Seedling diseases of some important forest tree species and their management

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Forest nurseries in Karnataka State provide planting stock for afforestation programmes. Consequently, to determine the kinds of diseases present in the nurseries, and the damage they cause an extensive survey was conducted for four important seedling diseases, i.e. (i) leaf spot and blight disease of *Dendrocalamus strictus* caused by *Myrothecium roridum* (ii) leaf spot disease of *D. strictus* caused by *Cercospora apii*, (iii) wilt disease of *Hardwickia binata* caused by *Fusarium oxysporum* and (iv) leaf blight disease of *Terminalia catappa* caused by *Fusarium solani*. Pathogenicity tests, made by inoculating seedlings with putative pathogens, produced disease symptoms identical to those observed in the field. Field evaluation of different fungicides at 0.2% concentration was carried out against three nursery diseases. Bavistin followed by Dithane M-45 and Captan reduced leaf spot and blight disease intensity of *D. strictus* caused by *M. roridum*. Both Bavistin and Benlate were efficient and could be recommended to manage leaf spot disease of *D. strictus* caused by *C. apii*. Bavistin followed by Captan and Dithane M-45 reduced wilt disease incidence of *H. binata* caused by *F. oxysporum*. *In vitro* evaluations of plant extracts, biological agents and fungicides were carried out against *F. solani*, the incitant of leaf blight disease on *T. catappa* seedlings. The plant extracts of *Lantana camera* and *Azadirachta indica* were efficient. Also, the biocontrol agents such as *Trichoderma harzianum* and *T. viride* were efficient while among the different fungicides tested, Captan and Dithane M-45 were efficient in inhibiting the mycelial growth of the fungus.

Introduction

The forest cover in most tropical countries is declining at an alarming speed. A recent account of the world's forests, FAO (1997) shows that with the exception of India, where there has been a small improvement, all tropical countries have lost forest cover during the 1990–1995 period. The deforestation rate is highest in Central America and South East Asia amounting to 1.2 and 1.7% annually (Schmidt 2000).

Fungal diseases are a serious problem in forest regeneration and sometimes fungi can cause heavy mortality in nurseries. Many of the fungus pathogens are carried through seeds into forest nurseries and become established on seedlings. Apart from these seed-borne fungal pathogens, soil-borne fungal pathogens have also been shown to be devastating by attacking young seedlings in forest nurseries. These seedlings are particularly susceptible to several diseases because of their tender tissues and as they often have difficulty in establishing themselves. When such diseased, substandard seedlings are used as planting stock, they further spread the disease to plantations and forests, causing heavy damage. Since seedlings grown in forest nurseries are the primary sources of planting stock, it is necessary to investigate the seedling diseases and apply control measures either before sowing the seeds or at the seedling stage. There is a strong need for better understanding of these microorganisms, the diseases they cause and their management.

Materials and methods

In the present investigations four seedling diseases were investigated in forest nurseries in Mysore District, Karnataka state.

Leaf spot and blight disease of *Dendrocalamus strictus*

Out of 135 species of bamboo grown in India *Dendrocalamus strictus* (Roxb.) Nees is one of the important forestry species that is grown in plantations and agro-forestry systems. While surveying for nursery diseases of *D. strictus*, leaf spot and blight were commonly encountered among young seedlings (10-month-old) in a forest nursery in Kukkarahalli, Mysore. The disease resulted in defoliation and weakening of seedlings. Infected leaves showed characteristic pale brown spots and blight symptoms (Figs. 1 and 2), and when severe resulted in distortion and defoliation of leaves.

Leaf spot disease of *Dendrocalamus strictus*

This foliar disease was observed among 6-month-old seedlings of *D. strictus* in a forest nursery in Paduvaralli area, Mysore District of Karnataka State. Affected leaves showed characteristic brown spots (Fig. 3). When severe the disease resulted in drying and defoliation of leaves. Further, infection sometimes spread to stems causing seedling death.

Wilt disease of *Hardwickia binata*

Hardwickia binata (Roxb.) is an important hardwood tree well distributed in the tropical and subtropical regions of India. It is considered as one of the important forest tree species in afforestation programmes. During a survey of forest nurseries, wilt disease of *H. binata* was observed among young seedlings in Nagavala forest nurseries of Mysore District, Karnataka State. The wilt symptoms started from the tip of the plant and along the margin of the leaves (Fig. 8). Subsequently, the disease advanced downward causing defoliation and eventual death of seedlings.

Leaf blight disease of *Terminalia catappa*

Terminalia catappa L., is commonly called ‘tropical almond’ or ‘Indian almond’. The seeds are eaten raw, the leaves are used as food for Tasar silk worms, the roots and bark are used for tanning, while the fruits are used as a source of dye (Nayer et al. 1994). Because of its multifarious uses, it has been given due importance in plantation programmes in nurseries. During a recent survey of forest nurseries, a severe leaf blight was observed on young seedlings of *T. catappa* (Fig. 9) in a forest nursery in Nagavala, Mysore.

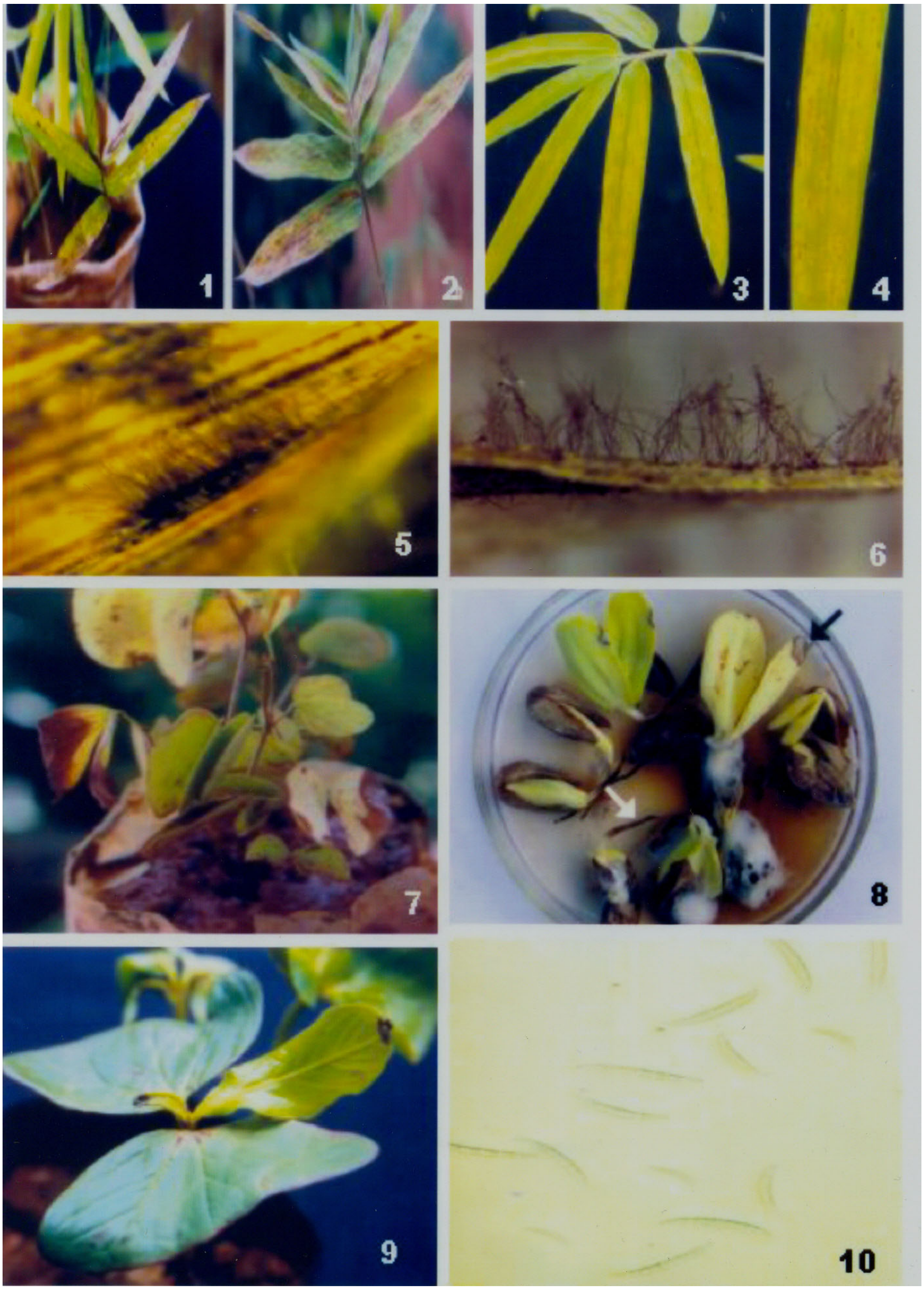

Figure 1. and 2. Seedlings of *Dendrocalamus strictus* showing leaf spot and blight disease.
Figure 3. and 4. Seedlings of *Dendrocalamus strictus* showing leaf spot disease caused by *Cercospora apii*.
Figure 5. and 6. Sporulation of *Cercospora apii* from the leaf spot of *Dendrocalamus strictus.*
Figure 7. Initiation of wilt symptom in seedlings of *Hardwickia binata* caused by *Fusarium oxysporum.*
Figure 8. Seedlings of *Hardwickia binata* showing wilt and root rot symptom on water-agar medium caused by *Fusarium oxysporum*.
Figure 9. Seedlings of *Terminalia catappa* showing leaf blight disease caused by *Fusarium solani.*
Figure 10. Microconidia and macroconidia of *Fusarium solani.*

For the purpose of identifying the pathogen, diseased seedlings were collected in sterilised polythene covers, brought into the laboratory where they were washed thoroughly under running tap water to remove debris. Next, they were washed in distilled water and surface sterilised with 4% NaOCl. The diseased parts were then cut into 1cm-long pieces. One set of pieces was placed on three layers of wet blotters equidistantly in Perspex plates and another set plated onto PDA medium. Both sets were incubated for 7 days under 12h/12h alternate cycles of near ultra violet light and darkness at 22±2 ^{0}C. After 8 days of incubation the diseased bits were evaluated for the causal organism.

Isolation, identification and multiplication of the causal organism

The diseased parts of the leaves were analysed in the laboratory. The causal micro-organism was isolated and grown on PDA medium. To study the pathogenicity of the micro-organism, a spore suspension was prepared from 8-day-old sporulating colonies using sterile distilled water. The spore load was calculated haemocytometrically and its load was adjusted to $5x10^{6}$ spores/ml of suspension. This spore suspension was inoculated to 50 young seedlings. The inoculated seedlings were incubated in a moist chamber and observed for disease symptoms.

Transmission studies

Transmission studies were carried out by using a water-agar and sand method. Four replicates of 100 seeds each inoculated with causal micro-organism were used to determine pathogenicity.

Management of seedling diseases

In vitro evaluation of *Terminalia catappa*

To determine the effect of fungicides, plant extracts and biological agents on the leaf blight causal organism of *Terminalia catappa*, an *in vitro* evaluation was carried out. The efficacy of the fungicides and plant extracts were tested using the Poisoned Food Technique (Grover and Moore 1962).

For *in vitro* fungicidal evaluation, 0.2 g of the fungicides Bayleton, Ridomil, Dithane M-45, Captan and Hadron were separately dissolved in 100 ml of sterile, distilled water, then 5 ml of fungicide solution was thoroughly mixed with 15 ml of PDA medium (v/v 5:15) at 45^{o} C. This was poured to a series of sterilised glass Petri plates. After solidification of the medium the plates were inoculated with 3 mm culture discs of the test micro-organisms (Fig. 11).

For the *in vitro* evaluation of plant extracts, leaf materials of selected plants viz., *Bacopa monniera*, *Acalypha indica*, *Azardirachta indica*, *Lantana camara* and *Derris indica* were studied. Each plant extract was separately mixed with 15 ml of molten PDA (v/v 5:15) and poured into sterilised glass Petri plates. After solidification the plates were inoculated with 3 mm diameter culture discs of micro-organisms. The colony diameter of the fungus was measured after 4, 6 and 8 days of incubation and compared with the colony growth of the fungus in the control plates (Fig. 12).

The fungal antagonistic effect of putative biocontrol fungi such as *Trichoderma harzianum, T. viride, T. koningii* and *Gliocladium virens* were tested *in vitro* for their bio-efficiency in inhibiting the punitive pathogens using the 'Dual Culture Technique' (Dennis and Webster 1971).

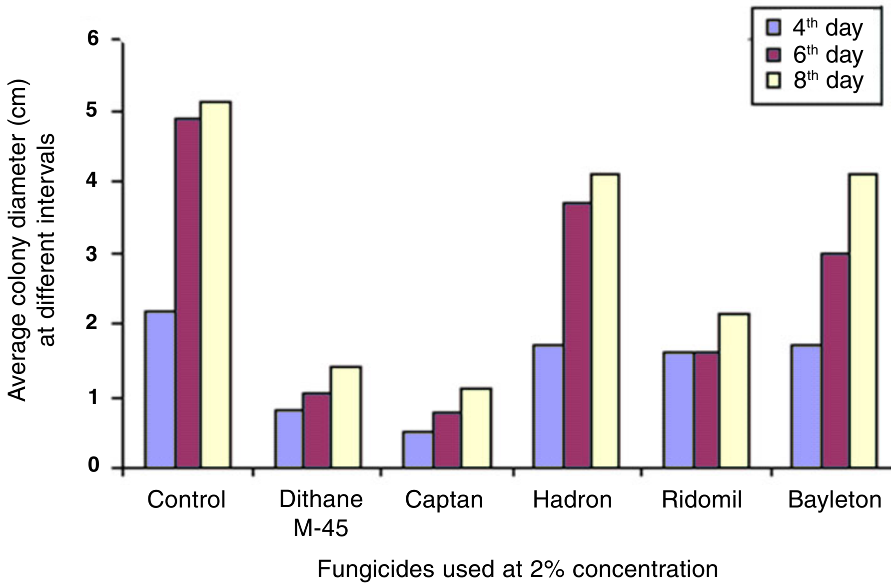

Figure 11. Effect of different fungicides on the colony growth of *Fusarium solani in vitro.*

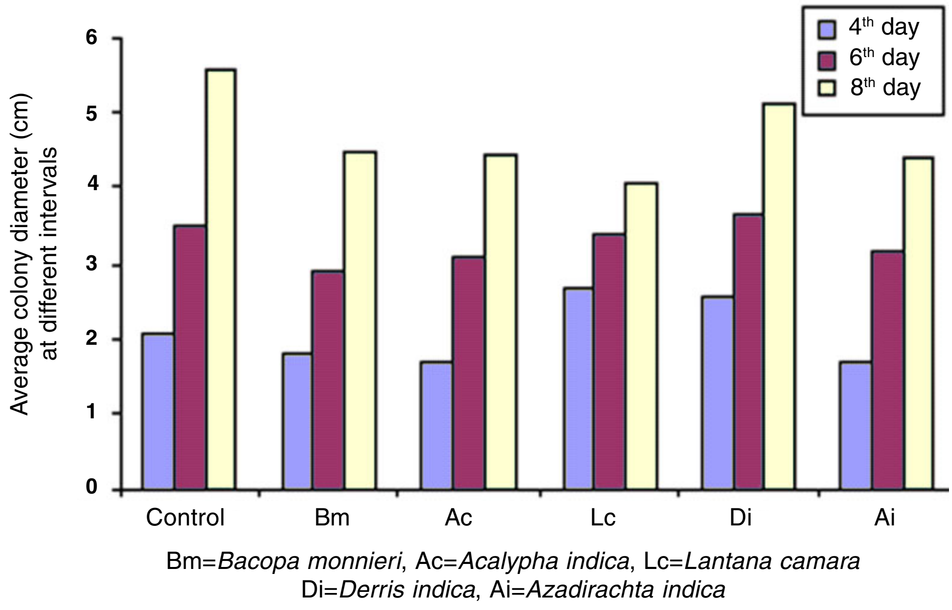

Figure 12. Effect of different fungicides on the colony growth of *Fusarium solani in vitro.*

Field evaluation of fungicides

Diseased seedlings grown in poly bags were used to study the effect of the different fungicides under field conditions. The same fungicides as used for *in vitro* studies were tested at 0.2% concentration. The fungicidal treatments were carried out by spraying the fungicidal solution onto the seedling and also by drenching the soil in which the seedlings were raised. These fungicidal treatments were applied twice at an interval of 10 days. For each treatment there were four replicates of 50 seedlings each. After 30 days of treatment, the effectiveness of the different fungicides was evaluated by calculating the percent disease incidence and percent disease reduction. For each test plant the total leaves and total diseased leaves were counted and the average of the 50 seedlings in four replicates was calculated.

Percent disease incidence (PDI) was calculated using the formula:

$$\text{PDI} = \frac{\text{Number of diseased leaves on each plant}}{\text{Total number of leaves on each plant}} \text{ X } 100$$

Percent disease reduction (PDR) was calculated using the formula

$$\text{PDI} = \frac{\text{PDI in control-PDI in treatment}}{\text{PDI in control}} \text{ X } 100$$

In all the cases seedlings without fungicide treatment served as the control.

Results

Leaf spot and blight of *Dendrocalamus strictus*

Laboratory examination of diseased *D. strictus* leaves revealed a high incidence of the fungus *Myrothecium roridum*, both when incubated on wet blotters and also on PDA medium. Thirty days after inoculation of young seedling with *M. roridum* pale brown spots and blights symptoms (identical to those observed in the field) developed on seeding leaves. Re-isolations made from artificially inoculated leaves yielded the same fungus and confirmed its pathogenicity.

In the water-agar seedling test 76% of the seeds with severe infection failed to germinate due to infected embryos (Table 1). Out of the remaining seeds which germinated 11.5% showed post-emergence mortality. The fungus sporulated on dead and diseased seedlings. Some of seedlings were killed even before the first leaf opened. Sometimes there was browning and rotting of the roots. Overall, 5.5% of the seedlings remained healthy. Severely infected seeds were colonised by *M. roridum* and completely rotted. In the sand method test 85% of the inoculated seeds failed to germinate (Table 1). Pre-emergence mortality was greater for the sand method than for the water agar method. Eight percent of the seedlings remained healthy compared to 61% in the control.

The effectiveness of the different fungicidal treatments on percent disease incidence and on percent disease reduction are shown in Table 2. Among the different fungicides tested, Bavistin treated seedlings showed ~ 11.6% disease incidence and 78.4% disease reduction followed by Dithane M-45 with 12.2 % and 76.5%, Captan with 13.3% and 75.1% and Bayleton with 21.3% disease incidence and 60.4% disease reduction, respectively.

Table 1. Seed to seedling transmission of *Myrothecium roridum* on *Dendrocalamus strictus.*

Method	Treatment	Seed germination Mean ± SE	Pre-emergence mortality or ungerminated seeds Mean ± SE	Post-emergence mortality Mean ± SE	No. of diseased seedlings Mean ± SE	No. of healthy seedlings Mean ± SE
Water-agar method	Control	75±1.29	25.00±1.29	0.00±0.00	0.5±0.50	74.50±1.70
	Inoculated	24.00±0.91	76.00±0.91	11.50±1.32	7.00±0.70	5.50±1.44
Sand method	Control	62.00±1.08	38.00±1.08	0.00±0.00	1.00±0.70	61.00±1.63
	Inoculated	15.00±1.47	85.00±1.47	3.25±1.10	3.75±0.85	8.00±0.40

Values are the means of four replicates. SE = Standard error.

Table 2. Field evaluation of fungicides against leaf spot and blight disease of *Dendrocalamus strictus* caused by *Myrothecium roridum.*

Treatments	PDI Mean ± SE	PDR Mean ± SE
Control	54.43±2.52[e]	0.00±0.00[a]
Captan	13.31±1.13[a]	75.09±3.31[d]
Bavistin	11.62±0.54[a]	78.44±1.68[d]
Dithane M-45	12.50±2.62[a]	76.49±5.54[d]
Bayleton	21.26±1.36[b]	60.35±4.39[c]
Ridomil	31.06±1.30[d]	42.84±1.93[b]
Fungihit	33.81±1.69[d]	37.60±3.65[b]

The values are the means of four replicates. In each column, values followed by the same letter are not significantly different at $P \leq 0.05$ level when subjected to Duncan's multiple range test.
PDI = percent disease incidence; PDR = percent disease reduction; SE = Standard error.

Leaf spot disease of *Dendrocalamus strictus*

Laboratory analysis of the disease parts of the leaves of *D. strictus* affected with leaf spot indicated a high incidence of the fungus *Cercospora apii* (Figs. 5 and 6), when incubated both on wet blotters and on PDA medium. *C. apii* when inoculated to young seedlings resulted in the development of identical spots within 25 days. It was confirmed that *C. apii* causes leaf spot disease with characteristic brown spots among young seedlings of *D. strictus*. In the water agar-seedling symptom test, 69% of the seeds showed pre-emergence mortality and 11% of the seeds suffered post-emergence mortality (Table 3). Based on germinated seedlings, 9.75% showed disease symptoms of characteristic brown spots. The diseased parts of the leaves showed sporulation of fungus. Although there was 31% germination, 11% of the seedlings could not survive as the sprouted seedlings were killed by the pathogen. In the sand method there was remarkably more pre-emergence mortality of 81% than post-emergence mortality of 9.5% when compared with the 44 and 1%, respectively for the un-inoculated control. In this method about 8.25% of the seeds resisted infection and developed as healthy plants. Inoculated seeds in the water agar method test showed more diseased seedlings than in the sand method.

Only fungicides were considered in the field evaluation of the different treatments against leaf

Table 3. Seed to seedling transmission of *Cercospora apii* on *Dendrocalamus strictus.*

Method	Treatment	Seed germination Mean + SE	Pre-emergence mortality or ungerminated seeds Mean + SE	Post-emergence mortality Mean + SE	No. of diseased seedlings Mean + SE	No. of healthy seedlings Mean + SE
Water-agar	Control	63.00+3.41	37.00+3.41	2.75+1.10	1.00+0.70	49.25+7.23
method	Inoculated	31.00+1.29	69.00+1.29	11.00+1.47	9.75+0.85	9.75+1.49
Sand	Control	56.00+1.77	44.00+1.77	1.00+0.40	0.75+0.75	45.25+3.68
method	Inoculated	19.00+1.29	81.00+1.29	9.50+1.04	1.25+0.75	8.25+0.85

Values are the means of four replicates. SE = Standard error.

spot disease. Table 4 gives the effectiveness of the different fungicidal treatments on percent disease incidence and percent disease reduction. Among the fungicides tested, Bavistin-treated seedlings showed ~11.7% disease incidence and 76.3% disease reduction followed by Benlate with 15.3% and 69%, Bayleton with 19.8% and 59.9% while Dithane M-45 showed 20% disease incidence and 59.5% disease reduction.

Table 4. Field evaluation of fungicides against leaf spot disease of *Dendrocalamus strictus* caused by *Cercospora apii.*

Treatments	PDI Mean + SE	PDR Mean + SE
Control	49.43+0.41[e]	0.00+0.00[a]
Bavistin	11.68+0.95[b]	76.32+2.16[d]
Benlate	15.31+1.24[c]	69.00+2.54[c]
Bayleton	19.81+1.53[a]	59.94+2.96[e]
Dithane M-45	20.00+0.64[c]	59.52+1.39[c]
Fungihit	25.93+0.73[d]	47.48+1.90[b]
Hadron	27.00+0.88[d]	45.36+1.91[b]

The values are the means of four replicates. In each column, values followed by the same letter are not significantly different at $P \leq 0.05$ level when subjected to Duncan's multiple range test.
PDI = Percent disease incidence; PDR = Percent disease reduction; SE = Standard error.

Wilt disease of *Hardwickia binata*

Diseased seedlings analysed in the laboratory had a high incidence of the fungus *Fusarium oxysporum*. The diseased parts showed heavy sporulation of the fungus when incubated both on wet blotters and on PDA medium. In the water agar seedling symptom test ~45.3 % of the seeds showed pre-emergence mortality (Fig. 7). The other 54.8% of the seeds germinated out of which 29% showed post-emergence mortality (Table 5). Diseased seedlings showed rotting of the roots and characteristic wilt symptoms on the leaves. The ungerminated seeds showed rotting due to heavy colonisation by the fungus. Among inoculated seeds, 9% developed into healthy seedlings. Un-inoculated healthy seeds produced healthy seedlings. In the sand method 68.5% of the inoculated seeds showed germination failure and ~13.8% showed post-emergence mortality when compared to 27.8% and 3.3% of the uninoculated healthy seeds (Table 5).

Table 5. Seed to seedling transmission of *Fusarium oxysporum* in *Hardwickia binata*.

Method	Treatment	Seed germination Mean ± SE	Pre-emergence mortality or ungerminated seeds Mean ± SE	Post-emergence mortality Mean ± SE	No. of diseased seedlings Mean ± SE	No. of healthy seedlings Mean ± SE
Water-agar method	Control	81.50±4.03	18.50±4.03	0.75±0.75	0.5±0.50	80.00±4.52
	Inoculated	54.75±0.75	45.25±0.75	29.00±0.40	13.75±1.31	9.00±1.87
Sand method	Control	72.25±1.65	27.75±1.65	3.25±1.49	1.25±0.75	67.75±2.42
	Inoculated	31.50±0.64	68.50±0.64	13.75±2.01	3.00±1.08	14.75±2.09

Values are the means of four replicates. SE = Standard error.

The effectiveness of the different fungicides under field conditions is given in Table 6. The field evaluations revealed Bavistin to be the most effective fungicide in controlling the disease showing ~18.8% disease incidence and 70.4% disease reduction followed by Captan, which showed 20% disease incidence and 67.6% disease reduction. Dithane M-45 was effective, with a disease incidence of 24.5% and percent disease reduction of 60.3 compared to 62.5% disease incidence and no percent disease reduction in the control.

Table 6. Field evaluation of fungicides against leaf spot disease of *Hardwickia binata* caused by *Fusarium oxysporum*.

Treatments	PDI Mean ± SE	PDR Mean ± SE
Control	62.50 ± 2.72^{c}	0.00 ± 0.00^{a}
Captan	20.00 ± 1.08^{b}	67.62 ± 2.42^{cd}
Bavistin	18.75 ± 3.77^{a}	70.43 ± 5.00^{d}
Dithane M-45	24.50 ± 1.70^{a}	60.32 ± 3.82^{cd}
Bayleton	27.00 ± 2.41^{a}	56.49 ± 4.33^{c}
Ridomil	35.00 ± 2.54^{b}	43.74 ± 4.44^{b}
Fungihit	39.00 ± 3.24^{b}	37.86 ± 2.83^{b}

The values are the means of four replicates. In each column, values followed by the same letter are not significantly different at $P \leq 0.05$ level when subjected to Duncan's multiple range test. PDI = Percent disease incidence; PDR = Percent disease reduction; SE = Standard error.

Leaf blight disease of *Terminalia catappa*

Diseased seedling screened for the causal organism revealed the presence of the fungus *Fusarium solani* (Fig. 9). When this fungus was inoculated onto young seedlings it produced identical symptoms within 30 days. Re-isolations from the inoculated leaves yielded the same fungus and proved its pathogenicity.

Among the different fungicides tested *in vitro* against the mycelial growth of *F. solani*, Captan and Dithane M-45 showed high fungitoxicity and inhibited the growth of the fungus to a considerable extent followed by Ridomil and Bayleton (Fig. 11). Hadron was the least effective fungicide.

Out of five leaf extracts tested, those of *Lantana camara* followed by *Azadirachta indica, Acalypha indica* and *Bacopa monniera* were found to be effective in inhibiting the growth of *F. solani in vitro* (Fig. 12).

All the fungal antagonists tested were found to be very effective in inhibiting the growth of *F. solani,* with *Trichoderma harzianum* being the most efficient followed by *T. viride, T. koningii* and *Gliocladium virens*.

Discussion

The present investigation revealed *M. roridum* to be the causal agent of leaf spot and blight on young seedlings of *D. strictus*. The pathogenic nature of *M. roridum* has been reported by several workers. This fungus is seed-borne, causing heavy seedling mortality in tomato (Srivastava and Tandon 1966), mungbean (Nath et al. 1970) and cotton (Srinivasan and Kannan 1974). Dake (1980) and Shivanna (1989) have also reported *M. roridum* causing reduced germination in cotton and cluster bean, respectively. Although there is no report of this fungus affecting forest tree species, it has been reported to cause leaf spot in *Bombax ceiba* (Sharma et al. 1985) and reduce seed germination in *Pterocarpus marsupium* (Ali and Sharma 1996).

The seedling symptom test showed both pre and post-emergence mortality of seedlings. The disease symptoms manifested themselves in the form of leaf blight, browning and rotting of root, revealing the bi-directional systemic movement of the fungus in the seedlings from the seeds. Earlier workers have also reported the pathogenic nature of *M. roridum,* i.e. it has been reported to inhibit seed germination, and cause seed rot and seedling mortality (Dake 1980, Sharma et al. 1985, Shivanna, 1989, Ali and Sharma 1996). Leaf spot and blight observed in the present study can be attributed to the pathogenic nature of *M. roridum*.

Chemotherapy is an effective strategy for controlling serious fungal diseases in forest nurseries. In the present study Bavistin followed by Dithane M-45 and Captan reduced the disease intensity under field conditions. Bavistin is an effective fungicide against many fungal pathogens and is being extensively used to control many fungus-caused diseases of forest tree specie *viz*, leaf spot and blight of *Michelia champaca* caused by *Rhizoctonia solani* (Mehrotra 1992) and root rot and leaf blight of *Boswellia serrata* caused by *Macrophomina phaseolina* (Mehrotra 1996). Apart from Bavistin, Dithane M-45 and Bayleton have also been widely used to control fungal diseases. Dithane M-45 is reportedly effective against leaf spot disease of *Ficus religiosa* caused by *Colletotrichum gloeosporioides* (Dadwal and Jamaluddin 1992) and Bayleton against *Melamspora larici-populina* on *Populus* in nurseries (Pandey et al. 1996), which agree with our results. Our studies show too that spraying with 0.2% concentrations of Bavistin or Dithane M-45 can be recommended against leaf spot and blight disease of *D. strictus* caused by *M. roridum* in forest nurseries.

In the present study the pathogen that caused many characteristic brown spots over the entire leaf blade of *D. strictus* was identified as *Cercospora apii.* Several reports are available on the leaf spot disease in forest tree species caused by *C. tectonae* reportedly causes leaf spot disease in *Tectona grandis* (Spaulding 1961), *C. wrightii* in *Wrightia tinctoria* (Siddaramaiah et al. 1980a), *C. subsessilis* in *Azadirachta indica* (Sankaran 1986), *C. bombacina* in *Bombax ceiba* (Sharma et al. 1988) and *C. dehradunii* in *Grevellia pteridifolia* (Misra 2001). Apart from forest tree species, *Cercospora* species also attacks, e.g. groundnut and safflower (Suryanarayana 1978; Siddaramaiah et al. 1979). Our results agree with those of these workers.

Among the different fungicides evaluated in the field for reducing the disease incidence, Bavistin and Benlate were the most effective. Bavistin is effective against a wide range of fungal pathogens and has been used to control many diseases such as leaf spot of *W. tinctoria* caused by *Cercospora wrightii* (Siddaramaiah et al. 1980a), leaf spot and blight of *Michelia champaca* caused by *Rhizoctonia* sp. (Mehrotra 1992) and post-emergence damping off of *Eucalyptus* hybrid caused by *Verticillium* sp. (Harsh et al. 1992). Siddaramaiah et al. (1980b) have recommended Bavistin and Benlate for managing *Cercospora* leaf spot of *Carthamus tinctorius*, which agrees with our results. Bayleton and Dithane M-45 are also effective in reducing the disease incidence of some diseases. The fungicides are effective against rust disease of poplars caused by *M. larici-populina* (Pandey et al. 1996) and leaf spot disease of *F. religiosa* caused by *C. gloeosporioides* (Dadwal and Jamaluddin 1992). Among our different fungicide treatments, 0.2% Bavistin or Benlate can be recommended to manage the leaf spot disease of *D. strictus* incited by *C. apii* in forest nurseries.

In the present investigation wilt disease was observed among young seedlings of *Hardwickia binata*. Laboratory analyse revealed *Fusarium oxysporum* as the causal organism. *F. oxysporum* also causes wilt in seedlings of *Dalbergia sisoo* (Harsh et al. 1992) and chick pea (Gupta et al. 1986). Using the water agar method, inoculated seeds showed pre emergence mortality, rotting of the roots and characteristics wilt symptoms. Ungerminated seeds were diseased and rotten. Most of the seedlings that were diseased did not survive. In sand method, seeds inoculated with this fungus showed more pre- and post-emergence mortality compared to the corresponding control. *F. oxysporum* has been reported on several tree seeds where it causes seed decay, germination reduction and seedling wilt (Ali and Sharma, 1996; Mamatha et al*.* 2000). In the present study among the different fungicidal treatments considered for field studies Bavistin, Captan and Dithane M-45 reduced disease incidence. Bavistin, Captan and Dithane M-45 have been reported to be effective against many plant diseases (Dey and Debata 2000, Gupta et al. 1989).

In our study, *F. solani* incited leaf blight disease of young, *T. catappa* seedlings in forest nurseries. *F. solani* is known to cause root rot and seedling blight of *Azadirachta indica* (Sankaran et al. 1986; Shukla 1992) and wilt of seedlings of *Albizzia falcataria, Eucalyptus camaldulensis* and *Paraserianthus falcataria* (Sharma and Sankaran 1987, Kumar and Vishwanath 1993; Sankaran and Sharma 1996).

Among the fungicides tested *in vitro* growth of *F. solani*, Captan and Dithane M-45 were highly fungitoxic and inhibited the growth of the fungus to a considerable extent followed by Ridomil and Bayleton. The effectiveness of Captan and Dithane M-45 against fungal pathogens is known, e.g. Gupta et al. 1989; Dadwal and Jamaluddin 1988. Dithane M-45 is effective against many fungal pathogens, being recommended for management of fungus-caused diseases like seedling blight of *A. falcataria* (Srivastava and Soni 1993), leaf spot disease of *Populus deltoids* caused by *Alternaria alternata* (Dey and Debata 2000), and leaf spot and blight of *Syzygium cumini* caused by *Cylindrocladium quinqueseptatum* (Mehrotra and Mehrotra 2000). Followed by Captan and Dithane M-45, Ridomil and Bayleton were effective against *F. solani*. The efficiency of Ridomil and Bayleton against fungal pathogens has been reported by Rathore and Pathak (2002) and Pandey et al. (1996).

Out of five leaf extracts tested, those of *Lantana camara* followed by *A. indica*, *Acalypha indica* and *Bacopa monniera* inhibited the growth of *F. solani in vitro*. Several reports describe the fungitoxicity of *L. camara*. Leaf extracts of *L. camara* exhibit maximum toxicity against spore germination of *Curvularia tuberculata* (Srivastava and Lal 1997). Leaf extracts of *Azadirachta indica* also effectively inhibited mycelial growth of *F. solani*. Many researchers have reported fungal inhibitory property of *Azadirachta indica* (Nair and Arora 1996, Singh and Dwivedi 1990), which agrees with our findings. Apart from the above, *Acalypha indica* and *B. monniera* also exhibit some fungitoxicity. These results can be attributed to the fact that several plants possess chemicals toxic to different micro-organisms, which serve as chemical protective barriers against the invasion of different micro-organisms.

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