorded from Malaysia (Norani *et al.*, 1985; Norani and Maziah, 1988). *C. gloesporioides* is a new pathogen record on rattans from India.

6. BIPOLARIS LEAF SPOT

Occurrence

Bipolaris leaf spot was recorded in 3 to 8-month-old *C. thwaitesii, C. pseudotenuis* and *C. hookerianus* bareroot and container seedlings in nurseries at Peechi and Palappilly. The disease appeared during the months of March - April and persisted till June.

Symptoms

The disease manifested as water-soaked greyish brown spindle shaped to irregular lesions which later spread and coalesced to form dark brown to greyish black large necrotic areas with dark brown margin.

Causal organism

Bipolaris ellisii (Danquah) Alcorn, anamorph of *Cochliobolus ellisii* Alcorn (IMI NO. 326948).

Discussion

Bipolaris spp. have earlier been recorded as causing seedling foliage infection in agricultural crops. In forestry seedlings, *Bipolaris* spp. have been recently recorded from Punjab and southern India (Mohanan and Sharma, 1988,1989; Chauhan and Pandey, 1992). *Bipolaris* spp. causing foliage infection is also recorded in bamboos. *B. ellisii* causing seedling foliage infection on rattan is a new disease record as well as new pathogen record from India.

7. CORYNESPORA LEAF SPOT

Occurrence

The leaf spot was recorded in 4 to 7-month-old *C. thwatesii, C. pseudotenuis, C. hookerianus, C. rotang* and *C. trachycoleus.* Inection occurred during the month of August and persisted till December. Among the four species of rattans, *C. hookerianus* and *C. pseudotenuis* were found severely affected by the disease.

Symptoms

Disease appeared as pale greyish brown water-soaked spindle shaped lesions on the abaxial side of the leaf. Lesions coalesced and formed large necrotic angular to irregular patches which often covered the entire leaf lamina. Heavy sporulation of the causa1 fungus obsered on the adaxial surface of the necrotic lesions as greyish black spore mass. Severe infection caused foliage blight.

Causal organism

Corynespora cassicola (Berk & M.A.Curtis) Wei (IMI NO. 327744).

Discussion

Corynespora cassicola is a common leaf infecting fungus in forest nurseries and plantations (Bakshi *et al.*, 1972; Bakshi, 1976; Sharma *et al.*,1985;). *C. cassicola* is a new record on rattans.

8,ALTERNARIA LEAF SPOT

Occurrence

Alternaria leaf spot was recorded in 3 to 8-month-old container seedlings of *C. thwaitesii,*

C. gamblei and *C. pseudotenuis* in a nursery at KFRI campus during 1989-'90. Disease incidence was low in all the three species. The disease occurred during the months of September-October and persisted till April-May,

Symptoms

The disease appeared as yellowish brown to pale brown angular lesions usually at the tip of the leaves. The individua1 lesions spread and coalesced to form yellowish brown large necrotic areas at the leaf tip.

Causal organism

Alternaria alternata (Fr.) Keissler (IMI NO. 327736).

Discussion

A. alternaria causing seedling leaf infecation has earlier been recorded in various forestry crops in Kerala (Sharma *et al.*, 1985). *A. alternaria* causing leaf spot is a new record on rattans.

9. PESTALOTIOPSIS LEAF SPOT

Occurrence

Leaf spot was recorded only in *C. pseudotenuis* seedlings in a nursery at Peermedu during 1987. The leaf spot was found intermixed with Colletotrichum leaf spots.

Symptom

The infecion manifested as pale brown angular lesions on the abaxial surface of the mature leaves. The lesions spread and coalesced to form irregular dark brown necrotic areas. The causal fungus sporulated on the adaxial surface of the necrotic lesions.

Causal organism

Pestalotiopsis theae (Saw.) Steyaert,

P. theae is a weak foliar pathogen and has earlier been recorded in many forestry crops grown in kerala (Sharma *et al.*, 1985). Earlier, *Pestalotiopsis* sp. has been recorded on rattan from Malaysia as causing leaf spot (Norani and Maziah, 1988). *P. theae* is a new record on rattan.

10. CURVULARIA LEAF SPOT

Occurrence

Curvularia leaf spot was recorded in 12-month-old *C. pseudotenuis* and *C. thwaitesii* container seedlings in a nursery at KFRI campus, Peechi.

Symptoms

Infection manifested as small pin-head sized greyish brown, water-soaked lesions on

the abaxial surface of the leaves. Under high humidity and presence of free water on the surface of the foliage, the lesions spread and coalesced to form larger greyish black necrotic lesions, usually at the leaf margins and leaf tip.

Casual organism

Curvularia lunata (Wakker) Boedijn,

Discussion

C. lunata is a common weak pathogen which usually cause infection of tender tissues. Earlier, a *Curvularia* sp. has been recorded on rattan as causing leaf spot (Norani and Maziah, 1988). Leaf spot of rattans caused by *C. lunata* is a new disease record.

11. PHOMOPSIS LEAF SPOT

Occurrence

Phomopsis leaf spot was recorded in 10 to 16-month-old *C. hookerianus*, *C. pseudotenuis*, *C. thwaitesii* and *C. travancoricus* container seedlings in a nursery at KFRI campus. The foliage infection was rcorded during the months of July-August.

Symptoms

Infection appeared as greyish brown water soaked, spindle shaped small lesions on the abaxial surface of the mature leaves. Later, the lesion spread and coalesced to form large oval to irregular dark brown necrotic lesions with a pale yellow halo. The centre of the lesion becomes greyish black and fructifications of the causal fungus developed as raised black structures on the abaxial surface of the lesion. Under high humidity the spore mass of the fungus extruded as pale yellow cirrii.

Causal organism

Phomopsis sp. (IMI No. 331634).

Discussion

Phomopsis spp. have been recorded as causing foliage infection in almost all the forestry crops grown in Kerala (Sharma *et al.*, 1985; Mohanan and Sharma, 1989; Sankaran *et al.*, 1986). Earlier, a *Phomopsis* sp. has been recorded from Malaysia on *C. manan* and *C. trachycoleus* as causing leaf spot (Norani and Maziah, 1988). The present isolate, a hitherto undescribed species of *Phomopsis* causing leaf spot is a new disease record on rattan from India.

3.2.2. Diseases in plantations and natural stands

In Kerala, small-scale trial planting of commercially exploted rattans has been taken up recently. One to two year-old container seedlings or wildings collected from the natural forest are used. Planting is done (usually underplanting) in pits taken at an espacement of

10 x 10 m after the onset of South-West monsoon. Disease survey conducted in rattan plantaions/trial plots and natural stands recorded a total of 12 diseases affecting various rattan species (Table 19).

Table 19: Checklist of diseases of rattans in natural forests and trial plantations and fungi associated

Sl.No.	Disease	Fungi associated	Rattan species affected
1.	**Colletotrichum leaf spot**	***Colletotrichum gloeosporioides***	CG,CH,CP,CT,CTR,CV
		C.crassipes	CD,CP,CV
2	**Bipolaris leaf spot**	***Bipolaris ellisii***	GG,CH,CTR
3.	**Corynespora leaf spot**	***Corynespora cassicola***	CP,CT
		Corynespora sp.	CP
4.	**Fusarium leaf blight**	***Fusarium pallidoroseum***	CT
5.	**Guignardia leaf spot**	***Guignardia calami***	CG,CH,CP,CT,CR
6.	**Pestalotiopsis leaf spot**	***Pestalotiupsis theae***	CG,CH,CP,CTR,CV
7.	**Phomopsis leaf spot**	***Phomopsis* sp.**	CC,CH,CT,CTR
8.	**Tar spot**	***Phyllachora calamigena***	CH,CT
9.	**Sphaerodothis leaf blight**	***Sphaerodothis* sp.**	CD,CG,CH,CP,CT,CR
10.	**Fusarium fruit rot**	***Fusarium moniliforme***	CH,CP
11.	**Thread blight**	***Pellicularia filamentosa***	CH,CTR,CP
12.	**Stem rot**	***Botryodiplodia theobromae***	CG,CT,CH

• CD: *Calamus drensefieldii,* CG : *Calamus gamblei,* CH : *C. hookerianus,* CP : *C.pseudotenuis,* CR : C .*rotang* CT : *C. thwaitesii,* CTR : *C.travancoricus,* CTRA : *C.trachycoleus* CV : *C.vattayila*

1. COLLETOTRICHUM FOLLAGE INFECTION

Occurrence

Disease is widespread in rattan growing areas in the State and was recorded in *C. drensefieldii, C.gamblei, C.* hookerianus, *C. thwaitesii, C. travancoricus* and *C. vattayila* in all the plots in natural stands surveyed and in a *C. pseudotenuis* plantation at Peermedu during 1987-'91. Disease severity was found low in all the plots. Among the rattan species surveyed, *C. thwaitesii* was found severly affected by the disease during South-West monsoon.

Symptoms

Infection occurred as small greyish brown angular to irregular lesions, usually on the newly expanded fronds. Infection was also observed on the unopened spear, and the lesions spread very rapidly after the expansion of the fronds. Severe infection was recorded during the South-West monsoon (June-July) often leading to rotting of young fronds. C. *thwaitesii* appeared to be more susceptible to foliar infection than other rattan species. Some rattan species showed distinct foliar symptoms. For example, leaf necrosis and withering

of the leaves were recorded in *C. travancoricus* while in *C. vattayila,* infection caused circular to irregular large necrotic areas.

causal organisms

Two species of *Colletotrichum* were found associated with the disease.

1. *Colletotrichum* state of *Glomerellacingulata* (Stonem.)Spauld.&Shrenk.(IMINo.331798).
2. *Colletotrichum crassipes* (Speg.) Arx.

Discussion

C. gloeosporioides is a common foliar pathogen in forestry species in Kerala and has been recorded as causing diseases lie shot hole, leaf spot, leaf blight, anthracnose, etc. in *Ailanthes triphysa, Tectona grandis, Eucalyptus* spp., *Gmelina arborea, Acacia* spp., etc. (Sharma *et al.,* 1985; Mohanan and Sharma, 1988; Sankaran *et al.,* 1989). Foliage infection caused by *C. gloeosporioides* has been recorded on various rattan species from Malaysia (Norani *et al.,* 1985; Norani and Maziah, 1988). *C. crassipes,* a weak pathogen has earlier been recorded as causing foliage infection in *Leucaena leucocephala* (Mohanan, 1988). Foliage infection on rattans caused by both the *Colletotrichum* species is a new disease record from India, and *C. crassipes* is a new pathogen record on rattan.

2. BIPOLARIS LEAF SPOT

Occurrence

Bipolaris leaf spot was observed in *C, gamblei, C. hookerianus* and *C. travancoricus* in natural stands at Nelliampathy, Chalakkayam, Ambumala, Kottiyoor and Chully. Disease seventy was found low in all these localities.

Symptoms

Infection appeared as pale brown spindle-shaped, water soaked lesions on young leaves which later spread and coalesced to form large oval to irregular, dark brown necrotic lesions with greyish brown margin. Heavy sporulation of the causal fungus was observed on the adaxial surface of the necrotic lesions during April-May.

Causal organism

Bipolaris ellisii (Danquah) AIcorn anamorph of *Cochliobolus ellisii* Alcorn (IMINo.326947).

Discussion

Bipolaris spp. are commonly recorded as associated with foliage infections of gramineaceous agricultural crops. Recently, *B. maydis, B. spicifera, B. urochloae* have been recorded on forestry crops in Kerala (Mohanan and Sharma, 1988). *Bipolaris* spp. are also found associated with foliage diseases of bamboos in the present study. *B. ellisii* is also recorded as causing seedling foliage infection of rattans. The fungus is a new pathogen record from India.

3. CORYNESPORA LEAF SPOT

Occurrence

Corynespora leaf spot was recorded in a plantation of *C. pseudotenuis* at Peermedu and plots of *C. thwaitesii* in natural stands at Peruvannamuzhy during 1987-1991. The leaf spot disease occurred during the months of April-May.

Symptoms

Infection appeared as pale brown small angular to irregular lesions on the young leaves. Later, individual lesions spread and coalesced to form large irregular dark brown necrotic lesions often covering the entire leaf lamina. The causal fungus sporulated heavly on the adaxial surface of the necrotic lesions which appeared as greyish black mass.

causal organisms

1. *Corynespora cassicola* (Berk & M.A. Curtis) Wei (IMI NO. 327744).
2. *Corynespora* sp. (IMI NO. 326952).

Discussion

C. cassicola has been recorded on many forestry species as causing foliage infection (Bakshi *et al.*,1972; Sharma *et al.*,1985). C.assicola is also found associated with the seedling foliage infection of rattans in the present study. This hitherto undescribed species of *Corynespora* and C. *cassicola* are new pathogen record on rattans.

4. FUSARIUM LEAF BLIGHT

Occurrence

Disease is widespread in rattan growing areas in the State and was recorded in all the rattan species surveyed. Infecation usually occurred in dry period during February - May.

Symptoms

Infection appeared as pale yellowish brown small lesions usually at the leaf margins and tips. The lesions coalesced and spread to form large yellowish brown to dark brown necrotic areas. Infection spread from leaf tip towards the leaf base as well as from the leaf margin towards the midrib. Severe infection lead to leaf blight and leaf withering. *C. thwaitesii* and *C. hookerianus* were found to be the severely affected rattans.

Causal organism

Fusarium pallidoroseum (Cooke) Sacc. (IMI NO. 322579).

Discussion

F. pallidoroseum is a common foliage pathogen and has been recorded as causing leaf blight of *Acacia* spp. and bamboos in Kerala (Mohananand Sharma, 1989; Mohanan, 1992). *F. pallidoroseum* is a new pathogen record on rattan.

5.GUIGNARDIA LEAF SPOT

Occurrence

The disease, widespread in rattans was recorded in almost all the rattan species surveyed. The leaf spot was recorded during the months of June-August. The disease severity was found low in all the plots surveyed.

Symptoms

Disease manifestedassmallpin-head sized,water-soaked greyish brown lesions on the abaxial surfaceof both young and mature leaves. Under high humidity, the lesions spread and coalesced to form circular to irregular, large greyish brown necrotic areas with a dark brown margin. Often two to three pale greyish brown concentric rings observed in the lesions.

Causal organiism

Guignardia calami (H. Sydow.& Sydow) von Arx. &E. Muller (IMI No. 319292).

Discussion

G.calami causing foliage infection is also recorded in rattan nursery both in bareroot as well as container seedlings. *G.calami* is a new pathogen record on rattans from India.

6. PESTALOTIOPSIS LEAF SPOT

Occurrence

Pestalotiopsis leaf spot was recorded in *C. gamblei, C. hookerianus, C. travancoricus, C. vattayila* and *C. pseudotenuis* from natural stands and plantations. Infection was recorded during the south west monsoon, June-August.

Symptoms

Infection initially appeared as greyish brown irregular lesions on both young and mature 1eaves.Under high humidityand with the free water on thehostsurface, thelesions coalesced and spread fast to form large greyish black irregular necrotic areas.

Causal organism

Pestalotiopsis theae (Sawada) Stey.

Discussion

Pestalotiopsis theae is a weak facultative pathogen which has earlier been recorded in forestry as well as agricultural crops (Bakshi *et al.*,1972; Bakshi, 1976; Sharma *et al.*, 1985). *P. theae* causing leaf spot in rattan is a new pathogen record.

7.PHOMOPSIS LEAF SPOT

Occurrence

The disease was recorded in *C. hookerianus , C. thwaitesii and C. travancoricus* in natural stands and trial plots and in *C.caecius* clumps at Sylvan, Kalady. Infection appeared during the months of May-July.

Symptoms

The disease manifested as small, pin-head sized, greyish brown, water-soaked lesions, which later spread and coalesced to form oval to circular necrotic lesions with dark greyish brown irregular margin. Usually, two to three such large necrotic patches were observed in one leaf. Severe infection was recorded in *C. caecius* clumps at Silvan, Kalady, which caused leaf blight and withering.

Causal organism

Phomopsis sp. (IMI No. 331633).

The isolate is very similar in cultural and morphological characters to P. *palmicola* (Winter) Sacc.

Discussion

In Kerala, most of the forestry species are found affected by species of *Phomopsis* and several new species have been errected on the basis of the host plant affected (Sharma *et al.,* 1985; Sankaran *et al.,* 1987; Mohanan, 1991). In the present study another *Phomopsis* spp.(IMI Nos. 331634,331634) differring in cultural and morphological characters are recorded as causing seedling foliage infection and leaf spot of rattans respectively. *Phomopsis* spp. recorded on rattans are new pathogen record from India.

8. TAR SPOT

Occurrence

Tar spot on foliage was recorded in *C. hookerianus* and *C. thwaitesii* in natural stands and trial plots surveyed during 1987-'91. Disease was recorded during the dry period, April-May.

Symptoms

Infection appeared as small pale to dark yellowish brown spindle-shaped lesions on the abaxial surface of the mature leaf. Later, the lesions spread and developed into large oval to spindle shaped spot with dark brown centre and pale yellow margin. Ascocarps developed as dark brown to black raised structures in the necrotic spot (Plate 17).

Causal organism

Phyllachora calamigena (Berk.& Broome) Sacc. (IMI No.322085).

Discussion

Tar spot on foliage caused by various species of *Phyllachora* has earlier been recorded on various forestry crops including bamboos in the present study from Kerala. *P. calamigena* causing tar spot is a new disease record on rattan as well as new pathogen record from india.

9. SPHAERODOTHIS LEAF BLIGHT

Occurrene

The disease, widespread in rattans both in plantations and natural stands, was recorded in all the plots surveyed during 1987-'91. The infection in rattan foliage persisted year-round and became Severe during the months of April-May. Though, all the rattan species were found affected by the disease, *C. thwaitesii* and *C. pseudotenuis* were the severely affected ones.

Symptoms

The disease manifested as small spindle shaped, pale yellow lesions on the leaves, and spread very fast by coalescence of the lesions; later the lesions became pale to dark brown with a yellow halo. Occasionally, infection also spread to the leaf rachii and then to the stem. Dark brown to black coloured fungal fructifications, arranged in linear rows, developed on the necrotic areas of the lesions on the adaxial surface of the leaves; often the fructifications also developed on leaf rachis and stem. Occasionally, fungal fructifications produced in linear rows spread to the entire adaxial surface of leaves. Though, infection was recorded in most of the rattan species in natural stands and plantations, C. *thwaitesii* and *C. pseudotenuis* were the severely affected ones. Severe infection of leaves resulted in foliage blight (Plate 17).

Causal organism

Sphaerodothis sp. (IMI Nos. 322088, 322089).

Discussion

Among the various foliage diseases recorded in rattans, Sphaerodothis leaf blight is the most widespread in occurrence and it affects all the rattan species in Kerala. So far, only three *Sphaerodothis* species have been recorded from India (Bilgrami *et al.,* 1991). Earlier, *S. coimbatorica* Ramkr. has been recorded on C. *rotang* from Tamil Nadu (Ramakrishnan, 1951). The present isolate of *Sphaerodothis* sp. differs from the earlier recorded *S. coimbatorica* in morphological characters, especially shape and size of ascospores. This hitherto undescribed species of *Sphaerodothis* is a new pathogen record .on rattans.

10. FUSARIUM FRUIT ROT

Occurrence

Fruit rot was recorded in *C. hookerianus* and *C. pseudotenuis* plots at Nelliampathy and Peermedu, respectively during the years 1990 and 1991. Disease affected the developing fruits during the months of December-January.

Symptoms

Infection manifested as water-soaked greyish brown lesions on the developing fruits in the bunch; the lesion spread to the entire fruit and also to the pedicel and neighbouring fruits in the bunch Cool nights alternating with hot days increased the disease severity and the infection often spread to all the fruits in a bunch. The affected fruits became shrivelled and the causal fungus were sporulates heavily on the necrotic tissues.

Causal organism

Fusarium moniliforme Sheldon

Discussion

F. moniliforme has earlier been recorded as causing infection on tender shoots, fruits and seeds of agricultural and forestry crops (Bilgrami *et al.*, 1991). *F. moniliforme* causing fruit rot of rattan is a new disease record. As the rot of developing fruits adversely affects the seed production, especially in a rattan seed orchard, control measures have to be adopted if the disease attains severe status. Application of Mancozeb (0.2% a.i.) has been suggested for controlling the infection.

11. THREAD BLIGHT

Occurrence

Thread blight occurred in clumps of *C. hookerianus* and *C. travancoricus* in natural stands and in *C. pseudotenuis* in a plantation at Peermedu. Infection was recorded during the months of August - October.

Symptoms

Infection was observed as growth of white mycelial strands over the basal part of the stem which arose from the debris on the forest floor. Fan-shaped mycelial strands of the fungus spread further to the upper part of the stem, rachis and leaves. Infection caused necrosis of the affected tissues followed by withering of the leaves, and white spongy rot of the stem and rachis (Plate 17).. The infection spreads very fast under high humidity and often the whole clump became affected. Severe infection caused rot and withering of the whole clump.

Causal organism

Pellicularia filamentosa (Pat.) Rogers

Discussion

Thread blight caused by *P. filamentosa* is a common disease in natural forests and also recorded on many forestry species raised in plantations very close to the natural forests. High humidity and free water on the host surface facilitate the rapid spread of the fungus over the host. *P. filamentosa* causing thread blight is a new disease record on rattan.

12 STEM NECROSIS AND ROT

Occurrence

The disease was recorded in *C.gamblei, C.thwaitesii* and *C.hookerianus* clumps in natural stands at Nilambur, Peruvannamuzhy, Achenkoil and Kottiyoor, where annual ground fires occurred. The infection was found to be predisposed by the fire injury on the stem.

Symptoms

Infection appeared as dark brown to black discolouration on the stem around the fire injury. Infection also spread to the core of the stem and caused severe staining. The causal fungus produced black fructifications and spore mass on the outer cortical tissues just beneath the outer rind of the affected stem. Usually, infection of fire-injured immature rattans caused severe staining and rot.

Causal organism

Botryodiplodia theobromae Pat. (IMI NO. 331794).

Discussion

B.theobromae has been recorded as the principal staining fungus in post-harvest rattans causing considerable loss of raw material (Mohanan, 1991,1992). Fire injury is known to predispose infection by a weak parasite like *B.theobromae* which causes staining and blemishes on the affected canes. Since, the fungus enters the host tissues through fire injury, to avoid the fungal staining and necrosis of the rattan canes, rattan stands have to be protected from fire hazards.

GENERAL DISCUSSION AND CONCLUSIONS

Periodical or continuous forest disease survey is to assess general disease situations, to detect or even predict disease outbreaks, to understand the actual potential threat of disease, appraise and diagnose the cause and a view to suggest control measures. Above all, disease survey forms the factual basis for assigning priorities for intensive research on specific disease problem. Recently, Sharma *et al.* (1985) carried out a systematic disease survey in forest stands in Kerala, covering a large number of industrially important forest plantation species, excluding bamboos and rattans. The present survey, carried out during 1987 to 1992, has generated a wealth of qualitative as well as quantitative data on diseases of bamboos and rattans in nurseries, plantations and natural stands. This survey has also led to identify economically important diseases which require detailed investigation.

The disease survey carried out in representative bamboo plantations, natural stands, nurseries, bamboo trial plots, Bambusetum, etc., facilitated a comprehensive coverage of bamboo species grown in Kerala, and also to record a large number of diseases of bamboos of both major or minor significance. The survey records a total of 42 pathogenic diseases including one of unknown etiology, possibly a virus, affecting different species of bamboos in nurseries, plantations and natural stands. Altogether 40 fungi and one mycoplasma-like organism (MLO) are found associated with these diseases (Table 20). Of these 30 fungal pathogens, including ten hitherto undescribed species and one MLO, are recorded for the first time on bamboos; 17 fungi including ten hitherto undescribed fungal species are recorded for the first time from India. Of these eight fungal pathogens are common to nursery, plantation and natural stand, whereas 22 fungi are common both in plantations and natural stands. Six fungal pathogens and one of unknown etiology (possibly a virus) restricted their occurrence in nurseries, whereas one fungus causing witches' broom and MLO causing little leaf recorded exclusively in natural stands. Since, the survey was exhaustive and intensive, it facilitated to assess the overall impact of diseases on bamboo production, besides it helped to expand the host list of pathogen(s) earlier recorded on bamboos. Majority of the pathogens recorded on bamboos are already established on a number of forestry as well as agricultural crops in the State. However, the pathogens like *Bipolaris urochloae, Exserohilum holmii, Rhizostilbella hibisci, Dactylaria sp., Balansia linearis,* etc. are new ones.

Table 20: List of pathogens recorded on different species of bamboos during the survey in Kerala and their status

Sl. No.	Pathogen	Nursery	Planta-tion	Natural stand	New pathogen record for bamboos	First record from India	New species
1.	*Alternaria alternata*	+	+	+	+		
2.	*Apiospora* sp.		+				
3.	*Ascochyta* sp.	+	+	+	+	+	+
4.	*Amylosporus campbelli*		+	+			
5.	*Balansia linearis*			+	+	+	
6.	*Bipolaris* sp.	+	+	+	+	+	+
7.	*B. maydis*	+	+	+	+		
8.	*B. urochloae.*	+			+	+	
9.	*Botryobasidium salmonicolor*		+	+	+		
10.	*Chaetospermum carneum*	+	+	+	+		
11.	*Coccodiella* sp.	+	+	+	+	+	+
12.	*Colletotrichum gloeosporioides*	+	+	+			
13.	*Curvularia lunata*	+	+	+			
14.	*C. pallescens*	+	+				
15.	*Dactylaria* sp.	+	+	+	+	+	+
16.	*Dasturella divina*	+	+	+			
17.	*Exserohilum holmii*	+	+	+	+	+	
18.	*E. rostratum*	+	+	+	+		
19.	*Fusarium equiseti*	+	+				
20.	*F. moniliforme*		+	+			
21.	*F. moniliforme* var.*intermedium*	+	+	+			
22.	*F. oxysporum*	+	+				
23.	*F. pallidoroseum*	+	+				
24.	*Ganoderma lucidum*		+	+			
26.	*Pestalozziella* sp.		+	+	+	+	+
27.	*Petrakomyces indicus*		+	+			
28.	*Phoma* sp.		+	+	+	+	+
29.	*P. herbarum*	+	+	+			
30.	*P. sorghina*		+	+	+		
31.	*Phomopsis* sp.		+	+	+	+	+
32.	*Phyllachora ischaemi*		+	+	+	+	
33.	*P. longinaviculata*		+	+	+	+	
34.	*P. shiraiana*		+	+			
35.	*Pythium middletonii*		+		+		
36.	*Rhizoctonia solani*	+			+		
37.	*Rhizostilbella hibisci*	+			+	+	
38.	*Rosenscheldiella* sp.		+	+	+	+	+
39.	*Septoria* sp.		+	+	+	+	+
40.	*Stagonospora* sp.		+	+	+	+	+
41.	MLO			+	+		
42.	Unknown etiology	+					
	Total	*15*	*32*	*32*	*31*	*17*	*10*

Diseases in bamboo nurseries

Disease survey in 27 bamboo nurseries situated in 18 localities during 1987-'92 revealed a total of 13 seedling diseases affecting 12 species of bamboos. The disease incidence and severity vary among localities depending on the microclimatic conditions, age of seedlings and the nursery practices. Seedlings of *B. bambos*, raised on a large-scale throughout the State, are found affected by most of the diseases recorded. *Rhizoctonia solani*, a facultative pathogen, has come to the forefront as the most destructive major nursery pathogen of bamboos causing four nursery diseases viz., damping-off, seedling spear rot, seedling wilt and web blight. Among these, web blight is the most widespread and economically important disease capable of causing high mortality under conducive microclimatic conditions.

Among the foliar diseases, leaf rust caused by *Dasturella divina* is a potential disease recorded in bamboo nurseries. It causes considerable loss of nursery stocks due to severe infection as observed at Chandhanathodu during 1991-'92. Though, *D. divina* was recorded on bamboos in India long time back there is not much information available on this pathogen. Considering the serious nature of the disease in Kerala, epidemiology of the leaf rust and control measures are needed. *Bipolaris rmaydis, B. urochloae, Bipolaris sp., Exserohilum rostratum* and *E. holmii*, which cause leaf blight and leaf spot diseases of minor significances are also new pathogen records. Other new disease records include an undescribed species of *Dactylaria* causing leaf infection, and leaf striping and stunting of bamboo seedlings caused by an unknown etiology, possibly a virus. The symptoms, occurrence and spread of the latter indicate that it is possibly transmitted through seeds. Since, information on seed transmitted diseases of tropical forestry species is lacking, the leaf striping and stunting disease of bamboo seedlings offers detailed investigations.

The survey has clearly demonstrated that there is a heavy pressure of different types of diseases on bamboo seedlings in Kerala which affect them to varying degrees depending upon the various factors including microclimatic conditions in the nursery, seedling age, etc. Nurseries located in the high rainfall areas of the State (Wynad Forest Divn.) recorded high disease severity as well as maximum number of diseases; intensive observations at periodic intervals possibly helped to record numerous diseases. In general, high incidence and spread of diseases in certain bamboo nurseries, which resulted in heavy mortality of seedlings, appears to be mainly due to the improper nursery practices followed. As pre-treatment of seeds can minimize the incidence of damping- off, this has to be done prior to sowing. Many of the nursery diseases can be checked by adopting proper nursery management practices, and prophylactic chemical control measures depending on the local climatic and edaphic conditions. The control measures to be adopted in a particular nursery have to be specific for a particular disease.

Diseases in bamboo plantations and natural stands

A total of 29 pathogenic diseases caused by 35 different fungi, belonging to 27 genera and one mycoplasma-like organism (MLO), are recorded from bamboo plantations and natural stands. Most of these diseases are common in plantations and natural stands; witches' broom and little leaf diseases occur exclusively in natural stands while rhizome

rot occurs only in young plantations. The diseases affect all the parts viz., rhizome, root, culm, sheath, branch and foliage, but their incidence, severity and spread vary in plantations and natural stands depending on the bamboo species, the microclimatic conditions prevailing in the locality and cultural and management practices followed; in natural, stands, where bamboo clumps are left unmanaged, the disease incidence is high possibly because of the incidence of annual ground fire and activities of wild animals.

In bamboo plantations and natural stands, rot of emerging and growing culms caused by *Fusarium moniliforme* var. *intermedium* and *F. equiseti,* respectively are the most widespread and economically important diseases affecting the stand productivity considerably. The former disease is soi1-bone affecting the emerging culms of 15 to 30cm in height, while the latter is an air-borne disease, probably predisposed by the injuries made by the sap sucking insect, *Purohitha cervina* on the growing and expanding culms. Though, emerging culms of seven species of bamboos are affected by the disease, *B. bambos,* the widely occurring species in the State, is the one severely affected. These culm diseases recorded in the present study are different in etiology and symptomatology from the bamboo blight, the most dreaded disease of bamboos earlier recorded from Bangladesh and recently from coastal belts of Orissa in lndia. Rot of emerging and growing culms have to be treated as potential diseases of bamboos, as they affect the stand productivity as well as pose threat to the establishment of young bamboo plantations.

Rhizome rot, though recorded only in a few plantations may pose problem in young plantations during the establishing phase. As the study indicates, the mechanical injuries during and after the planting, predispose the fungal infection, the planting stocks have to be handled properly in order to minimize the disease hazards. Witches' broom and little leaf diseases which occur exclusively in natural stands are new disease records as well as pathogen records on bamboos. Though, witches' broom caused by *Balansia linearis* is widespread in reed bamboo growing areas, the overall disease incidence and severity at present are low; since, the disease appears to be systemic and the inoculum is produced in large quantities in the affected areas, possibility of its further spread attaining economic dimensions can not be ruled out. Little leaf of *D. stricuts* occurring in the dry tracts of the State is found to be caused by MLO. It also affects the stand productivity considerably. The present study shows that more than 90% of the clumps of *D. strictus* in the plots at Mannarkkad Forest Division succumbed to little leaf infection with a medium severity. Since, the disease incidence of little leaf is very high further detailed investigations on its nature of spread, epidemiology and control measures are needed, so that appropriate measures may be adopted.

Branch die-back caused by *Fusarium pallidoroseum* and thread blight caused by *Botryobasidium salmonicolor* are the other important diseases recorded both in plantations and natural stands. Though, the severity of branch die-back is low in all the areas surveyed, percent incidence is comparatively high in plantations affecting mostly the new culms. Thread blight is found widespread both in plantations and natural stands, especially in the high rainfall areas of the state affecting more than 15 species of bamboos. Necrosis of culm internodes caused by *Curvularia lunata* is encountered only in a plantation of *Thyrsostachys oliveri* and the disease is unimportant since it affects only the culms emerged late in the

season.

Among the foliar diseases affecting the bamboos in plantations and natural stands, foliage blight caused by *Bipolaris maydis* and *Bipolaris* sp., and leaf rust caused by *Dasturella diviana* are widespread which affect most of the bamboo species in the State. *B. maydis* and *Bipolaris* sp., the foliar pathogens recorded in bamboo nursery cause infection in plantations and natural stands. Similarly, *D. divina,* the leaf rust pathogen recorded in nursery seedlings, also causes infection of 14 species of bamboos in plantations and natural stands. Among these, *B.bambos, B.vulgaris, B. ventricosa, 0. monostigma and D. strictus* are the severely affected bamboos; eleven bamboo species are new host record for the leaf rust.

Since, the disease survey was carried out extensively for a period of five years, quite a large number of fungi causing diseases of minor importance also could be recorded. Altogether 24 species of fungi belonging to 19 genera causing leaf spot, culm sheath spot, culm staining and die-back and basal culm decay were recorded. Leaf spot diseases of minor significance are found to be caused by 20 different species of fungi belonging to 15 genera. Among these, *Exserohilum rostratum, E. holmii, Dactylaria* sp., *Colletotrichum gloeosporioides* are widespread in occurrence in bamboo plantations and natural stands in the State. These fungi are also recorded as causing seedling diseases in bamboo nurseries.

Disease survey in plantations and natural stands clearly demonstrates that the bamboo species raised in plantations as well as growing in natural stands are equally vulnerable to various diseases. Diseases like little leaf and witches' broom are host specific and occur only in natural stands. The former disease restricted in dry tracts of the State, affects the stand productivity to a great extent, while the latter is widespread and occurs in almost all the reed bamboo growing areas of the State; on account of its serious nature, the witches' broom disease may pose threat to culm produdion in future. Among the culm diseases, rot of emerging culms, which occurs in most of the bamboo species surveyed, is the economically important disease affecting the stand productivity considerably. The incidence and seventy of the disease vary depending on the bamboo species and locality. A detailed study on the epidemiology and disease management is warranted. Since, rot of growing culms in plantations and natural stands is predisposed by the injury caused by the sap sucking insect, disease incidence can be managed by taking appropriate steps in reducing the build up of the insect population in the plantation or natural stand during the period of culm production. Among the bamoo species raised in plantations, *T. oliveri* is affected by only a few pathogens that too of minor significance. This may possibly be due to the resistant nature of the species as well as the proper stand management. In general, the severity of culm diseases is low in plantations than in natural stands where bamboos are unmanaged. These observations suggest that by proper stand management the disease can be minimized to a greater extent.

Diseases of rattans

Until recently, very little attention was paid to commercial cultivation of rattans, and also to study the factors affecting regeneration and growth. The disease survey conducted in representative plots in rattan natural stands (11) and plantations/trial plots (5) and nurseries (4) facilitated a comprehensive coverage of as many rattan species as possible

grown in the State and also to record a large number of diseases affecting rattans, though, most of them are of minor significance. The survey records a total of 23 pathogenic diseases affecting different species of rattans in nurseries, plantations and natural stands. Altogether 21 fungi are found associated with these diseases. Of these, 13 fungi are recorded in rattan nurseries, 14 in plantations and natural stands. Six fungi occur both in nurseries as well as natural stands / plantations.

Table 21 : List of pathogens recorded on different species of rattans during the survey in Kerda and their status

Sl. No.	Pathogen	Nursery	Plantation/ natural stands	New pathogen record for rattans	First record from India	New species
1.	*Alternaria alternata*	t		t		
2.	*Bipolaris ellisii*	t	t	t	t	
3.	*Botryodiplodia theobromae*		+			
4.	*Colletotrichum crassipes*		t			
5.	*C. gloeosporioides*	+	t	t		
6.	*Coynespora cassicola*	t	t	t		
7.	*Corynespora* sp.		t	t	t	t
8.	*Curvularia lunata*	t		t		
9.	*Fusarium longipes*	t		+	+	
10.	*F. moniliforme*		t	t		
11.	F. *oxysporum*	t				
12.	*F. pallidoroseum*		+	t		
13.	F. *solani*	+		+		
14.	*Guignardia calami*	t	+		t	
15.	*Pellicularia filamentosa*		t	+		
16.	*Pestalotiopsis theae*	t	t	t		
17.	*Phomopsis* sp.	t	+	+	+	+
18.	*Phyllachora calamigena*		t	+	t	
19.	*Rhizodonia solani*	t				
20.	*Sclerotium rolfsii*	+		t		
21.	*Sphaerodothis* sp.		+	+	t	+
	Total	*13*	*14*	*16*	*7*	*3*

The disease survey in rattan nurseries indicates that all the rattan species raised both in seedbeds and containers are susceptible to various diseases. Among the 11 nursery diseases recorded, seedling collar rot is an economically important disease since it affects the seedling stocks considerably. seedling collar rot, a complex disease caused by three pathogens viz., *Fusarium longipes, Rhizoctonia solani* and *Sclerotium rolfsii* affects both the bareroot and container seedlings. Seedling blight caused by *Guignardia calami* is also a

potential disease, as it affects most of the rattan species to the level of medium severity. By prophylactic fungicidal pre-sowing and post-sowing treatments, the disease incidence can be minimized and thereby healthy planting stocks can be assured. Among the seven foliar diseases encountered in rattan nurseries, leaf spot caused by *Colletotrichum gloeosporioides* is the important one which affects most of the rattan species. *Alternaria alternata, Bipolaris ellisii, Corynespora cassicola, Curvularia lunata, Pestalotiopsis theae* and *Phomopsis* sp., which cause leaf spots of minor significance, are new pathogen records.

Disease survey in rattan plantation and natural stands reveals that rattans are not affected by serious diseases which affect the survival and stand productivity. However, comparatively a large number (9) of foliage diseases are found affecting all the rattan species, both in plantations/trial plots and natural stands. Among these leaf blight caused by a hitherto undescribed species of *Sphaerodothis* is widespread and almost all the rattan species are susceptible to it. Fungi causing leaf spots in nurseries viz., *B. ellisii, C. gloeosporides, corynespora cassicola, G. calami, P. theae, Phomopsis* sp. also cause leaf spots in plantations/trial plots and natural stands. *C. crassipes,* a weak pathogen is also found associated with the Colletotrichum leaf spots of rattan. Though, most of the fungi causing foliar infections also caused minor lesions on the rattan cane, none of them caused any serious damage. *F. moniliforme* causing rot of developing fruits of rattans is a noteworthy disease. This disease requirs further detailed investigation as it may pose threat to the seed production, especially in rattan seed orchard. *Botryodiplodia theobromae,* the important staining fungus of post-harvest rattan canes, affects the rattan stands stressed by fire injuries. Fungal staining and deterioration of post-harvest rattan canes are the major problem confronting the rattan industry in Kerala which deteriorate the physical properties as well as lowers the aesthetic and economic value of rattan canes and their products. To avoid infection of rattan canes in the clumps by *B. theobromae*, proper protective measures against incidence of fire in the rattan growing areas need to be adopted.

6. LITERATURE CITED

Anon., 1951. Index of fungi CMI, 2 (2): 15-34.

Anon., 1960. Index of Plant Diseases in the United States. United States Department of Agriculture, Hand bookNo. 165.

Anon., 1990. Administration Report of the Kerala Forest Department for the year 1988-'89. Kerala Forest Department, Trivandrum, Kerala, India.

Ali, M.I.M. 1993. Studies on seed pathology and seedling diseases of some important indigenous tree species of Kerala. Ph.D. Thesis, Cochin University of Science & Technology, Kerala, India.

Anahosur, KH. 1970. Ascomycetes of Coorg (India) II. Sydowia 24: 177-182.

Ananthanarayanan, S. 1962. *Rosenscheldiella eugeniae* Petch. a new record to India. Cuur. Sci. 31: 517-518.

Anderson, N.A. 1982. The genetics and pathology of *Rhizoctonia solani.* Annu. Rev. Phytopathol. 20: 329-347.

Arentz, F. 1991. Forest nursery diseases in Papua New Guinea. Pages 97-99. In: Diseases and Insects in Forest Nurseries (Proc. First Meeting of IUFROWP S2.07-09, Victoria, British Columbia, Canada, Aug. 22-30,1990). Forestry Canada, Pacific Forestry Centre, Information Report BC-X-331, Victoria, B.C. 298 p.

Awati, J.B and Kulkarni, KK. 1972. A new species of *Phyllachora* Nke. from India. Curr. Sci.41: 31-33.

Aycock, R. 1966. Stem rot and other diseases caused by *Sclerotium rolfsii*. North Carolina Agricultural Experiment Station Tech. Bull. No. 174,202 pp.

Azmy, Hj. M. and Maziah, Z. 1990. Leaf disease of bamboo. FRlM Technical Information No. 18. Forest Research Institute, Malaysia.

Baker, K.F. 1970. Types of *Rhizoctonia* diseases and their occurrence. Pages 125-140. In: *Rhizoctonia solani:* Biology and Pathology J.R. Parmeter Jr.(ed.), Univ. California Press, Berkeley.

Bakshi, B.K. 1971. Indian Polyporaceae on Trees and Timber. Indian Counc. Agric. Res., New Delhi, 246p.

Bakshi, B.K. 1976. Forest Pathology - Principles and Practice in Forestry. Controller of Publications, New Delhi. 400 pp.

Bakshi, B.K. Reddy, M.A.R., Puri, Y.N. and Sujan Singh 1972 Forest Disease survey (Final Technical Report). Forest Pathology Branch, F.R.I., Dehra Dun, 117p.

Bakshi, B.K. and Sujan Singh 1967. Rusts on Indian Forest Trees. Indian Forest Records (NS), Forest Pathology 2 139-198.

Balakrishnan, B, Chandrasekharan Nair, M. and Lulu Das 1990. Some common diseases of bamboo and reeds in Kerala. Pages 184-189. In: Bamboos Current Resarch. I.V. Ramanuja Rao, R. Gnanaharan and C.B. Sastry (eds.). Kerala Forest Research Institute, Peechi, India and International Development Research Centre, Canada.

Banerjee, S.N. 1947. Fungous flora of Culcutta and suburbs. I. Bull. Bot. Soc. Bengal 1: 37-54.

Banik, R.L. 1984. Emerging culm mortality at early developing stages in bamboos. Bano Biggyan Patrika 12:47-52.

Basha, S.C. 1992 Bamboo reed - a vanishing asset of forests in South India. Pages 18-26. In: Bamboo in the Asia Pacific. Proc. IV Int. Bamboo Workshop, 27-30 Nov., Chiangmai, Thailand, FORSPA Publication 6.

Berkeley, M.J. 1856. Decades of fungi, Decas 1-620 Nos. In Hooker London. J. Bot. 3-8: 1844-1856.

Bhat, M.N., Hegde, R.K., Hiremath, P.C. and Kulkarni, S. 1989. Unrecorded pathogen on bamboo causing blight in India. Curr. Sci. 58 (2): 1148-1149.

Bilgrami, K.S., Jamaluddin and Rizwi, M.A. 1991. Fungi of India. List and References. Today and Tomorrows' Printers and Publishers, New Delhi.

Boa, E.R. 1987. The occurrence of bamboo blight in Bangladesh with reference to *Sarocladium oryzae*. Pages 280-299. In: Recent Research on Bamboos. A.N. Rao, G. Dhanarajan, G. and C.B. Sastry (eds.). The Chinese Academy of Forestry, Peoples' Republic of China & International Development Research Centre, Canada.

Boa, E. R. and Brady, B.L. 1987. *Sarocladium oryzae* associated with a blight of *Bambusa* spp. in Bangladesh. Trans. Br. mycol. Soc. 8 9 : 161-166.

Boa, E.R. and Rahman, M.A. 1987. Bamboo blight and bamboos of Bangladesh. Bull. I. Forest Pathology Series, Forest Research Institute, Bangladesh, 43p.

Borja, D. and Austara, 0.1991. Diseases and insects in Norwegian forest nurseries. Pages 9-15. In: Diseases and Insects in Forest Nurseries (Proc. First Meeting of IUFRO WP S2.07-09, Victoria, British Columbia, Canada, Aug. 22-30,1990). Forestry Canada, Pacific Forestry Centre, Information Report BC-X-331, Victoria, B.C. 298p.

Brown, B.N. and Wylie, F.R. 1991. Diseases and pests of Australian forest nurseries: past and present. Pages 3-5.In: Diseases and Insects in Forest Nurseries (Proc. First Meeting of IUFRO WP S2.07-09, Victoria, British Columbia, Canada, Aug. 22-30, 1990). Forestry Canada, Pacific Forestry Centre, Information Report BC-X-331, Victoria, B.C. 298p.

Butler, E.J. and Bisby, G.R. 1931. The fungi of India. Imp. Coun. Agric. Res. India Sci. Monogr. I. 237p.

Butler, E.J. and Bisby, G.R. 1960. The Fungi of India (Revised by R.S. Vasudeva). Indian Council of Agricultural Research, New Delhi, India.

Chauhan, S. and Pandey, B.N. 1992. A new leaf blight of *Populus deltoides* caused by *Bipolaris maydis*. Indian Phytopath. 45 (1):130-133.

Chen, C.C. 1970. Witches' broom - a new disease of bamboo in Taiwan. Memoirs College Agriculture, National Taiwan University 11 (2): 101-112.

Chen, C.C. 1971. Some studies on witches broom of trees and bamboos in Taiwan. Memoirs College Agriculture, National Taiwan University 12 (2): 67-82.

Choudhry, P.N. 1982. Notes on Indian Hyphomycetes-VI. *Dactylaria arundica* sp. nov. Indian Phytopath. 3 5 : 532-534.

Cummins, G.B. 1974. The Rust Fungi of Cereals, Grasses and Bamboos. Springer-Verlag, Berlin, Heildelberg, New York, 570p.

DasGupta, S.N., Shome, U. and Shome, S.K. 1964. Preliminary report of predaceous fungi in India. Cum. Sci. 33: 145-148.

Davis, R.E., Whitecomb, RF., and Steere, R.L.. 1968. Remission of aster yellows disease by

antibiotics. Science 161: 793-795.
Deeley, J., Stevens, W. A. and Fox, R.T.V. 1979. Use of Dienes' stain to detect disease induced by mycoplasma like organisms. Phytopathology 69: 1169-1171.
Deka, P.C., Baruah, G. and Devi, M. 1990. A preliminary investigation of disease of bamboo in northeast region of India. Indian Forester 116 (9): 714-716.
Duryea, M.L. 1984. Nursery cultural practices: Impacts on seedlings quality. Pages 143-164. In: M.L. Duryea and T.D. Landis (eds.). Forest Nursery Manual: Production of Bareroot Seedlings. Martin Nijhoff /Dr. W. Junk Publishers, The Hague/Boston/ Lancaster, 386 pp.
Ellis, M.B. 1976. More Dematacеous Hyphomycetes. Commonwealth Agricultural Bureaux, Farnham, U.K. 507p.
Ferreira, F.A. and Muchovej, J.J. 1991. Diseases of forest nurseries in Brazil. Pages 17-23. In: Diseases and Insects in Forest Nurseries (Proc. First Meeting of IUFRO WPS 207-O9, Victoria, British Columbia, Canada, Aug. 22-30, 1990). Forestry Canada, Pacific Forestry Centre, Information Report BC-X-331, Victoria, B.C. 298p.
Florence, E.J.M., Sharma, J.K., Sankaran, K.V. and Mohanan, C. 1985. Some diseases of forest tree seedlings in India caused by *Sclerotium rolfsii* and *Rhizoctonia solani*. Eur. J. For. Path. 15: 187-190.
Gamble, J.S. 1896. The Bambusae of British India. Annts. Roy. Bot. Gdns. Calcutta, India.
Ghosh, S.K., Mohamed Ali, M.I. and Balasundaran, M. 1984. Light and fuorescent mocroscopic studies on little leaf disease of *Eucalyptus*. Phytopath. Z. 110: 207-212.
Ghosh, S.K., Balasundaran, M. and Mohamed Ali, M.I. 1985a. Studies on the spike disease of sandal. KFRI Res. Report 37. Kerala Forest Research Institute, Peechi, Kerala, 56 p.
Ghosh, S.K., Balasundaran, M. and Mohamed Ali, M.I. 1985b. Studies on the little leaf disease of eucalyptus. KFRI Res. Report 25. Kerala Forest Research Institute, Peechi, Kerala, 15p.
Gibson, I.A.S. 1956. Sowing density and damping-off in pine seedlings. E. Afr. Agric. For. J. 21: 183-188.
Harsh, N.S.K., Nath, V. and Tiwari, C.K. 1989. A common foliar diseases of *Dendrocalamus strictus* in nurseries. Proc. Seminar on Silviculture and Management of bamboos, Dec. 13-15. IDF, Jabalpur.
Hiruki; C. and Sukla, P. 1973. Mycoplasma like bodies associated with witches' broom bleeding heart. Phytopathology 63: 86-92.
Hsieh, H.J. 1984. Survey of diseases of woody plants in Taiwan (VIII). Quarterly Journal of Chinese Forestry 17 ; 61-73.
Hsieh, H.J. 1987. Survey of diseases of woody plants in Taiwan (XIII). Quarterly journal of Chinese Forestry 20 (1): 65-75.
Hsiung, W.Y. 1983. The distribution, production and research of bamboo in the world. Bamboo Research. 2:6-16.
Hsiung, W.Y. 1991. prospects of bamboo development in the world. J. Amer. Bamboo Soc. 8(1&2): 168-178.
Ishiie, T., Doi, Y., Yora, K., and Asuyama, H. 1967. Suppressive effects of antibiotics of

tetracycline group on symptom development of mulberry dwarf disease. Ann. Phytopathol.Soc. Japan 33: 267-275.

Jamaluddin, Gupta, B.N., Bohidar, S.C. and Dadwal, V.S. 1992. Mortality of bamboo *(Bambusa nutans* Wall.) in coastal areas of Orissa. Journal of Tropical Forestry 8: 252 261.

Johnston, A. and Booth, C. 1989. Plant Pathologists Pocketbook. 2nd edition. CAB, U.K. 439 PP.

Johnson, G.T. 1985. Rust (*Dasturella divina)* of Bambusa spp. in Australia. Austr. Plant Pathol. 14 54-55.

Kadambi, K 1949. On the ecology and silviculture of *Dendrocalamus strictus* in the bamboo forests of Bhadravati Division, Mysore State and comparative notes on the species of *Bambusa arundinacea, Ochlandra travancorica, Oxytenanthera monostigma* and *0. stocksii.* Indian Forester 75: 289-299; 334-349; 398-426.

Kao, C.W. and Leu, L.S. 1976. Finding perfect stage of Aciculosporium take Miyake, the causal organism of bamboo witches' broom disease and its conidial germination. Plant Prot. Bull., Taiwan 18 (3): 276-285.

Kondas, S. 1982. Biology of two Indian bamboos, their culm potential and problems of cultivation. Indian Forester 108: 179-189.

Kornerup, A. and Wanscher, J.H. 1978. Methuen Handbook of Colour. 3rd edition. London, Mathuen, 252p.

Krishnankutty, C.N. 1991. Market study of bamboo and reed in Kerala. Pages 77-92. In: Bamboo (India): Silviculture, management and utilization of bamboo resources of Kerala. Final Technical Report. Kerala Forest Research Institute, Peechi, Kerala, India.

Kuai, S. 1987. Blight of basket-bamboo *(Phyllostachys* sp.). Subtropical Forest Science and Technology 15 (3): 237-238.

Lin, N.S., Chai, Y.J. and Huang, T.Y. 1993. Incidence of bamboo mosaic potexvirus in Taiwan. Plant Disease 77 (5): 448-450.

Lin, N.S., Chen, M.J., Kiong, T., and Lin. W.C. 1979. Preliminary studies on bamboo mosaic disease in Taiwan. Bull. Taiwan For. Res. Instt. No. 317, l0p.

Lin, N.S., Lin, C.W., Kiong, T. and Chang, T.Y. 1981. Investigation and study of bamboo witches' broom in Taiwan. Quarterly Journal of Chinese Forestry 14 (1): 135-148.

Lin, X. and Wu, G. 1987. Study on witches' broom of fish-scale bamboo I. symptoms and pathogens. Journal of Central-South Forestry College 7 132-136.

Lin, Z.L. and Sinclair, J.B. 1992. Genetic diversity of *Rhizoctonia solani* amostomosis group 2. Phytopathology 82 778-787.

Mani Varghese, K.I. and Rao, V.C. 1979. Some addition to the Indian fungi. J. Univ. Poona. 5 2 309-312.

Mao, T.V. 1993. Impact of diseases in nurseries, plantations and natural forests in Vietnam. Proc. IUFRO Symp. Impact of Diseases and Insect Pests in Tropical forests. 23-26, Nov. 1993. Kerala Forest Research Institute, Peechi, Kerala.

Mathur, R.S. 1936. Notes on the fungi of Lucknow. I. On the perithecial stage of *Sphaerostilbe bambusae* Pat. on *Bambusa indica.* Proc. Ind. Sci. Congr. 23: 288.

Maziah, Z. 1986. Fusarium rot of *Calamus manan* plantlets derived from tissue culture. *RIC* Bulletin 5(3):7-8.

Mehrotra, M.D. 1989. Leaf blight of some hard wood species in Assam and Meghalaya and its control in the nursery. Indian Forester 115 (6): 378-384.

Mehrotra, M.D. 1990. *Rhizoctonia solani*, a potentially dangerous pathogen of khasi pine and hardwoods in forest nurseries in India. Eur. J. For. Path. 20: 329-338.

Mitter, J.H. and Tandon, R.N. 1932. Fungous Flora of Nainital 1. J. Ind. Bot. Soc. 11: 178–180.

Mohanan, C. 1988. Colletotrichum foliar infection on *Leucaena leucocephalain* Kerala, India. Curr. Sci. 57 (23): 1299-1300.

Mohanan, C. 1990a. Diseases of bamboos in Kerala. Pages 173-183. In: Bamboos Current Research. I.V. Ramanuja Rao, R. Gnanaharan and C.B. Sastry (eds.). Kerala Forest Research Institute, Peechi, India and International Development Research Centre, Canada.

Mohanan, C. 1990b. Diseases of rattans in India. RIC Bulletin, Malaysia 9: 1-17.

Mohanan, C. 1991. Fungal staining and biodegradation of rattans RIC Bulletin l0(2) 211.

Mohanan, C. 1993. Biodeterioration of post-harvest rattan. Pages 266-280. In: Rattan management and Utilization. S.C. Basha, K.M. Bhat (eds.). Kerala Forest Resarch Institute, Peechi and International Development Research Centre, Canada.

Mohanan, C. 1993. Diseases of rattans in Kerala and their possible management. Pages 160-169. In: Rattan management and Utilization. S.C. Basha, K.M. Bhat (eds.). Kerala Forest Resarch Institute, Peechi and International Development Research Centre, Canada.

Mohanan, C. 1994. Studies on Diseases of Bambous and Nursery Management of Rhizoctonia Web Blight in Kerala. Ph. D. Thesis. Cochin University of Science & Technology, Kerala 316p.

Mohanan, C. and Liese, W. 1990. Disease of bamboos. Int. J. Tropical Plant Disease 8: 1-20.

Mohanan, C. and Muraleedharan, P.K. 1988. Rattan resources in the sacred groves of Kerala, India. *RIC Bulletin* 75-6.

Mohanan, C. and Sharma, J.K. 1986. *Bipolaris spicifera* and *Exserohilum rostratum* causing leaf spots of *Eucalyptus* tereticornis-new record from India. Curr. Sci. 55: 990-992.

Mohanan, C. and Sharma, J.K. 1987a. *Phomopsis eucalypti* and *Bartalinia terricola*, new pathogen records on eucalypts from India. Trans. Br. mycol. Soc. 88 (1): 125-126.

Mohanan, C. and Sharma, J.K. 1987b. *Phomopsis leucaenae* sp. nov. causing foliar infection on *Leucaena leucocephala* in Kerala, India. Curr. Sci. 14: 732733.

Mohanan, C. and Sharma, J.K. 1988. Diseases of exotic Acasias in India. J. Trop. For. 4: 357-361.

Mohanan, C. and Sharma, J.K. 1989. Occurrence of new diseases of *Casuarina equisetifolia* in India. Indian Forester 115 : 33-37.

Mohanan, C. and Sharma, J.K. 1991. Seed pathology of forest tree species in India -present status, practical problems and future prospects. Commonwealth Forestry Review 70 : 133-151.

Mohanan, C. and Sharma, J.K. 1993. Diseases of *Casuarina equisetifolia* in India. Common-

wealth Forestry Review 72 (1): 48-52.
Morris, J.K. 1965. A formaldehyde glutaraldehyde fixative of high osmolality for use in electron microscopy. J. Cell. Biol. 27: 137-139.
Mukerji, K.G. and Bhasin, J. 1986. Plant Diseases of India - a Sourse Book Tata Mcgraw-Hill publishing Company Ltd. New Delhi.
Muketeshkumar, 1990. Reed bamboos *(Ochlandra)* in Kerala: distribution and management. Pages 39-43. In: Bamboos Current Research. I.V. Ramanuja Rao, R Gnanaharan and C.B. Sastry (eds.). Kerala Forest Research Institute, Peechi, India and International Development Research Centre, Canada.
Mundkur, B.B. and Kheswala, K.F. 1943. *Dasturella* - a new genus of the Uredinales. Mycologia 35: 201 -206.
Muniappa, V., Vijayakumar, N., Subbarao, M. and Kushalappa, K.A. 1980. Studies on sandal spike disease in the forest of Karnataka State. Part I. University of Agricultural Science, Hebbal, bangalore, 284 p.
Muraleedharan, P.K. and Rugmini, P. 1990. Problems and prospects of traditional bamboo-based industry in Kerala. Pages 328-333. In: Bamboos Current Research. I.V. Ramanuja Rao, R. Gnanaharan and C.B. Sastry (eds.). Kerala Forest Research Institute, Peechi, India and International Development Research Centre, Canada.
Muthappa, B.N. 1967. A new species of *Rosenscheldiella* Theiss. & Syd. from India. Sydowia 21: 163-164.
Nagraj, T.R. and Kendrick, B. 1972. Genera Coelomycetum III-*Pestalozziella*. Canad. J. Botany 50: 607-617.
Nair, C.T.S. 1986. Bamboo-based industry in Kerala State, India. FAO/Finland Expert Consultation on Appropriate Forest Industries, Jakarta (Indonesia), FAO Forestry Paper No. 68.
Nayar, R. and Ananthapadmanabha, H.S. 1970. Isolation, cultivation and pathogenicity trials with MLO associated with sandal spike. J.Ind. Acad. Wood Sci. 1: 59-61.
Nayar, R. and Ananthapadmanabha, H.S. 1977. Little leaf disease in collateral hosts of sandal (*Santalum album* L.). Eur. J. For. Path. 7 (3): 152-158.
Nema, K. G. and Mishra, R.P. 1965. The Uredineae of Jabalpur, M.P. Nagpur Agric. Coll. Magz. 6: 7-9.
Norani, A., Tho, Y .P. and Hong, L.T. 1985. Pests and diseases of rattans and rattan products in Peninsular Malaysia. Pages 131-135. In: Proceedings of the Rattan Seminar, Kuala Lumpur, K.M.Wong and N.Manokaran (eds.). The Rattan information Centre, Forest Research Institute, Kepong.
Norani, A. and Maziah, Z. 1988. Diseases of *Calamus* spp. (Rattan). FRIM Technical Information No.4. Forest Research Institute Malaysia.
Nozu, M. and Yamamoto, M. 1972. Ultrastructure of fasciculated tissue of *Phyllostachys bambusoides* infected with *Aciculosporium take*. Bulletin of the Faculty of Agriculture, Shimane University No 6: 49-52.
Ogoshi, 1987. Ecology and Pathogenicity of amastompsis and intraspecific groups of *Rhizoctonia solani* Kuhn. Ammn. Rev. Phytopathol. 25: 125-143.
Patel, M.K., Kamat, M.N. and Bhide, V.P. 1949. Fungi of Bombay. Supplement I. Indian Phytopath. 2: 142-155.

Perrin, R. 1991. Diseases and insects in western European forest nurseries. Pages 117-124. 1n: Diseases and Insects in Forest Nurseries (Proc. First Meeting of IUFRO WPS2.07-09, Victoria, British Columbia, Canada, Aug. 22-30, 1990). Forestry Canada, Pacific Forestry Centre, Information Report BC-X-331, Victoria, B.C. 298 p.

Rahman, M.A. 1978. Isolation of fungi from blight affected bamboos in Bangladesh. Bano Biggyan Patrika **7** 42-47.

Rahman, M.A. and Khisha, S.K 1983. Bamboo blight with particular reference to *Acremonium strictum*. Bano Biggyan Patrika 10: 1-13.

Rahman, M.A. and Zethner, 0.1971. An interim report on results obtained in the Forest Pathology Section from September 1969 to August 1971. Forest Dale News 4(1): 45-48.

Rajagopalan, S. and Ramakrishnan, K 1967. Phycomycetes in agricultural soils with special reference to Pythiaceae 11. Species of *Pythium* isolates. Madras Univ. J. 37-38. (B): 100-117.

Ramakrishnan, T.S. 1951. Additions to fungi Madras XI Proc. Ind. Acad. Sci. 348: 157-164.

Ramakrishnan, T.S. and Ramakrishnan, K. 1949. Ergot on bamboo. Curr. *Sci.* 18 (9): 344-345.

Rangaswami, G., Sheshadri, V.S. and Lucy Channamma, K.K. 1970. Fungi of South India. Univ. of Agric. Sci. Bangalore, 193 p.

Ray, J.N. 1991. Nursery diseases and insect problems in New Zealand. Pages 85-90. In: Diseases and Insects in Forest Nurseries (Proc. First Meeting of IUFRO WP S2.07-09, Victoria, British Columbia, Canada, Aug. 22-30, 1990). Forestry Canada, Pacific Forestry Centre, Information Report BC-X-331, Victoria, B.C. 298p.

Renuka, C. 1992. Taxonomy of South Indian canes. Pages 76-91. In: Rattan Management and Utilization. S.C. Basha and K.M. Bhat (eds.). Kerala Forest Research Institute, Peechi and International Development Research Centre, Canada.

Renuka, C., K.M. Bhat and V.P.K. Nambiar 1986. Morphologica1, anatomical and physical properties of *Calamus* species of Kerala Forests. KFRI Res. Report 46. Kerala Forest Research Institute, Peechi, Kerala 58p.

Reynolds, E.W. 1963. The use of lead citrate at high pH as an electron opaque stain in electron microscopy. J. Cell. Biol. 17:208-212.

Rogers, D.P. 1943. The genus *Pellicularia* (Thelephoraceae). Farlowa 1:95-110.

Russel, W.C., Newman, C. and Williamson, D.H. 1975. A simple cytochemical technique for demonstration of DNA in cells infected with mycoplasmas and viruses. Nature 256: 461-462.

Saglio, P., Lafleche, D., Banissol, C. and Bove, J.M. 1971. Isolement et culture in vitro des mycoplasmas associes 'Stubborn' des agrumes etleur observation all microscope electronique. C.R. Acad. Sci. Ser. D. 272 1387-1390.

Sankaran, K.V. and Balasundaran, M. 1986. Seedling diseases of *Azadirachta indica* in Kerala, India. Eur. J. For. Path. 16: 324–328.

Sankaran, K.V., Florence, E.J.M. and Sharma, J.K. 1987. Two new species of *Phomopsis* from India. Trans. Br. mycol. Soc. 89: 404-407.

Sankaran, K.V., Florence, E.J.M. and Sharma, J.K. 1988. Foliar diseases of some forest trees

in Kerala-new records. Ind. J. For. 11 (2): 104-107.
Sathe, A.V. 1965. A new species of *Dasturella* (uredinales) from India. Sydowia 19: 148-149.
Sharma, J.K. and Mohanan, C. 1986. Management of seedling diseases of eucalypts in nurseries. Pages 377-383. In: Eucalyptus in India: Past, Present and Future. J.K. Sharma, C.T.S. Nair, S. Kedharnath and S. Kondas (eds.). Kerala Forest Research Institute, Kerala, India.
Sharma, J.K. and Mohanan, C. 1991a. Epidemiology and control of diseases of *Eucalyptus* caused by *Cylindrocladium* spp. in Kerala. KFRI Res. Report 70, Kerala Forest Research Institute, Peechi, Kerala, 155p.
Sharma, J.K. Mohanan, C. 1991b. In *vitro* evaluation of fungicides against *Cylindrocladium* spp. causing diseases of *Eucalyptus* in Kerala, India. Eur. J. For. Path. 21: 17-26.
Sharma, J.K. and Mohanan, C. 1992. Effect of some nursery practices on incidence and severity of diseases and growth of *Eucalyptus grandis* seedlings. Eur. J. For. Path. 22: 125-135.
Sharma, J.K., Mohanan, C. and Florence, E.J.M. 1983. A little leaf disease of *Eucalyptus* in Kerala, India. Eur. J. For. path. 13: 385-388.
Sharma, J.K., Mohanan, C. and Florence, E.J.M. 1984b. Two species of mycelia sterilia parasitic on the foliage of hardwood seedlings in Kerala State, India. Trans. Br. mycol. Soc. 83 (2): 342-344.
Sharma, J.K., Mohanan, C. and Florence, E.J.M. 1985. Disease Survey in Nurseries and Plantations of Forest Tree Species Grown in Kerala. KFRI Res. Report **36.** Kerala Forest Research Institute, Peechi, Kerala, 268p.
Sharma, J.K. and Sankaran, K.V. 1984. Web blight of *Albizia falcataria* in India. Eur. J. For. Path. 14: 261-2.64.
Shinohara, M. 1965. Studies on witches' broom of *Phyllostachys bambusoides* Sieb. et Zucc. 1. Symptoms and morphology of the causal fungus. Bull. Coil. Agri. Vet. Medicine, Nihon University No. 21 : 42-60 .
Shukla, A.N., Singh, S. and Sehgal, H.S. 1988. Diseases and deterioration of bamboos in India. Indian Forester 114 (10): 714-719.
Shukla, D.N. and Bhargava, S.N. 1975. Foot rot of Celosia, a new disease. Plant Dis. Reptr. 59: 806.
Singh, B.P. and Joshi, L.K. 1972. Studies on the diseases of *Piper* betle in Jabalpur, M.P.-four new world records of *Fusaria* Sci. & Cult. 38: 285.
Singh, D.V. and Khanna, B.M. 1970. Some Sphaeropsidous fungi from Kanpur. Indian Phytopath. 23: 465-469.
Singh, S.L. and Pavgi, M.S. 1974. *Pythium middletonii* parasitic in the roots of crucifers. Cum. Sci. 43: 351-352.
Soderstrom, T.R. and Ellis, P.P. 1988. The woody bamboos (Poaceae: Bambuseae) of Sri Lanka: a morphological and anatomical study. Smithsonian Contribution No. 72.
Subramanian, C.V.-and Ramakrishnan, K. 1953. *Petrakomyces*, a new genus of Sphaeropsidales. Proc. Ind. Acad. sci. 37 B: 110-113.
Sujan Singh and Bakshi, B.K. 1964. Notes on some Indian tree rusts. Indian Forester 90: 469-472.

Sujan Singh and Pandey, P.C. 1971. *Tunicospora,* a new rust genus on bamboo. Trans. Br. mycol. Soc. 56.301-303.

Sutherland, J.R. 1991. Diseases and insects in forest nurseries in Canada. Pages 25-32. In: Diseases and Insects in Forest Nurseries (Proc.First Meeting of IUFRO WPS207-09, Victoria, British Columbia, Canada, Aug. 22-30,1990). Forestry Canada, Pacific Forestry Centre, Information Report BC-X-331, Victoria, B.C. 298 p.

Sutton, B.C. 1980. The Coelomycetes -Fungi Imperfecti with Pycnidia, Acervuli and Stroma. Commonwealth Mycological Institute, Kew, England. 696p.

Sydow, H. and Butler, E.J. 1911. Fungi Indiae Orientalis Pars III Ann. Mycol. 9: 372-421.

Sydow, H. and Butler, E.J. 1916. Fungi Indiae Orientalis. Pars V. AM. Mycol. 14 177-220.

Sydow, H. and Mitter, J.H. 1933. Fungi lndici I. AM. Mycol. 31: 84-97.

Tahir, M., Soni, KK. and Jamaluddin, 1992. Root and rhizome rot of *Dendrocalamus strictus* caused by *Amylosporus campbelli* (Berk) Ryv. Myforest 28 (1):88-90.

Thirumalachar, M.J. 1950. Some new or interesting fungi II Sydowia 4: 63-73.

Thirumalachar, M.J., Narasimhan, M.J. and Gopalakrishnan, G. 1947. Morphology and spore forms and heteroism of the giant bamboo rust. *Dasturella divina.* Bot. Gaz. 108 (3): 371-379.

Tilak, S.T. and Rao, R. 1967. Contribution to our knowledge of Ascomycetes of India XVII. Sydowia 21: 308-312.

Tilak, S.T. and Viswanathan, T.S. 1960. Addition to fungi of Bombay V. Mycopath. et Mycol. appl. 13: 100-106.

Tiwari, D.N. 1991. A Monograph on Bamboo. International Book Distributors, Dehra Dun, India, 498p.

Vaartaja, 0. 1952. Forest humus quality and light conditions as factors influencing damping-off. Phytopathology 46: 391 -397.

Vongkaluang, I. 1989. Pests and diseases of rattan in Thailand. Pages 164-166. In: In Recent Research on Rattans. Proceedings of the International Rattan Seminar, Chiangmai, 12-14 Nov., 1987, A.N. Rao, I. Vongkaluang, J. Dransfield, N. Manokaran, C.B. Sastry, G. Dhanarajan (eds.). Faculty of Forestry, Kasetsart University, Thailand and International Development Research Centre, Canada.

Xie, Q., Lin. Y. and Lin, C. 1987. A study on the wilt disease of *Dendrocalamus latiflorus* 1. Identification of the pathogen, bionomics and control. J. Fujian College of Forestry 7: 15-21.

Zhu, X.Q. 1989a. Study on witches' broom of bamboos (II) Form and biological properties of the pathogenic fungus. Journal of Bamboo Research 8 (1):44-51.

Zhu, X.Q. 1989b. The study on witches' broom of bamboos (III)-Infection characteristics and control experiment of germs. Journal of Nanjing Forestry University 13 (2): 46-51.

Zin, N.S., Zin, W.C., Kiong, J., and Chang, T.Y. 1981. Investigation and study of bamboo witches broom in Taiwan. Quarterly Journal of Chinese Forestry 14 135-148.

Appendix 1:List of representative plots selected in bamboo natural stands and plantations in Kerala for disease survey during 1987 - 1991

S1.No.	Locality	Forest Division	Year of planting	Bamboo species
Natural stands				
1.	Thirunelly	Wildlife Divn. Wynad		*Bambusa bambos*
2.	Muthanga	Wildlife Divn. Wynad		*B. bambos*
3.	Noolpuzha	Wildlife Divn. Wynad		*B. bambos*
4.	Periya	North Wynad		*Ochlandra scriptoria*
5.	Anarnari	Nilambur		*B. bambos*
6.	Agaly	Mannarkkad		*Dendrocalamus stridus*
7.	Thakarapady	Mannarkkad		*D. strictus*
8.	Goolikadavu	Mannarkkad		*D. strictus*
9.	Watchurnararn	Vazhachal		*0. travancorica*
10.	Vazhachal	Vazhachal		*0. scriptoria*
11.	Marayoor	Munnar		*B. bambos*
12.	Chinnar	Munnar		*D. strictus*
13.	Pachakanam	Ranni		*0. travancorica*
14.	Kottoor	Trivandrum		*0. ebracteata.*
Plantations				
1.	Nilambur	Nilambur	1987	*B. bambos*
2.	Nadukani	Nilambur	1970	*D. stridus*
3.	Mundoor	Palakkad	1973	*T. oliveri*
4.	Irumpu alam	Trichur	1986	*B. bambos*
5.	Palapply	Chalakkudy	1986	*B bambos*
6.	Ezhatturnugarn	Vazhachal	1986	*B. bambos*
7.	Kollathirumedu	Vazhachal	1986	*B. bambos*
8.	Kaliyar	Kotharnanagalam	1986	B. *bambos*

Appendix 2: List of representative plots selected in natural stands and plantations of rattans for disease survey during 1987-1991

S1.No.	Locality	Forest Division	Rattan species
1.	Kottiyoor	Wayanad	CT,CG,CH,CV
2.	Ambumala	Nilambur	CT,CH, CG
3.	Mancheri	Nilambur	CT,CG, CH
4.	Nelliampathy	Nenmara	CT, CH. CV
5.	Peruvannamuzhy	Calicut	CT, CH, CG,CV, CTR
6.	Chully'	Vazhachal	CT, CH
7.	Dhoni	Palakkade	CT,CH,CD
8.	Nilakkal	Ranni	CT,CH
9.	Achenkoil	Thenmala	CT,CH
10.	Chauzhiacode'	Trivandrum	CT,CH,CTR
11.	Arippa '	Trivandrum	CT,CH
12.	Kottoor	Trivandrum	CT,CH
13.	Harippad''	Quilon	CR
14.	Chenagiri	Thenmala	CT,CH,CTR
15.	Peermedu'	Peermedu	CP
16.	Chalakkayam	Ranni	CT,CH

' Plantation/trial plot, "Sacred groves. CD: C. *dransfieldii* CR: *C. rotang,* CT: *C.Thwaitesii,* CH:C. *hookerianus,*CP:C *pseudotenuis,* CTR:C *travancoricus,* CV:*C.vattayila*

Appendix 3: List of bamboo and rattan nurseries surveyed during 1987-1992

Sl. No.	Locality	Forest Division	Year	Bamboo and rattan species
Bamboo				
1.	Vadavukodu	Emakulam Social Forestry	1987-'88	BB
2	Kalamassery	Emakulam S.F.	1987-'88	BB
3.	Dhoni	Palakkad	1987-'88	Ds
			1988-'89	Ds
4.	Peechi	Trichur	1988-'89	BB,OS,OT
			1889-'90	BB,PP
			1990-'91	BB,DL
5.	Nilambur	Nilambur	1988-'89	BB,DS
			1989-'90	BB,DS
6.	Pattikad	Trichur	1987-'88	BB
7.	Pallappilly	Trichur	1990-'91	BB,DM,OW
			1991-'92	BB,DS,DB
8.	Pariyaram	Chalakkudy	1989-90	BB
9.	Kulanjithodu	Ranni	1989-'90	BB
10.	Vadasserikkara	Ranni	1990-'91	BB
11.	Niravilpuzha	South Wynad	1990-'91	BB
			1991-'92	BB
12.	Thettamala	South Wynad	1991-'92	BB
13.	Periya	South Wynad	1990-'91	BB
			1991-'92	BB
14.	Vattapoyil	South Wynad	1991-'92	BB
15.	Begur	South Wynad	1990-'91	BB
16.	Paneli	Malayattoor	1990-'91	BB
			1991-'92	BB
17.	Pezhad	Malayattoor	1990-'91	BB
			1991-'92	BB
18.	Chandhanathodu	Cannanore	1991-'92	BB,DS,DB,TS
Rattan				
1.	Peechi	KFRI Campus	1987-'92	CG,CT,CH,CP,CTR,CTRC
2.	Palappilly	Trichur	1991-'92	CT,CH,CP
3.	Nilambur	Nilambur	1990-'91	CT,CH
4.	Peermedu	Peermedu	1987-'89	CP

'Container seedlings.

BB:*B.bambos;*DB*: D.brandsii;* DS*: D.strictus;*DM *D.membranaceus;* DL *D. longispathus;* OS*: ochlandra scriptoria;*OT:*O.travancorica;*OW:*O.wightii.*TS:*Thyrsostachys siamensis;*PP*:Phykkistacgts pubescens;* CG:C.*gamblei;*CT: C *thwaitesii;* CH:C.*hookerianus;* CR: C.*rotang;*CTR:C. *travancoricus;*CTRC: C.*trachycoleus;* CP:C. *pseudotenuis*

Appendix 4: List of bamboo and rattan species surveyed in Kerala during 1987-1992

Sl. No.	Species	Habitat
	Bamboos	
1.	*Arundinaria* Michaux. sp.	NS
2.	*Bambusa balcooa* Rox.	BM,PP
3.	*B. bambos* (L.) Voss	N,PN,PP,BM
4.	*B. glaucescens* (Willd.) Sieb. ex Munro	BM
5.	*B. polymorpha* Munro	BM,PP
6.	*B. tulda* Roxb.	BM
7.	*B. ventricosa* Kurz.	BM,BG
8.	*B. vulgaris* Schrad	BM,BG,PP
9.	*Dendrocalamus brandsii* Kurz.	BM
10.	*D. hamiltonii* Nees	BM,PP
11.	*D. longispathus* Kurz.	BM,PP
12.	*D. membranaceus* Munro	BM,N
13.	*D. strictus* Nees	N,PN,BM,PP
14.	*O. ebracteata* Raizada & Chatterji	NS
15.	*Ochlandra scriptoria* (Dennst.) Fisch.	NS,BM
16.	*O. travancorica* (Bedd.) Benth. ex Gam.	NS,BM,PP
17.	*O. travancorica* Benth. var. *hirsuta* Gam.	NS
18.	*O. wightii* Fisch.	N
19.	*Oxytenanthera monostigma* Bedd.	BM,NS,PP
20.	*Phyllostachys pubescens* Maze1 ex Lahaie	N
21.	*Thyrsostachys oliveri* Gamble	PN,BM, PP
22.	*T. siamensis* Cam.	N
23.	*Thyrsostachys* sp.	PP
	Rattans	
1.	*Calamus Caesius Bl.*	PP
2.	C. *dransfieldii* Ren.	NS
3.	C. *gamblei* Becc.	NS,N
4.	C. *hookerianus* Becc.	NS,N
5.	C. *pseudotenuis* Becc.	N,PN
6.	C. *rotang* L	N,NS
7.	*C. thwaitesii* Becc.	NS,N,PN
8.	*C. travancoricus* Bedd.	NS,N,PP
9.	C. *trachycoleus*	N
10.	C. *vattayila* Ren.	NS

N:Nursery; NS:Natural stand; PN:Plantation; PP:Preservation plot; BM:Bambusetum;BG: Botanic garden

Appendix 5: Disease index to assess the severity of diseases in nurseries, plantations and natural stands

Disease severity	Damping-off	Web blight	Foliage infection	Culm and branch infection	Disease seventy rating
Nil	Nil	Nil	Nil	Nil	0
low (L)	1-25 damped-off patches in 12x1m seed bed	1-25 infection foci in 12x1 m seedbed	upto 25% of the foliage affected	upto 25% of the culm and branches affected; >10% die-back of branches	1 (0.1-1)
medium (M)	26-50 damped-off patches in 12x1m Seedbed	>25-50 infection foci in 12x1 m Seedbed	>25-50% of the foliage affected; >10% defoliated prematurely	>25-50% of the culm and branches affected; >25% dieback of shoot	2 (1.1-2)
severe (S)	>50 damped-off patches in 12x1m seed bed	>50 infection foci in 12x1m seed bed; in-fection still	>50-75% or more foliage infected; >25% defoliated prematurely spreading	>50-75% of the culm and branches affected; >50% of die-back of shoot infection spreading	3 (2.1-3)

Appendix-6 List of fungicides evaluated against various pathogens

Sl. No.	Tradename	Common name	Chemical name
1.	Bavistin	Carbendazim	Methyl-1H-benzimid azole-2 yl-carbamate
2.	DithaneM-45	Mancozeb	Manganese ethylenebisdithio-carbamate + Zn ions
3.	Emisan-6	MEMC	2-methoxyethylmercuric chloride
4.	Hexathir	Thiram,Thiride	Tetramethyl thiuram disulphide
5.	Vita vax	Carboxin	5,6-dihydro-2-methyl-l, 4-oxathiin-3-carboxanilide

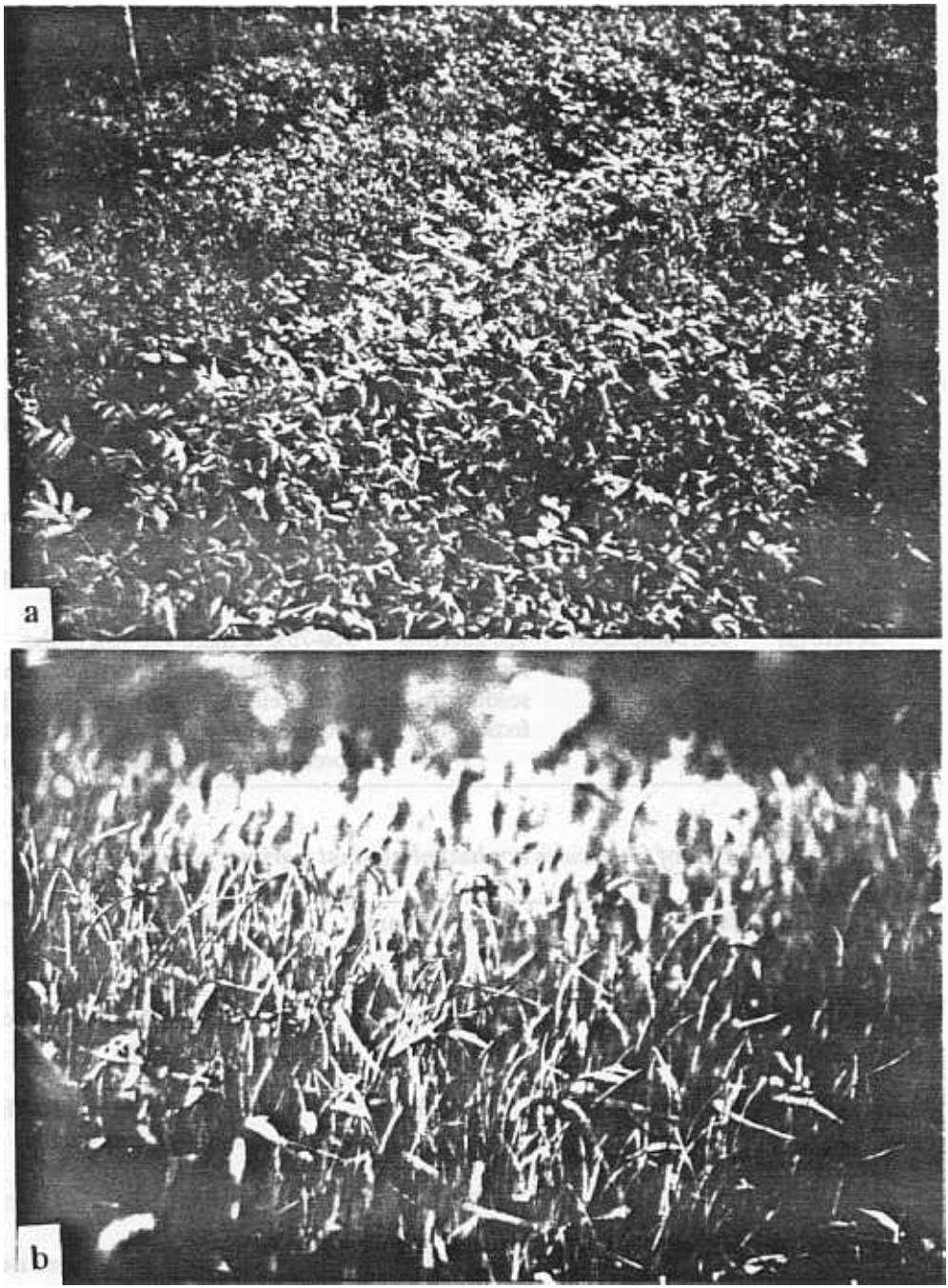


Plate 1. Web blight of bamboo seedlings (*Bambusa bambos*) caused by *Rhizoctonia solani*. a: A view of the seedbed nursery showing diseased and dried up *B. bambos* seedlings, b: A close-up of severely affected seedlings.

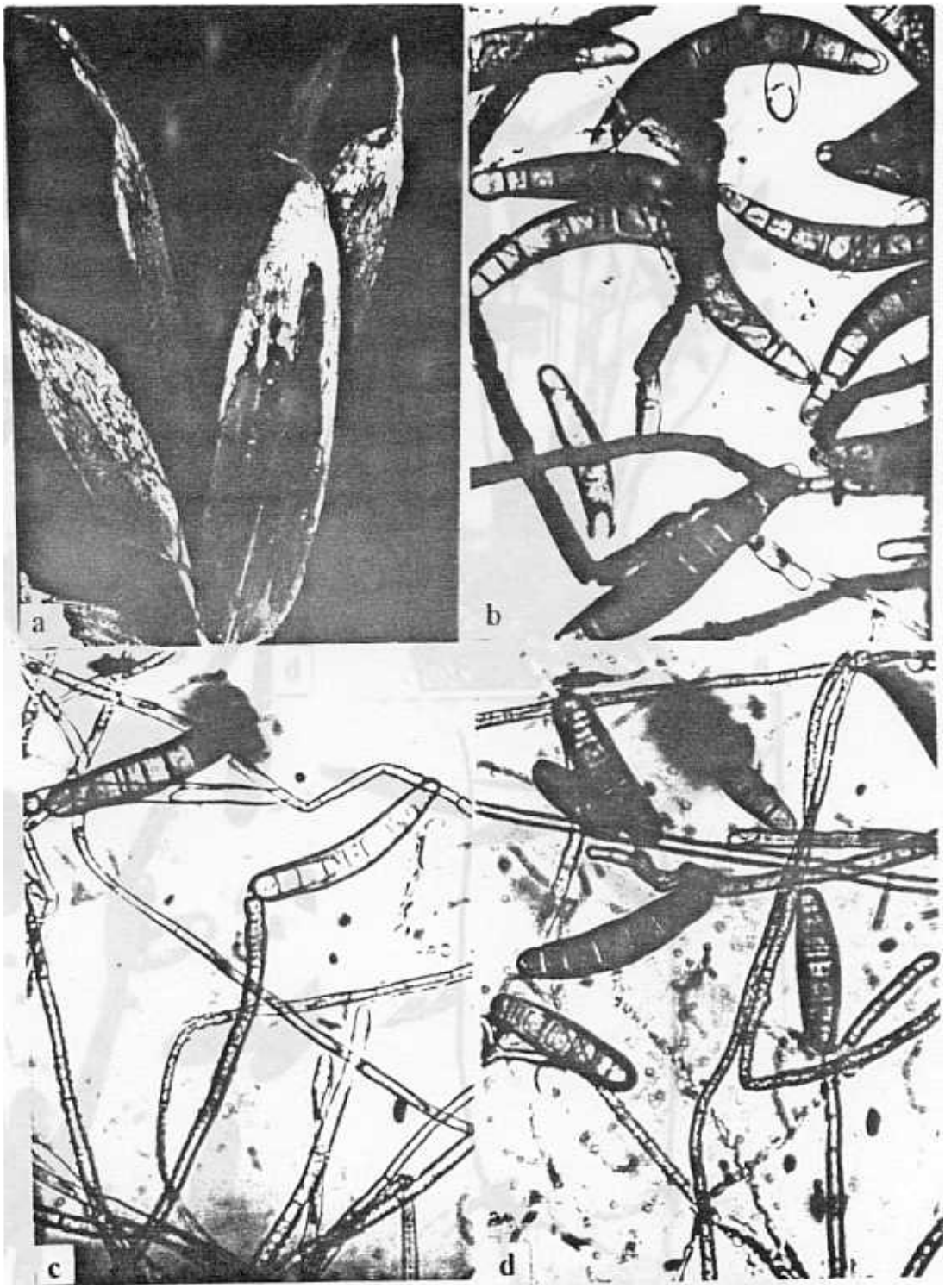


Plate 2. Foliar infection caused by *Bipolaris* spp. a: *Bambusa bambos* leaves showing disease symptoms of Bipolaris leaf blight, b: Conidiophores and conidia of *Bipolaris maydis* (440 x), c: Conidiophores and conidia of *Bipolaris urochloae* (440 x), d: Conidiophores and conidia of *Bipolaris* sp. (440 x).

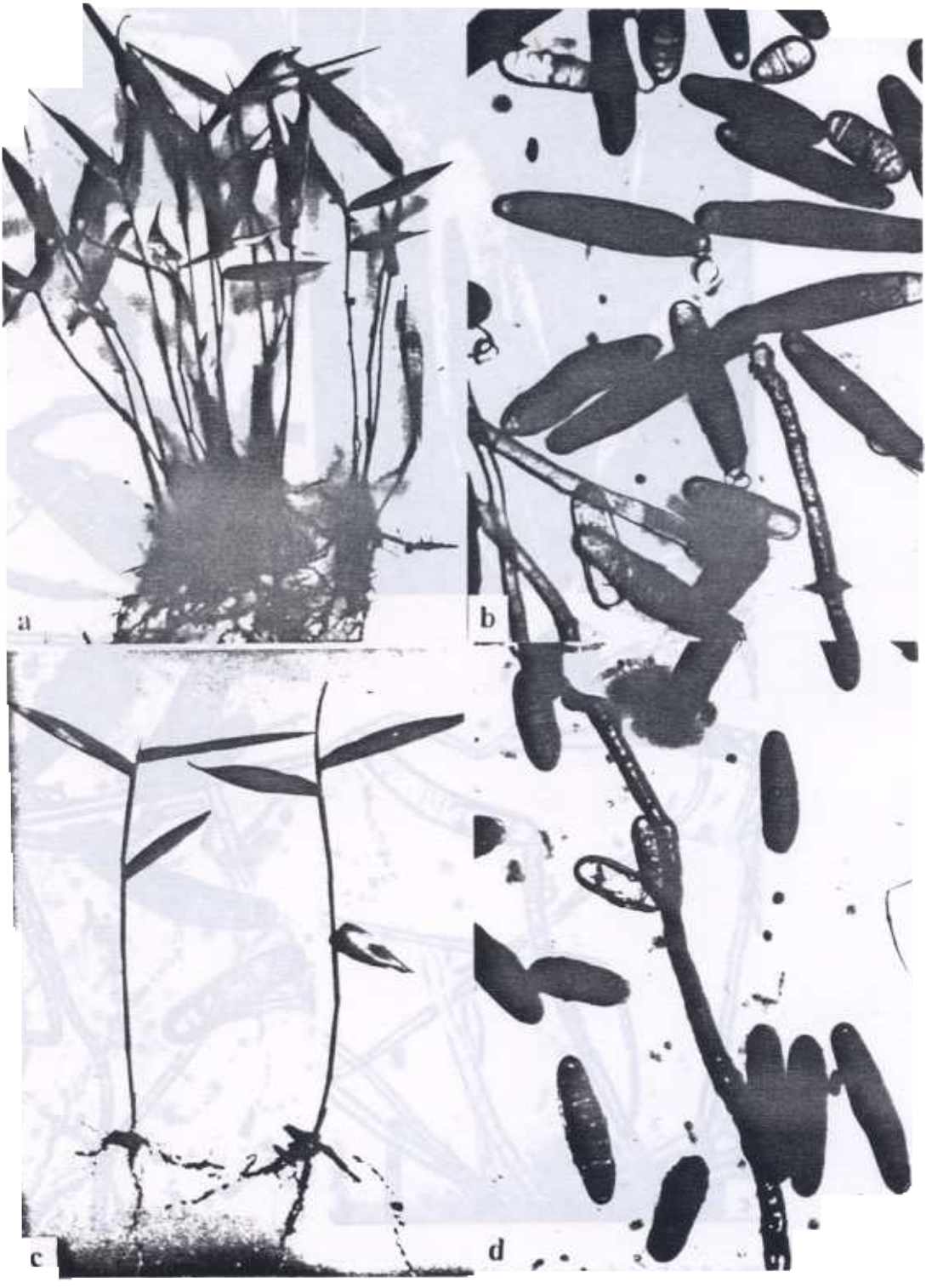


Plate 3. Seedling foliage infection caused by *Exserohilum* spp. a: *Bambusa bambos* seedlings showing Exserohilum leaf spot symptoms, b: Conidiophore and conidia of *Exserohilum rostratum* (440 x), c: *Dendrocalamus strictus* seedlings affected with *Exserohilum holmii*, d: Conidiophores and conidia of *Exserohilum holmii* (440 x).

Plate 4. Witches' broom of reed bamboos. a: Witches' broom affected shoot of *Ochlandra travancorica* bearing fructifications of *Balansia linearis*, b: A magnified view of the fructification of *B. linearis*, c: A part of the transverse section of the leaf bearing fructification of *B. linearis* showing ascocarp and asci (160 x), d: A magnified view of asci containing ascospores of *B. linearis* (980 x)

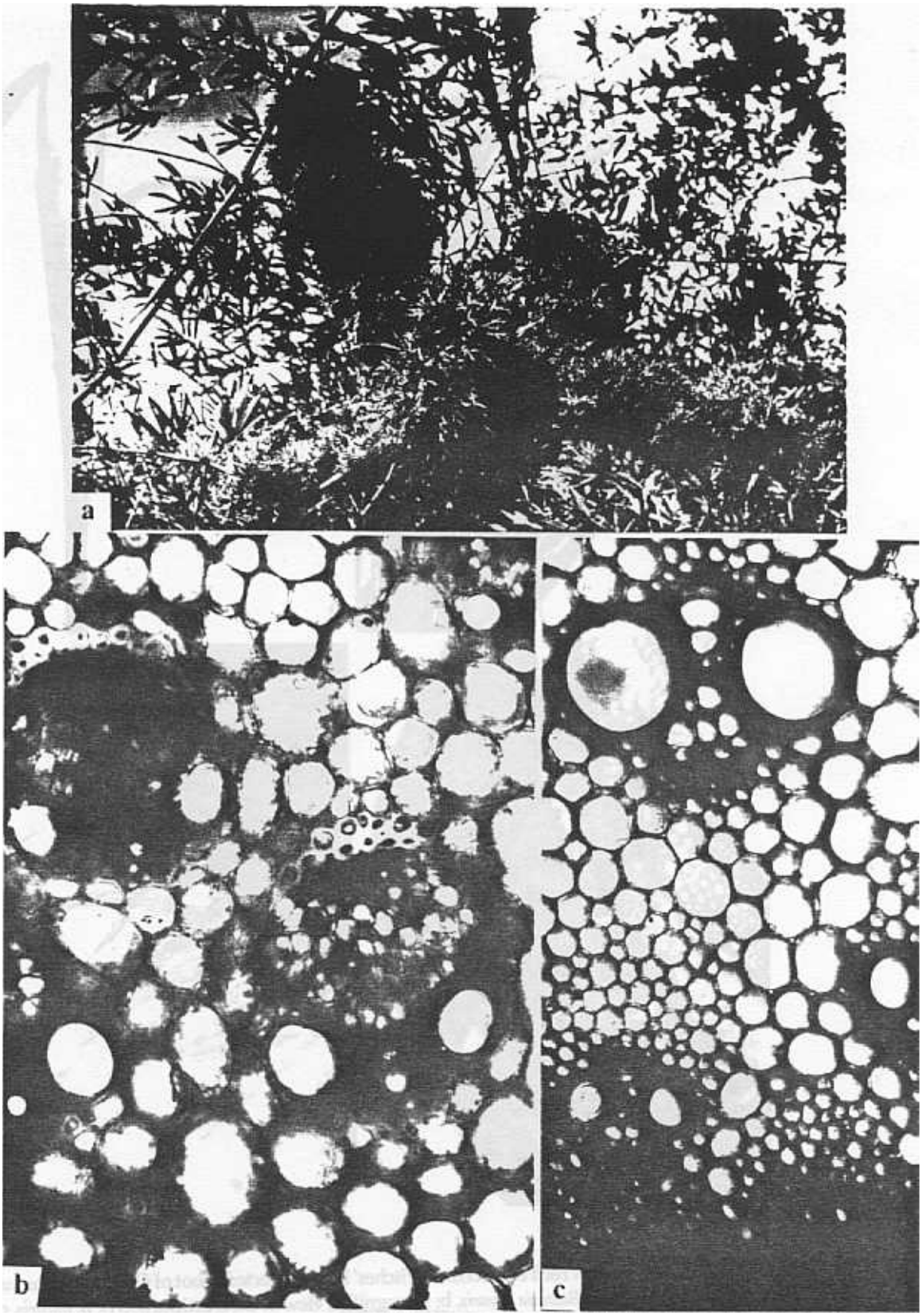


Plate 5. Little leaf disease of *Dendrocalamus strictus*. a: A close up of the diseased culms, b: Diene's staining reaction (note the deep blue staining in phloem tissues) of diseased culm internodal tissues (870 x), c: Diene's staining reaction of healthy tissues (no deep blue staining in phloem tissues) (870 x).

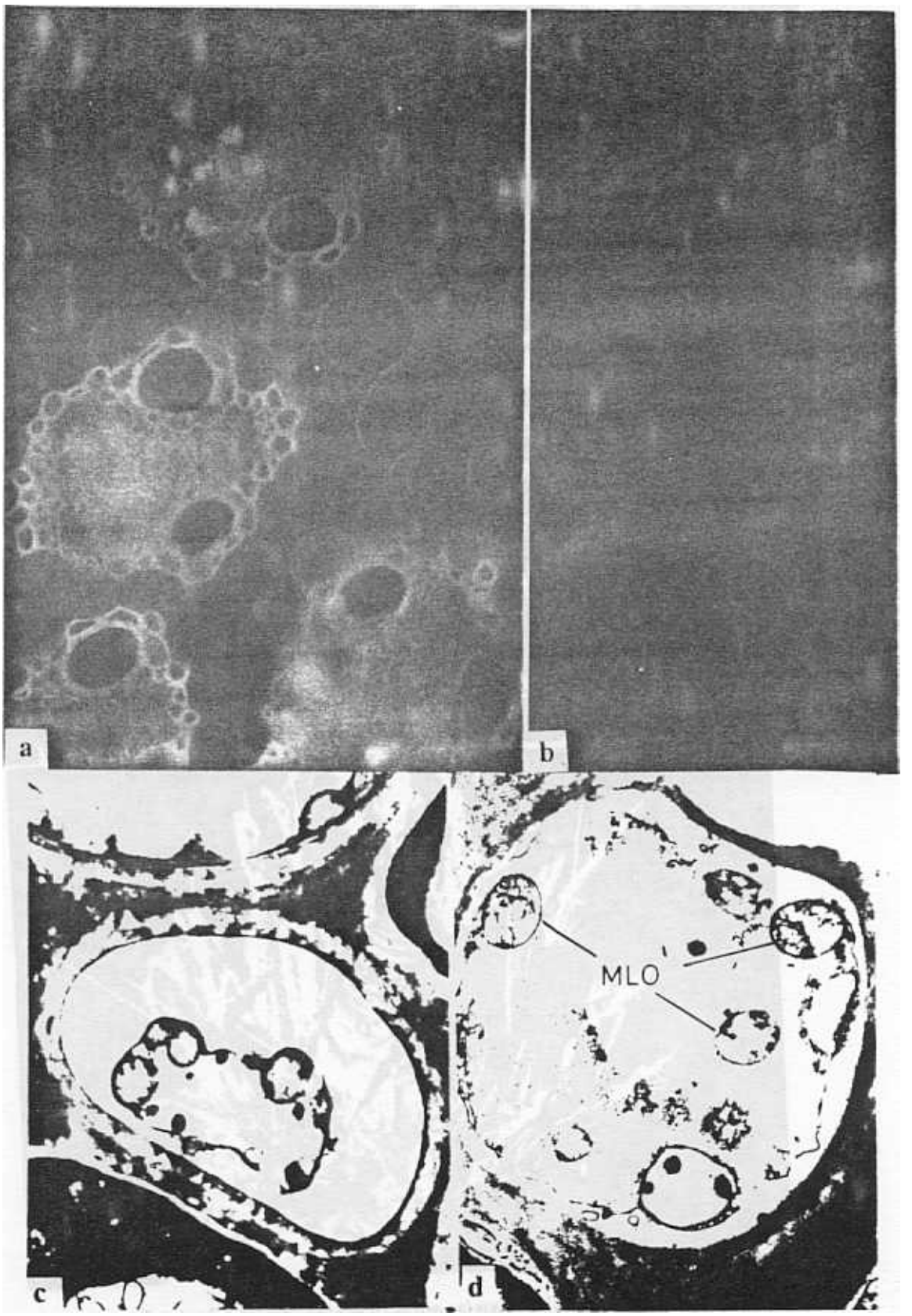


Plate 6. Little leaf disease of *Dendrocalamus strictus*. a: Diseased internodal tissues of *D. strictus* showing Aniline blue staining reaction (870 x). Note the yellow green fluorescent spots in the phloem tissues, b: Aniline blue staining reaction of healthy tissues (870 x), c,d: Transmission electron micrographs of diseased tissues showing MLOs in the phloem sieve cells (18000 x, 19200 x).

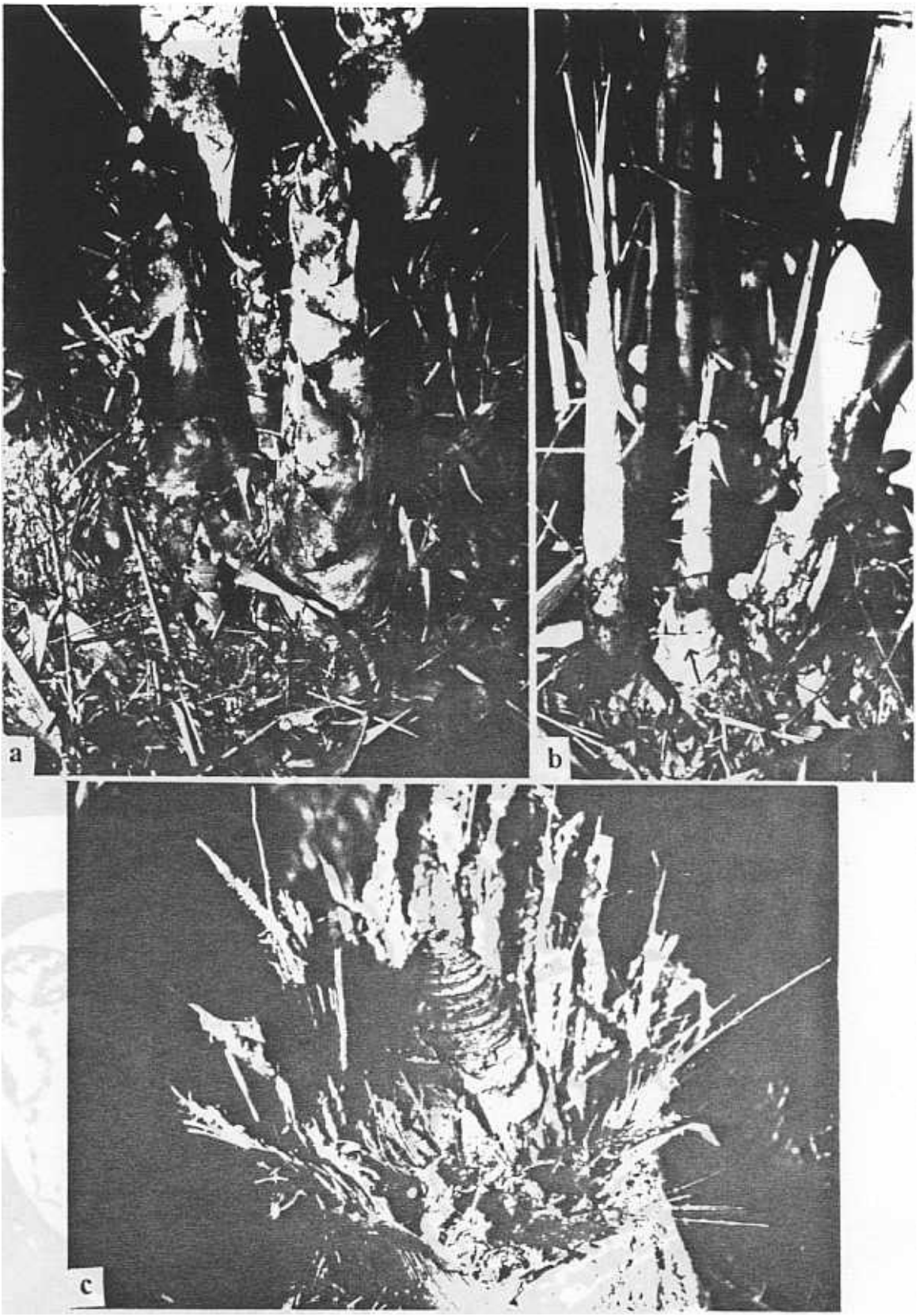


Plate 7. Rot of emerging culms of bamboos (an arrow shows the affected culms). a: Emerging culms of *Bambusa balcooa* showing typical symptoms, b: Rot of emerging culms of *Dendrocalamus longispathus*, c: A close up of emerging culm of *Bambusa bambos* showing browning and rot of culm sheaths, and unexpanded culm internodes.

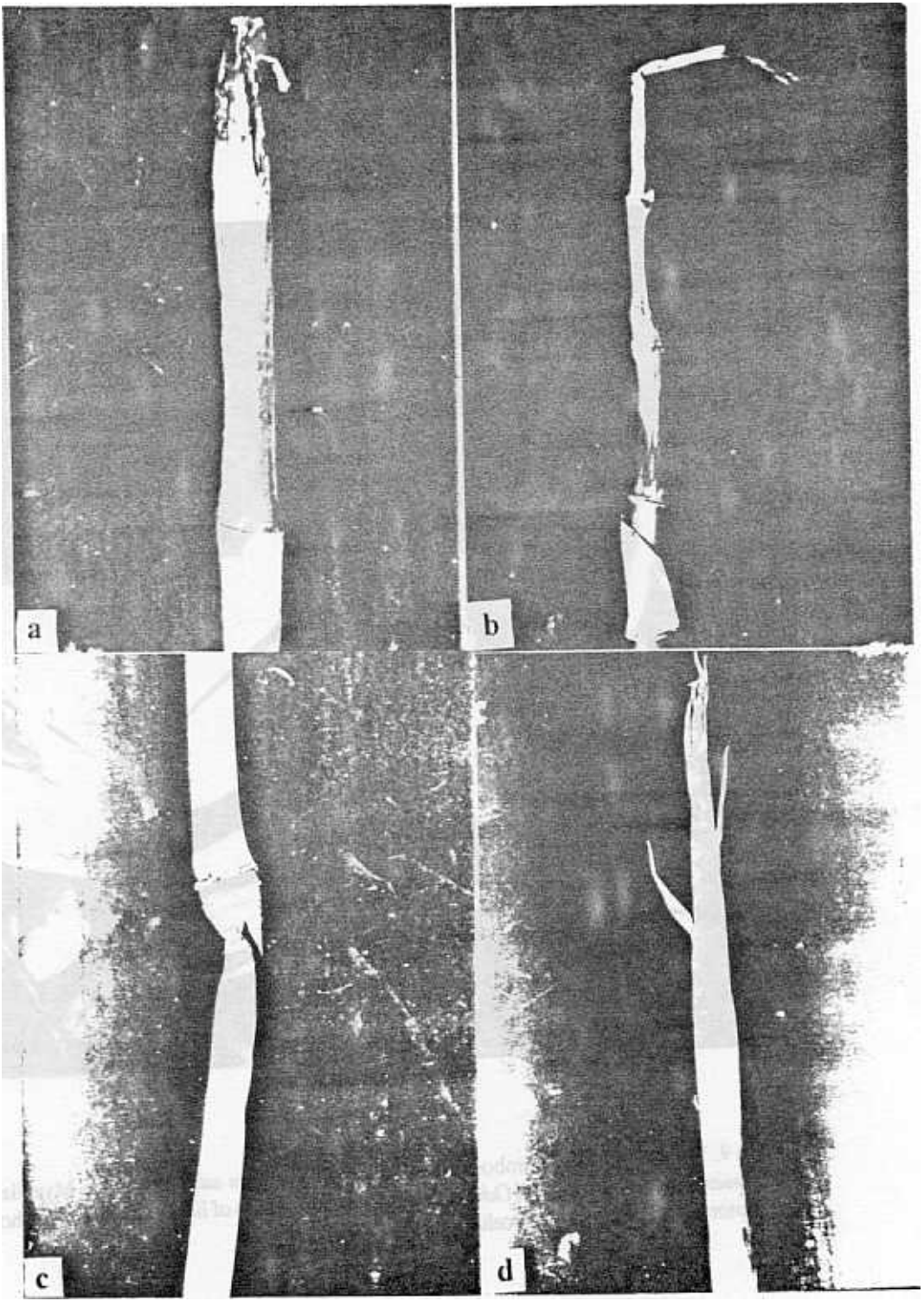


Plate 8.Rot of growing culms bamboos. a-d: different stages culm infection of *Bambusa polymorpha* caused by *Fusarium equiseti*

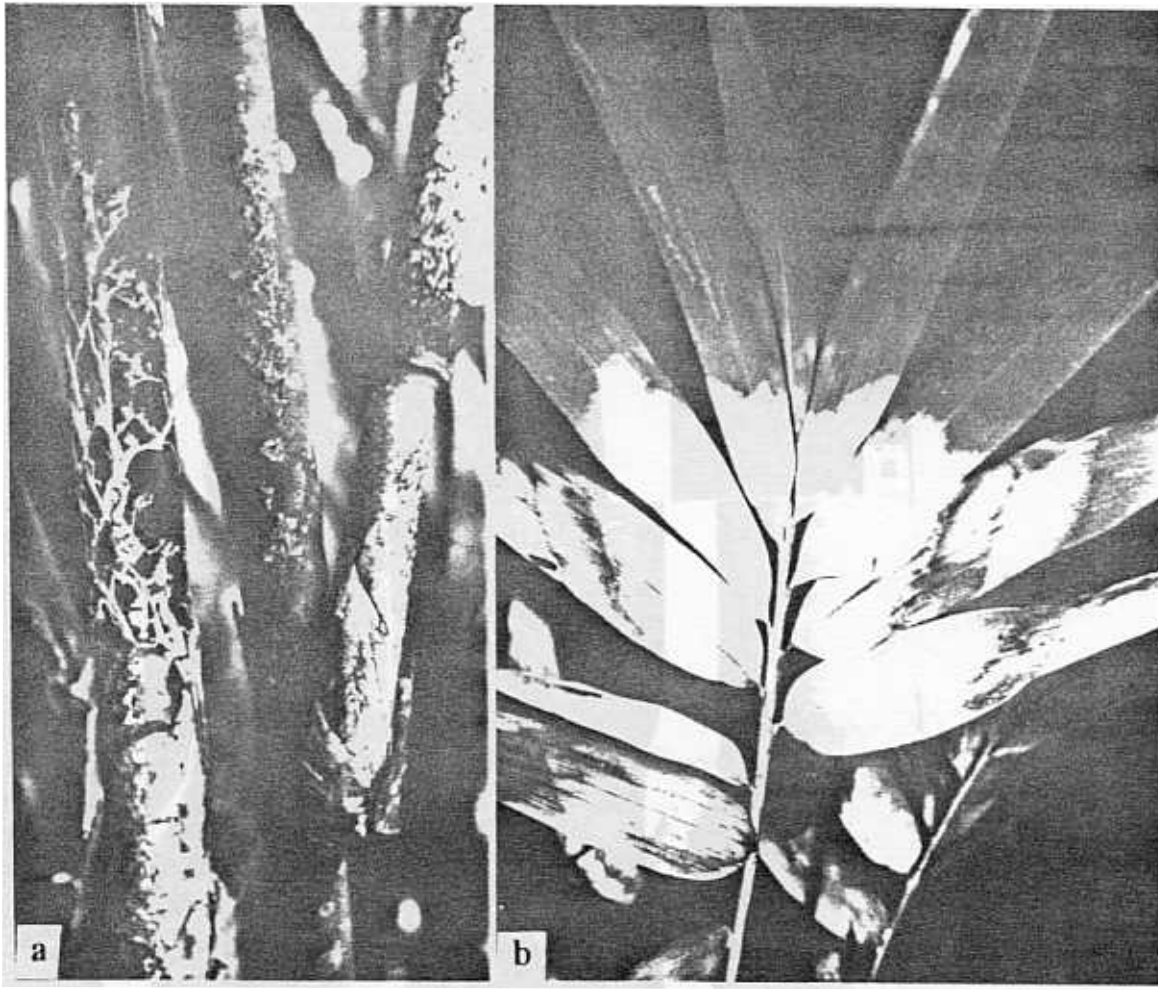


Plate 9. Thread blight of bamboos caused by *Botryobasidium salmonicolor*. a: Mycelial weft of *B. salmonicolor* on culm surface of *Ochlandra travancorica*, b: Leaves of *Bambusa polymorpha* showing blight symptoms and advancing mycelial weft.

Plate 10. Leaf rust of bamboos caused by *Dasturella divina*. a: A magnified view of uredinial sori on leaf of *Bambusa bambos* (320 x), b: A vertical section of leaf of *B. bambos* through uredinium (430 x), c:Urediniospores(680 x).

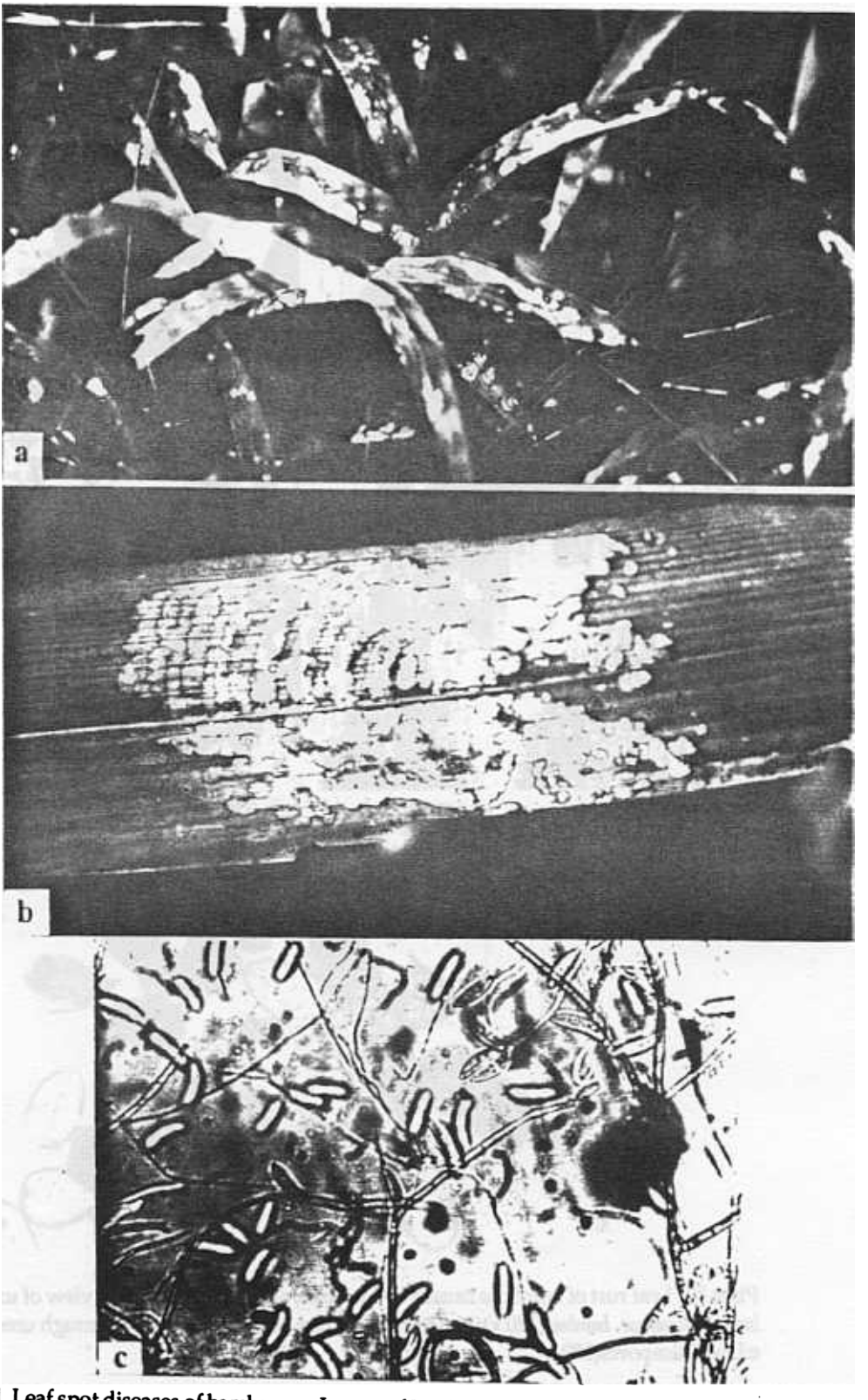
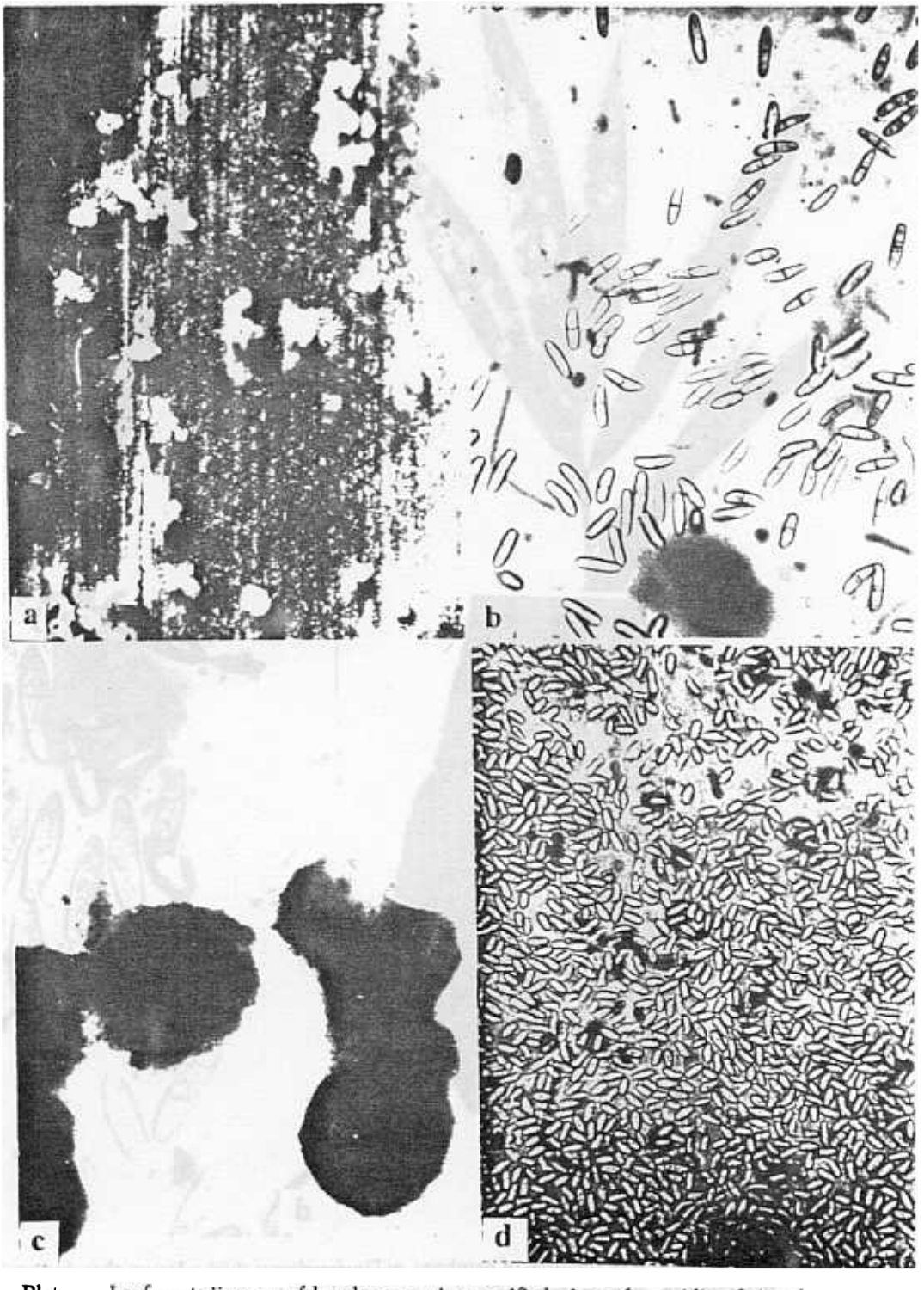


Plate 11. Leaf spot diseases of bamboos. a: Leaves of *Bambusa bambos* showing typical symptoms of zonate leaf spot caused by *Dactylaria* sp., b: Leaf of *Ochlandra travancorica* showing charasteristic large zonate spot, c: Conidiophores and conidia of *Dactylaria* sp. 670 x).



Plat Leaf spot diseases of bamboos. a: A magnified view of pycnidia of *Ascochyta* on *Dendrocalamus strictus* leaf (note the pycnidial ooze)(160 x), b: Conidia of *Ascochyta* sp.(640 x), close up of pycni of *Phoma* sp. on *D. strictus* leaf (320 x), d: Conidia of *Phoma* sp. (675 x)

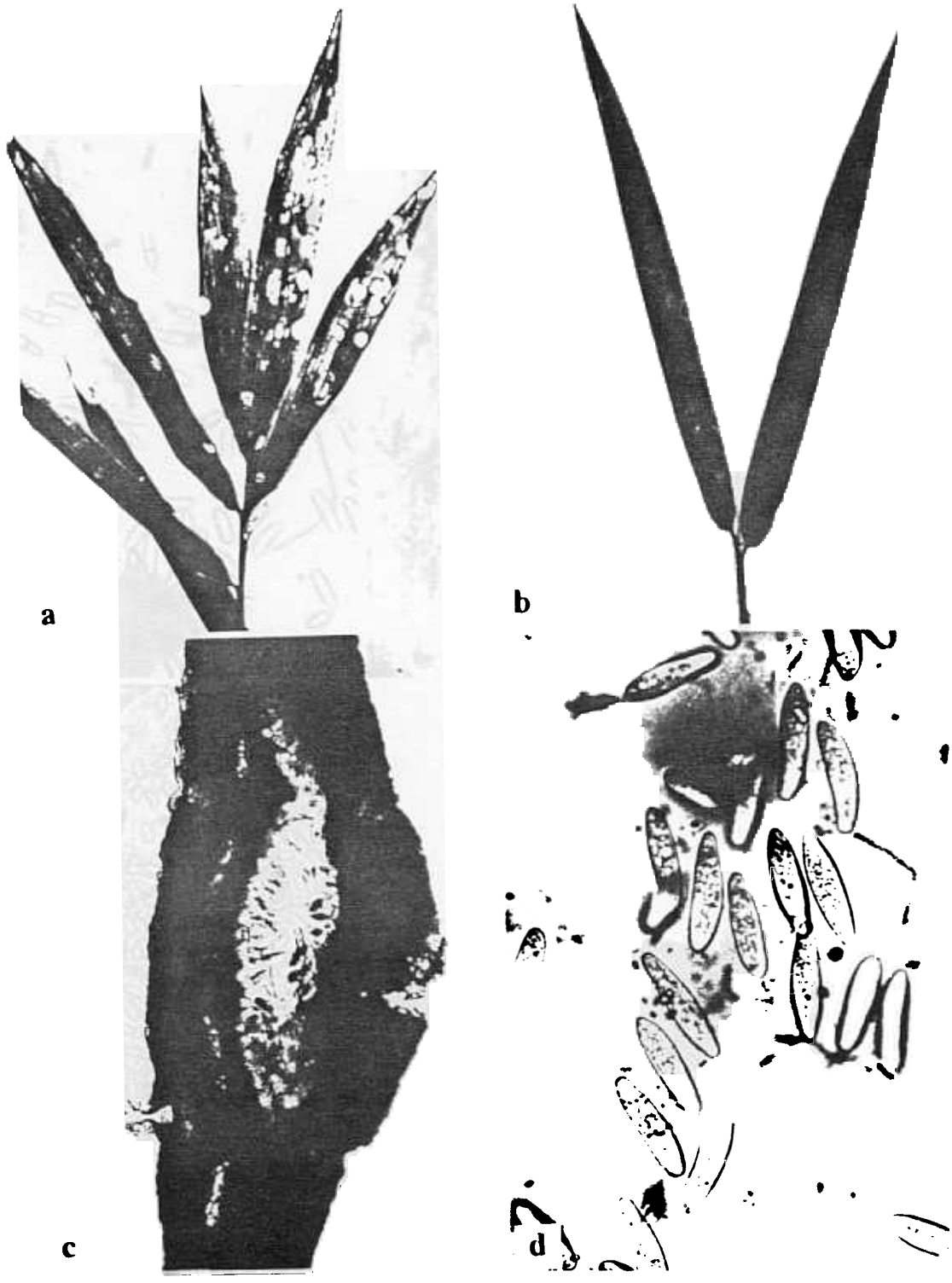


Plate 13: Leaf spot diseases of bamboos. a: *Dendrocalamus strictus* leaves showing spots caused by *Phomopsis* sp., b: Symptoms of leaf spot caused by *Petrakomyces indicus* on *Thyrsostachys* sp., c: A vertical section of leaf through pycnidium of *P. indicus* (430 x), d: Conidia of *P. indicus*(680 x)

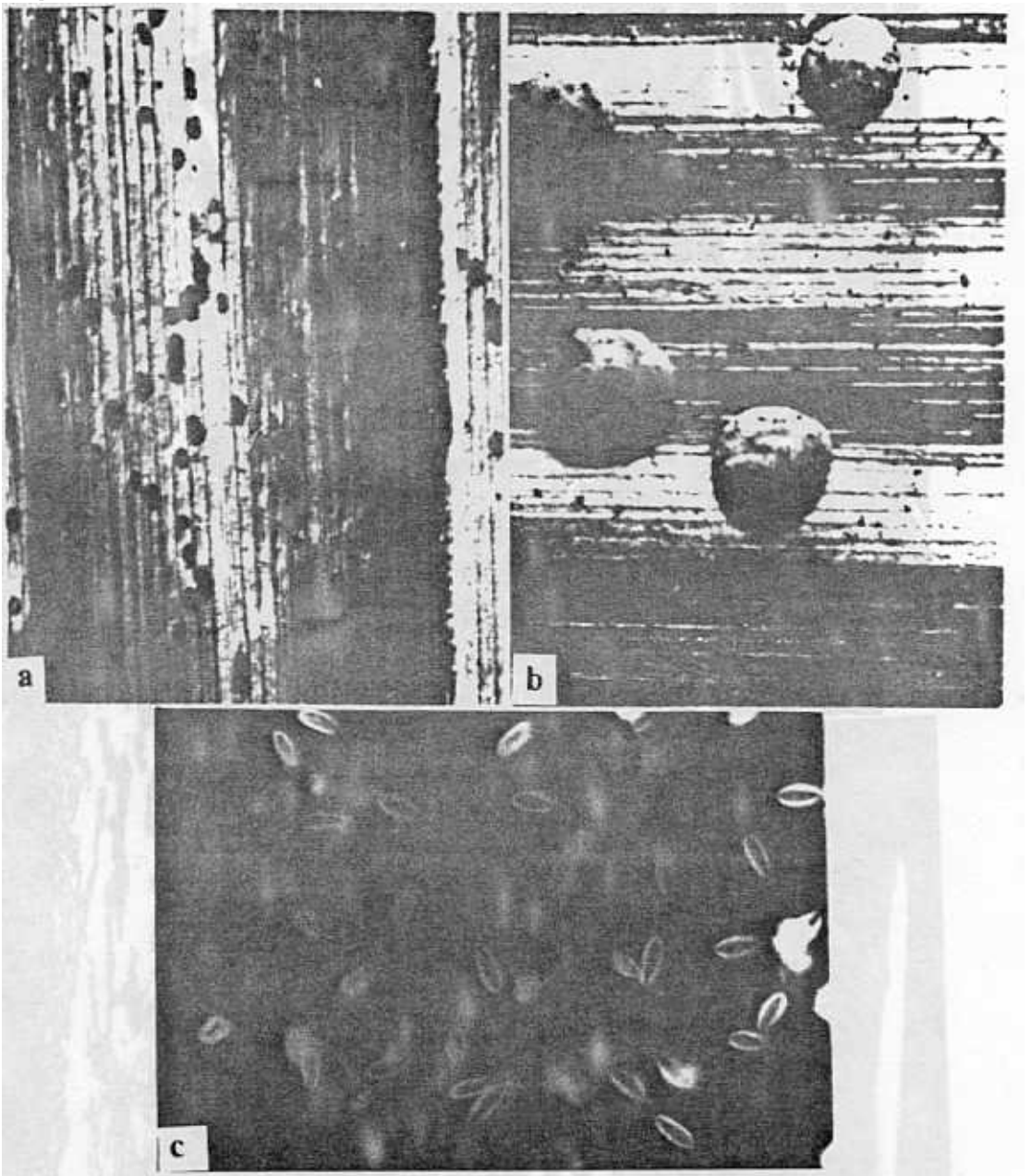


Plate 14. Leaf spot diseases of bamboos. a: *Ochlandra travancorica* leaf showing fructifications of *Rosenscheldiella* sp. (160 x), b: A magnified view of ascocarps of *Coccodiella* sp. on *O. travancorica* leaf (540 x), c: Conidia of *Pestalozziella* sp. (in dark field) causing culm sheath spot (640 x).

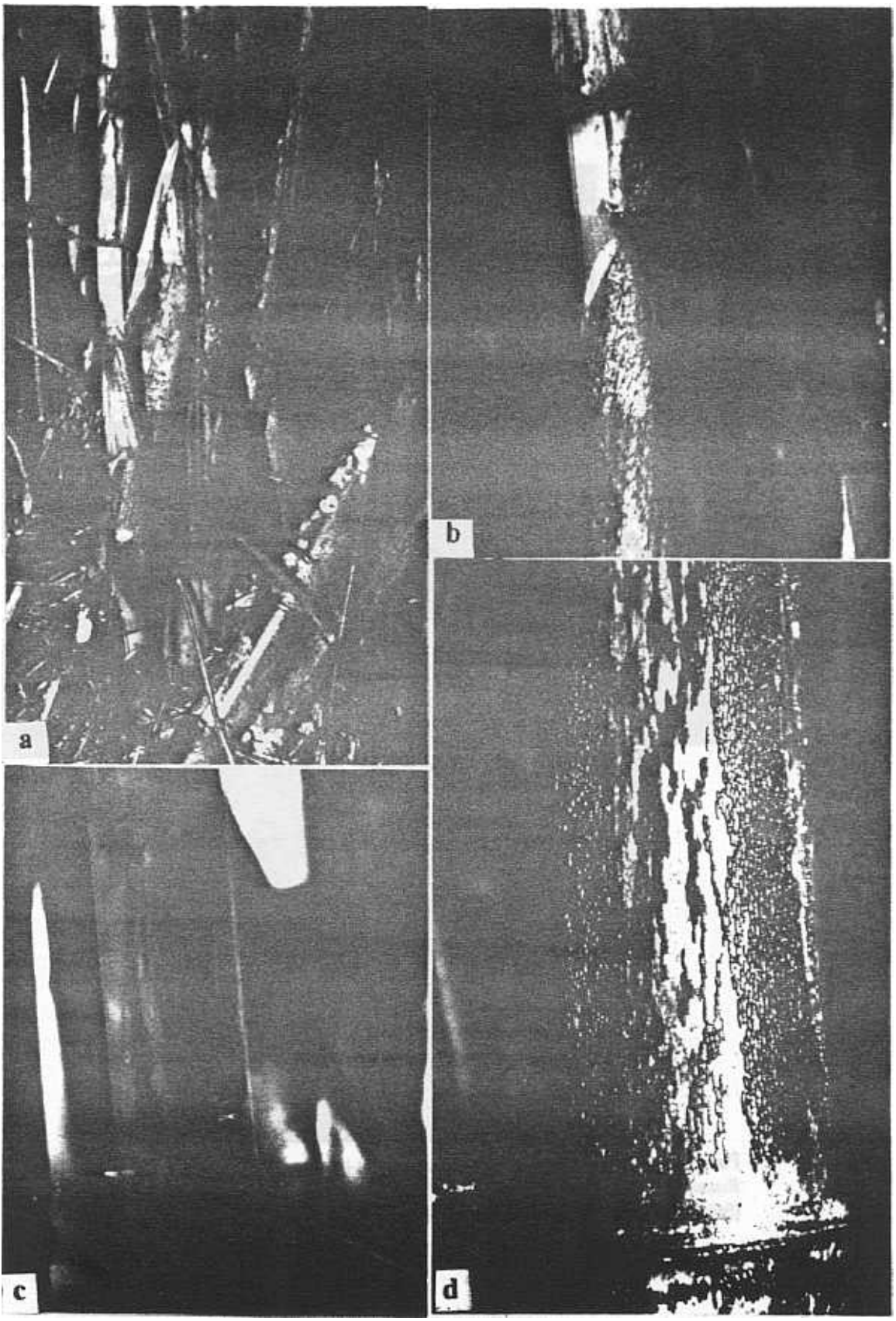


Plate 15. Culm staining and die-back of bamboos. a: A clump of *Bambusa vulgaris* showing advanced stage of infection, b: A bore hole made by insect (*Estigmenia chinensis*) on the young growing culm, c: Early staining symptoms on the culms, d: Fructifications of *Apiospora* sp. on the affected culm.

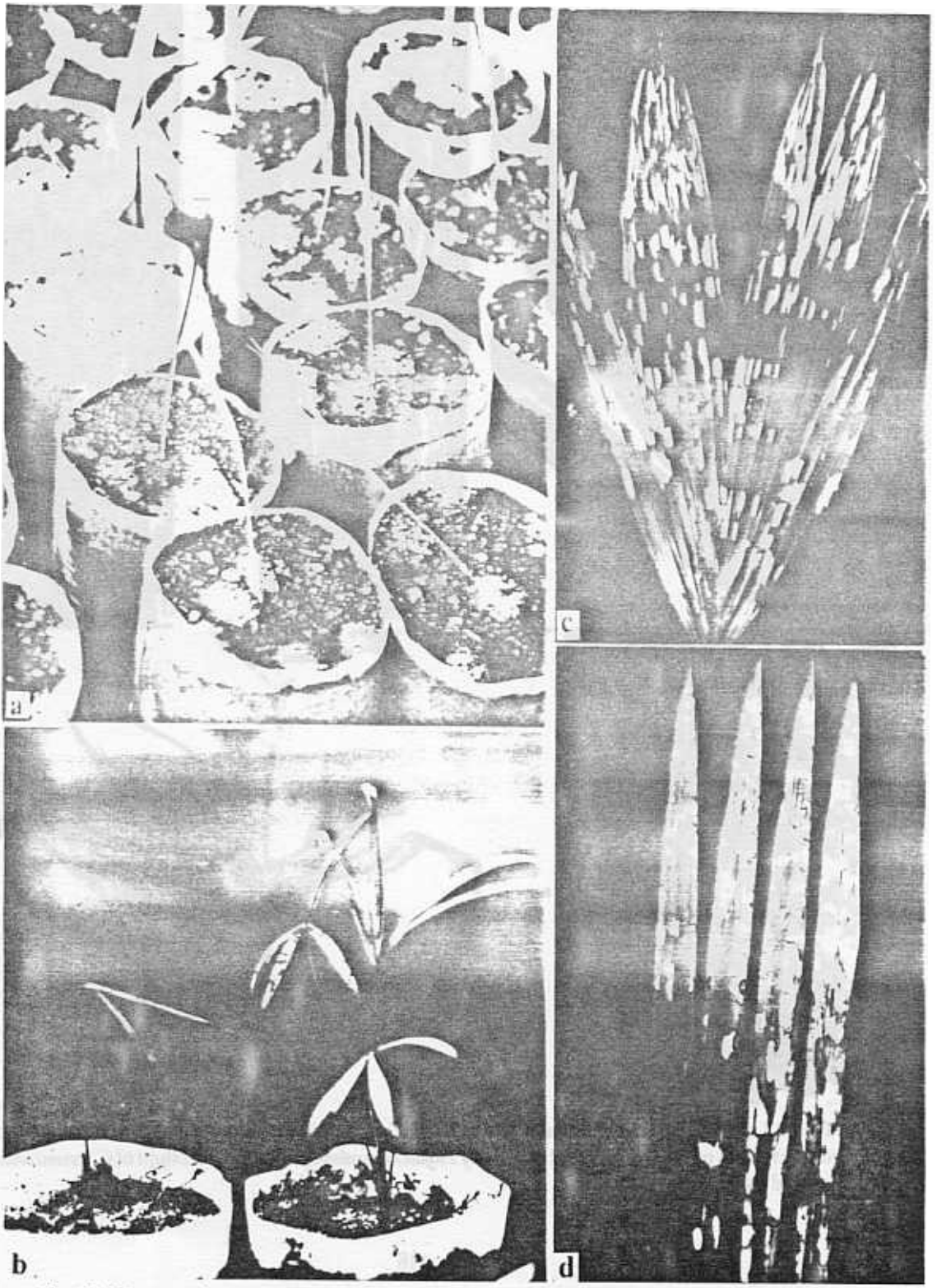


Plate16. Diseases of rattans. a: Damping-off of *C. thwaitesii* container seedlings caused by *Fusarium oxysporum*, b: seedling blight of *C. thwaitesii* caused *Guignardia calami*, c: leaf spot caused by *Colletotrichum gloeosporioides* on *C. thwaitesii*, on *C. hookerianus* (d).

Plate 17. a: Leaf spot caused by *Sphaerodothis* sp. on *C. thwaitesii*, b,c: magnified view of fructifications of the fungus on leaf, d: leaf spot caused by *Phyllachora calamigena*, e: thread blight of *C. travancoricus* caused by *Pellicularia filamentosa*.