Discussion
DISCUSSION

Parasitism involves the interaction between the host plant and micro or macro organisms. There are different levels of parasitism which originated from saprophytism. Parasitism has evolved in order to escape competition from other saprophytic microorganisms. Facultative saprophytes, facultative parasites, obligate parasites (also called biotrophs) and symbionts are the various levels of parasitism.

Powdery mildew, the subject of the present thesis comes under the category of obligate parasitism. The obligate parasites could not be grown in lab culture media. Hence, it is difficult to determine their nutritional requirements and their mechanisms of pathogenesis in their host plants. The physiological changes during disease development were determined which give indications of mechanism of pathogenesis. Disease management with chemicals, fungicides, botanicals and hyperparasites have been worked out and the results are presented.

Powdery mildew fungus on teak plantations have been identified by several earlier workers (Bagchee, 1952; Kamala Dalme, 1956; Bakshi et al., 1972; Sharma et al., 1985 and Bagyanarayana et al., 1996).

In the present study it was observed that the mycelium of the fungus was restricted to the upper surface of the leaf which agrees with the findings of Kamala Dalme (1956). The anamorphic characters which have been successfully
used for establishing the identity of causal agent of powdery mildew on teak such as ectophytic mycelium, unbranched conidiophores with cylindrical foot cell and ellipsoidal, single celled, cylindrical conidia arranged in long chains in basipetal succession corroborate the findings of earlier workers (Kamala Dalme, 1956 and Srinivasulu, 1997). Conidial dimensions exhibited slight variations with Kamala Dalme (1956) and closely agree with those of Srinivasulu (1997).

Conidia germinated by one or more simple germ tubes which was supported by the findings of Kamala Dalme (1956). Lobed appressoria were formed from germ tube during conidial germination which agree with the observations of Srinivasulu (1997). The morphology of germ tubes have been reported to be of taxonomic value for the identification of powdery mildew fungus.

Teleomorphic characters which include the cleistothecia were globular, brown with numerous appendages, variable in number and as long as the cleistothecial diameter. Appendages were unbranched, unicellular, with uncinate-circinate or subhelicoid apex. The cleistothecial morphology, particularly the appendagial characters of the fungus agreed with those reported by Kamala Dalme (1956) and Srinivasulu (1997). Based on these appendagial characters, presence of 2-8 asci per asccocarp, and 4-6 ascospores per ascus, the teak powdery mildew fungus of the present study was identified as Uncinula tectonae Salm.
Since there is no literature available on the aspects of disease incidence of teak powdery mildew fungus, the present study was carried on the progress of the disease due to leaf infection.

The intensive observations in the present study have showed an increase in the percentage of disease incidence for two consecutive years (Table-I). The severity of plant and leaf infection was more than 75 per cent. On severe infection premature defoliation occurred in the month of February and by the end of March total leaf fall occurred every year.

Srinivasulu (1997) remarked that the fungus causes a very dense infection on the host leaves infecting nearly 70% of the teak plants.

Due to severe infection premature leaf fall occurred which substantially reduces the net photosynthetic area (Sharma et al., 1985). The leaf infection may affect the overall photosynthetic activity of the plant (Shukla et al., 2001).

The effect of various environmental factors on powdery mildews varied with the species studied and the conditions under which it was studied. Laboratory studies on temperature effects are generally conducted at controlled conditions viz., constant temperature, light and humidity, whereas in nature there is daily fluctuation in all the three factors. Consequently, many investigators have used glass slides or agar for germination counts and for measuring germ tube length (Schnathorst, 1965).
In the present study, maximum conidial germination was recorded at 25°C. Conidial germination was more than 50 per cent at 20 and 30°C. Too low and too high temperatures did not favour the conidial germination. Germ tube length was also maximum at 25°C (Table-2).

Since no literature was found on the studies on optimal environmental conditions against the conidial germination of teak powdery mildew fungus the observations of present study are to be considered as the first reports on the conidial germination. But these observations showed similarities with the findings of earlier workers on other powdery mildew pathogens.

Rapid conidial germination, infection and growth of grape powdery mildew fungus took place from 21°C to 30°C and 25°C and germination ceased at 33.5°C (Delp, 1954). Extreme temperatures above 35°C did not favour the conidial germination of Uncinula necator (Munshi and Singh, 1994). Many workers reported that 25°C to be optimum for the development of grape powdery mildew fungus (Delp, 1954; Oku et al., 1975). Maximum conidial germination of apple powdery mildew fungus (Podosphaera leucotricha) was at 20 and 25°C (Sharma and Gupta, 1993). The conidia of Sphaerotheca fuliginea (cucumber powdery mildew) showed maximum germination at 25°C followed by 30°C and 20°C in descending order (Gupta et al., 2001). These findings support the present observations.
Sharma and Gupta (1993) reported optimum germination at 20°C and
germ tube length at 20 and 25°C in *Podasphaera leucotricha*, apple powdery
mildew fungus. Several workers have reported a temperature range of 20-26°C to
be optimum for germ tube growth of most powdery mildew pathogens (Manners

Conidial germination was maximum at 100 per cent relative humidity
where the germ tube length was maximum at 90 per cent relative humidity
(Table-3). The results of conidial germination are in similarity with the
observations of Sharma and Gupta (1993); Gupta et al. (2001) on other powdery
mildew pathogens.

Grainger (1947) reported that *Erysiphe graminis* sp. *avenae* required 100
per cent RH for germination. Nour (1958) concluded that the powdery mildews
germinated best between 95 to 100 per cent RH.

The optimum conditions for germ tube growth of powdery mildews were
25°C and 100 per cent RH (Schnathorst, 1965) which correlates with the findings
of the present investigation.

Germ tube length increased with increasing relative humidity up to a
maximum at 96% and at 100% germ tube length was lowered (Hewitt, 1974).
Munshi and Singh (1994) stated that 75 and 92 per cent RH levels were found to
be optimum for the growth of *Uncinula necator*.
The studies on the biochemical nature of pathogen may give an idea of the contribution of the pathogen in the changed metabolism of the host due to host-pathogen interaction. Hence, the present investigation deals with the biochemical changes during disease development may be the additive effects of the pathogen present in the host.

Chlorophyll 'a', 'b' and total chlorophyll content was reduced considerably in powdery mildew infected leaves as compared to healthy leaves which show a steady decrease with age (Table-4). Similar results have been obtained in the studies of Thite et al. (1980) in powdery mildew infected teak leaves supporting the present investigation.

A considerable decline in chlorophyll content of infected leaves when compared to healthy leaves was reported by several workers (Nagel and Leonard, 1940; Govindarajulu, 1976; Akutsu and Watanabe, 1978; Gupta et al., 1987; Das et al., 1988; Nema, 1991; Veeramohan et al., 1994; Rajiv Kumar and Singh, 1996 and Reeti Singh et al., 1998) during their studies of host-pathogen interactions.

Degeneration of chloroplast may also possible due to proteolysis (Mayer et al., 1960). The reduction of chlorophyll content may be due to decreased synthesis of pigment in the infected tissues or destruction of a part of chlorophyll due to infection (Diener, 1963).
The reduction in the chlorophyll content may be due to inhibition of its production by the fungus (Pero and Main, 1970). The decreased chlorophyll content in the infected leaf tissue has been attributed to metabolic distribution or direct destruction by the pathogen (Padmanabhan et al., 1974).

It may be due to enhanced activity of chlorophyllase (Peterson and McKinney, 1938; Diener, 1963; Krishnamani and Lakshman, 1976). The breakdown of photosynthetic apparatus was reflected in the drastic reduction of chlorophyll 'a' and 'b' in the diseased leaves. Reduction of photosynthetic pigment also reported by Bhaskaran and Kandaswamy (1977) in the necrotic, halo and prehalo tissues of sunflower leaves.

Reduction in chlorophyll might be due to distribution of chlorophyll or higher accumulation of sugars (Curtis and Clark, 1950) which would make the nitrogen unavailable for chlorophyll formation by binding it in the formation of protein (Subramanyam et al., 1976).

Though it is difficult to find out the reason for chlorophyll reduction at present it is quite certain that such a pigment would undoubtedly impair the photosynthesis of leaves (Thite et al., 1980).

One of the significant changes induced by pathogen is the considerable reduction in the carbohydrate level (Table-5). Among the carbohydrate fraction the level of reducing, non-reducing and starch considerably decreased due to infection are in agreement with the results of Thite et al. (1980). Similar trend has been noticed by Veeramohan et al. (1994) in case of chillies infected by *Alternaria solani*. 
Total sugars decreased as a consequence of rust fungus infection of safflower (Prasad et al., 1976). Carbohydrates also play decisive role in resistance mechanism in peas against powdery mildew (Gupta, 1981). Reduction in carbohydrate levels due to infection was given by Nema (1983); Veeramohan et al., (1994) and Rajiv Kumar and Singh (1996).

Reduction in reducing and non-reducing sugars was obvious as greater proportion of their nutrients, present in plants was utilized by the pathogen (Vyas and Panwar, 1976; Bhaskaran and Kandaswamy, 1977 and Rajiv Kumar and Singh, 1996). It may also occur due to degradation metabolism in diseased tissues (Nema, 1983). It is suggested that reduction in the sugar level might be due to reduced photosynthetic rate in the infected leaves (Allen, 1942) or rapid utilization by the pathogen, utilization of considerable proportion of sugars for the biosynthetic conversion of some compounds like phenols (Neish, 1964).

Proteins also play a vital role in the resistance mechanism in plants. Changes in protein metabolism in plant tissues during the disease development have been reviewed by Uritiani (1971) and Maheswari et al. (1984). In the present investigation, a lower amount of total proteins was observed in infected leaves in all sampling days in comparison to healthy leaves (Table-6).

Phenols are antimicrobial compounds which restricts the advancement of the pathogen in the host giving resistant reaction. Enhanced biosynthesis of phenols during pathogenesis is a common phenomenon in several host pathogen interaction and is often implicated in susceptibility and resistance of plants to disease.
The present investigation revealed marked increase in total phenol content (Table-7) in infected tissues than in the healthy ones suggesting an increased synthesis of phenols with ageing of plants and their further stimulation as a result of infection. Similar trend was noted in powdery mildew infected teak leaves (Thite et al., 1980).

There has been a considerable increase in the amount of total phenol levels following the inoculation of *U. tectonae* in teak leaves during all sampling days. Similar observations have been made earlier by Govindarajulu (1976); Jite and David (1987) and Veeramohan et al., (1994). Phenolic compounds have been claimed largely to be responsible for imparting general resistance in higher plants to parasitic fungi and bacteria (Kue, 1963). It is believed that polyphenol accumulation takes place in the infected plant tissues as a defensive mechanism adopted by the host plant (Goodman et al., 1967).

The post infectional increase in phenolic compounds and decrease in carbohydrates might be due to enhancement of synthesis of phenolic compounds and hydrolysis of phenolic glycosides by fungal glycosides to yield free phenols (Sharma et al., 1983).

Thompson (1964) reported increased peroxidase activity from the infected leaf tissues than the healthy leaves. The altered enzyme levels are very often correlated with the symptom development. Peroxidase activity is more noticeably increased in susceptible variety than in resistant variety (Jennings et al., 1969).
The activity of peroxidase enzyme is higher (Table-8) in inoculated leaves as compared to healthy leaves. However, this increase is not so significant as to account for any metabolic shift (Thite et al., 1980). The infection of Erysiphe graminis in barley leaves caused an increase in peroxidase enzyme activity (Hislop and Stahman, 1971).

Phyllosphere was the term used by many workers to describe the leaf surface environment which was first used by Ruimen (1956). Kerling (1950) suggested the term phylloplane to explain the leaf surface, both these are in usage and became synonym to one another. The nature of specialized microhabitat on leaf usually referred to as the phyllosphere (Last, 1955) or phylloplane (Preece and Dickison, 1971; Dickinson and Preece, 1976; Blakeman, 1981). Thus, phyllosphere or phylloplane is an external leaf surface environment for microbial habitat.

The microflora of phylloplane includes either saprophytes or pathogenic organisms. Their occurrence, activity and interactions of saprophytic and parasitic microflora on phyllosphere have been studied extensively by several workers (Sinha, 1965; Sinha and Bahadur, 1974; Fokkema and Lorbeer, 1974; Collins, 1976; Dickinson, 1976; Wadje and Deshpande, 1979; Garg and Sharma, 1983; Sharma et al., 1985; Bopariah et al., 1991).

Since no work has been carried out on the study of phylloplane mycoflora of teak (Tectona grandis) in the present investigation it was studied about the saprophytic fungi on both healthy and powdery mildew infected leaves and their antagonistic effects against Uncinula tectonae.
About 13 species of fungi were isolated (Table-9) which include species of *Alternaria*, *Aspergillus*, *Curvularia*, *Cladosporium*, *Drechslera*, *Fusarium*, *Penicillium*, *Trichoderma* and a non-sporulating fungus. Among these *Cladosporium oxysporum* and *Alternaria alternata* were the dominant fungi in infected leaves. They were also colonized mostly by *A. niger*, *Fusarium oxysporum* and *P. rubrum*, *T. viride* were occurred in least counts.

Studies of earlier workers reported that the genera such as *Alternaria*, *Aspergillus*, *Cladosporium*, *Fusarium*, *Curvularia*, *Penicillium*, *Trichoderma* are the common phylloplane fungi (Last, 1955; Ruscoe, 1971; Sharma and Mukherji, 1976; Omar and Heather, 1979; Kita, 1988; Dhawan et al., 1995).

In the present study powdery mildew infected leaves possessed higher populations of fungi than healthy leaves. Similar reports were found in the work of Sharma and Garg (1979). They observed quantitative difference in the mycoflora of powdery mildew infected and non-infected leaves of barley. Hayes (1982) while studying the phylloplane microflora of the hybrid tea-rose, also observed that following infection by *Diplocarpon rosae*, the microbes showed a marked increase in their populations. Rust infected leaves invariably supported higher population of fungi than non-infected leaves of triticale (Garg and Sharma, 1983). White blister infected mustard leaves colonized comparatively high populations of phylloplane fungi than healthy leaves (Garg and Sharma, 1985).
Among the isolated phylloplane saprophytes the spore suspensions of *Cladosporium oxysporum* and *Alternaria alternata* inhibited the spore germination of pathogen (Table-10). Maximum inhibition was noted with the spore suspension of *C. oxysporum*. The number and size of the lesions were also reduced maximum by *Cladosporium oxysporum* and *Alternaria alternata* (Table-11). Other saprophytes were found to be less effective to inhibit the germination of powdery mildew fungus.

*Cladosporium herbarum* (Pers.) Lk. ex. S.F. Gray and *Alternaria alternata* (Fr.) Keissl. have been shown to inhibit the germination of *Botrytis cinerea* Pers. ex. Fr. conidia and once established, prevented the colonization of the leaves by *B. cinerea* (Newhook, 1957). Significant reduction in germination of urediniospores of *Melampsora occidentalis* in contact with suspensions of leaf saprophytes has also been reported (Bier, 1964).

The inhibitory substances produced by leaf surface mycoorganisms have fungistatic potentiality against the pathogens (Sinha and Bahadur, 1974).

The studies of Omar and Heather (1979) were also reported that phylloplane fungal species of *Cladosporium, Alternaria* and *Penicillium* reduced the spore germination and development of *Melampsora larici-populina* Kleb. The results of Bopaiah *et al.* (1991) indicated that the growth of the pathogenic fungi, *Helminthosporium oryzae*, *Phytophthora arecae* and *Pyricularia oryzae* was inhibited by the leaf saprophyte *Penicillium islandicum.*
The present study revealed that, *Alternaria alternata* and *Cladosporium oxysporum* penetrated into the conidia of *U. tectonae* with appressorium like structure at the point of contact. The parasitic growth of *A. alternata* and *C. oxysporum* over the powdery mildew fungus in naturally infected leaves indicating the mycoparasitism of saprophytes over the pathogen.

Scanning electron microscopic studies revealed an intimate association between *C. oxysporum* and *U. tectonae*. Mycoparasitism took place by the penetration of germ tube of *C. oxysporum* into the hyphae, conidiophores and conidia of *U. tectonae* causing lysis of conidia.

Lysis of conidiophores of the pathogen may be due to production of certain toxic chemicals produced by the mycoparasite, causing death of the host cells and utilizing nutrients released (Barnett and Binder, 1973).

Generally the powdery mildews are parasitized by *Ampelomyces quisqualis* (Shama Rao and Sullia, 1981). It was proved by several workers that *A. quisqualis* as hyperparasite on powdery mildews (Yarwood, 1932; Jarvis and Slingsby, 1977; Sztejnberg, 1979; Sundheim and Amundsen, 1982; Sundheim, 1986; Beuther et al., 1981; Rajasab and Vidyasagar, 1993). *Ampelomyces quisqualis* parasitized the cucumber powdery mildew *Sphaerotheca fuliginea* (Fr.) Poll. and produced appressorium like structures at the point of contact (Sundheim and Krekling, 1982).
Alternaria and Cladosporium species were hyperparasitic, penetrating and causing lysis of the urediniospores of Melampsora larici populina (Omar and Heather, 1979).

Keen observation of literature showed very few reports about Alternaria and Cladosporium species as hyperparasites (Bagyanarayana and Niranjan Rao, 1981). Alternaria alternata (Fr.) Keissler and Cladosporium oxysporum spongiosum Berk. & Curt. have been reported as hyperparasites on conidia and mycelium of Acrospermum dentrophthoe parasitizing Dendrophthoe falcata (Bagyanarayana and Niranjan Rao, 1981).

The leaf surface is a good site for both saprophytic and parasitic fungi. Among the phylloplane fungi a few have been reported as hyperparasites (McKenzie and Hudson, 1976).

Cladosporium chlorocephalum parasitized the conidia and lysis of conidiophores of the pathogen Peronospora arborea causing downy mildew of opium (Chaurasia and Dayal, 1985). Cladosporium sps. have been reported as hyperparasite on various pathogens (Keener, 1954; Bolland, 1973; McKenzie and Hudson, 1976; Heather and Sharma, 1977; Bagyanarayana and Niranjan Rao, 1981; Shama Rao and Sullia, 1981; Mathur and Mukerji, 1981; Chaurasia and Dayal, 1985).

From the present investigation it was found that Alternaria alternata (Fr.) Keissler and Cladosporium oxysporum Berk. & Curt. as new hyperparasites on teak powdery mildew fungus, Uncinula tectonae and is considered as the first report.
Parasitism of fungi has been classified into two broad divisions (Hashioka, 1973). These are biotrophic which includes haustorial, non-haustorial and indirect reactions, and necrotrophic. In necrotrophic or destructive mycoparasitism, the parasite destroys the host after or even before invasion and absorbs nutrients from the disorganized or dead host cells.

In the present investigation, *A. alternaria* is found to be a biotrophic haustorial parasite and *C. oxysporum* is both haustorial and necrotrophic causing lysis of the host cells after contact which correlate with reports of Omar and Heather (1979). The mode of mycoparasitism of *Cladosporium chlorocepha\(l\)um was necrotrophic (Barnett and Lilly, 1962; Skidmore and Dickinson, 1976).

The lysis of conidia may be due to the secretions from the conidia of *C. oxysporum* which was reported earlier by Omar and Heather (1979) during their studies on effect of phylloplane saprophytes on *Melampsora larici-populina*.

Spore germination of *Uncinula tectona\(e\)* was inhibited in both the culture filtrates of mycoparasites analysed (Table-12). Low percentage of spore germination in lower concentration and more inhibition in higher concentration indicates that increase in the concentration of culture filtrates increases the inhibition. Of the culture filtrates of two mycoparasites, *C. oxysporum* was more effective to inhibit the spore germination of the pathogen than *A. alternata*.

Culture filtrates of *Trichothecium roseum* inhibited the uredospore germination of *Puccinia graminis-tritici* (Sreekantaiah and Joshi, 1958). Ahmad (1970) reported that the culture filtrate of *Trichothecium roseum* inhibited the spore germination of twelve rusts tested at high concentrations (50 and 100%).
As the concentration of culture metabolites increased the conidial germination was reduced and at higher concentration (80%) totally inhibited the conidial germination of *Peronospora arborescens* by mycoparasite *Cladosporium chlorocephalum* may be due to production of chemical substances which are inhibitory or toxic in nature (Chaurasia and Dayal, 1985). Both conidia and culture filtrates of *Acremonium obelavatum* significantly reduced germination of uredospores of *Puccinia arachidis* (Jayapal Gowda, 1986).

Species of *Alternaria, Botrytis* and *Aureobasidium* have been reported to produce antibiotics. The majority of strains of *Alternaria* have been reported to produce antibiotics active against gram positive bacteria and fungi (Lindenfelser and Ciegler, 1969). Cell-free culture filtrates or extracts of culture filtrates have been used to demonstrate the possible role of antibiosis in biocontrol. Filtrates of various mutants of *Trichoderma harzianum* were suppressive of the white rot pathogen *Sclerotium cepivorum* (Papavizas *et al.*, 1982). The culture filtrate of *Penicillium islandicum* inhibited the growth of *Helminthosporium oryzae, Phytophthora oraeae* and *Pyricularia oryzae* was due to the production of non-volatile antimicrobial substances (Bopaiah *et al.*, 1991).

Carbon is a fundamental element required by all living organisms. In addition to being the main structural element, carbon compounds play an equally important functional role in fungi (Lilly and Barnett, 1951). Studies on growth and sporulation of *A. alternata* and *C. oxysporum* to different carbon sources of nutritive elements showed the specificity of organisms to utilize those elements.
Present studies on carbon requirements indicated that the mycoparasites could utilize all the carbon sources tried for growth and sporulation (Table-13). *A. alternata* recorded maximum growth and sporulation in maltose followed by sucrose, fructose, starch and glucose. Pectin and xylose are the least sources for sporulation. The best source of carbon for maximum growth of *C. oxysporum* was noticed as fructose followed by sucrose, lactose, maltose and glucose and sporulation was maximum in sucrose only. The least growth and sporulation was recorded in xylose.

The findings clearly showed the best utilization of disaccharides. This was in conformity with the work of Pande and Varma (1992) who reported that *A. alternata* and *C. cladosporioides* preferred disaccharides.

Third (1977) found that monosaccharides were good carbon sources of *A. alternata* which supports the best growth of *A. alternata* in fructose, a monosaccharide in the present study. Suvarnalatha Devi (1991) reported that sucrose was the best carbon source for the growth and sporulation of *A. alternata*.


Carbon sources such as glucose, sucrose and inulin supported good growth of *Cladosporium cladosporioides* (Anil Kumar and Sastri, 1980). *C. cladosporioides* was found to grow well in maltose followed by sucrose.
and starch in the works of Pande and Varma (1992) carried out. Monga (2001) stated that sucrose was best for sporulation of all species of *Trichoderma* except for *T. viride*.

In case of nitrogen sources potassium nitrate was best for the growth of *A. alternata* followed by ammonium chloride, casein hydrolysate and ammonium nitrate. Ammonium oxalate forms the least source (Table-14). For maximum sporulation the best source of nitrogen was ammonium chloride. Casein hydrolysate was proved best source for maximum growth of *C. oxysporum*, whereas potassium nitrate and sodium nitrate were the other best sources. Sporulation was maximum in potassium nitrate and casein hydrolysate.

Maximum growth of *A. alternata* in potassium nitrate, ammonium chloride, ammonium nitrate corroborate with the findings of Suvamalatha Devi (1991) who reported that the fungus grows well on inorganic nitrogen sources like sodium nitrate, potassium nitrate, ammonium chloride and ammonium nitrate. *A. alternata* preferred ammonium salts like asparagine and histidine for better growth (Pande and Varma, 1992).

Casein hydrolysate was proved to be excellent nitrogen source for *Darlula filum* (Nicolas and Villanueva, 1965). Also casein hydrolysate was proved to be good source of nitrogen for growth of *C. cladosporioides* (Anil Kumar and Sastri, 1980) supporting the present studies. Maximum growth of *Penicillus atramentosum* occurred on casein hydrolysate followed by yeast.

Biochemical resistance or susceptibility in plants against any disease depends mainly on pre-existing, pre-formed or induced substances by the pathogen in the host. The nutritional status and concentration of biochemical constituents in plants prior to infection may determine the severity of the disease.

Powdery mildews are usually well controlled with sulfur dust, but there are many situations where other chemicals are preferable (Yarwood, 1957).

In the present investigation, all the chemicals tested at different concentrations were significantly inhibited (Table-15) the conidial germination of *U. tectonae*. Of all the chemicals, copper sulphate has been found to be most toxic with complete inhibition. Zinc sulphate inhibited maximum at higher concentration indicates that increase in concentration increased the inhibition. Manganous sulphate was least effective among all the chemicals.

Copper sulphate has been toxic to powdery mildews or even effective in disease control in limited trials (Yarwood, 1945).

Although considerable studies have been made on effects of fungicides on fungal pathogens, the action of fungicides and few chemical compounds on phytopathogenic fungi is relatively meagre.
Vigorous efforts are being made to find out fungicides which can effectively control the disease. Investigation by several workers had indicated the efficacy of fungicides in controlling the disease incited by phytopathogenic fungi (Bhaskaran and Shanmugam, 1973; Saksena et al., 1979; Ashok Krishna and Singh, 1983; Bhargava and Singh, 1992; Pandey et al., 2000; Sawashe et al., 2003 and Abraham Mathew et al., 2003). The present study was carried out to find out the effectiveness of certain fungicides against the pathogen.

The pathogen was sensitive to all the fungicides in different concentrations used. Of all the tested fungicides, Karathane was found to be more effective with complete inhibition of conidial germination followed by Captan, Dithane M-45 and Blitox (Table-16). Chlorothalonil was the least inhibitor of conidial germination.

Karathane at higher concentrations (1500 ppm) inhibited the spore germination (62.69%) of Alternaria cucumerina which causes blight of bottle gourd was proved by Bhargava and Singh (1992). Karathane was proved to be the best inhibitor against the powdery mildew of sesame (Karunanithi, 1996). Karathane (0.05%) was found to be an effective fungicide to reduce severity of powdery mildew of pea (Abraham Mathew et al., 2003).

Dithane M-45 was proved to show complete inhibition of early blight of tomato at 1000 ppm (Lodha and Prasad, 1975). The studies of Bhargava and Singh (1992) showed that Dithane M-45 and Blitox-50 increase in concentration
(1000 ppm) the spore germination of *Alternaria cucumerina* was inhibited completely. Captan was found to be the best fungicide to inhibit (91.43%) the spore germination of *Alternaria alternata* at 1000 ppm which causes leaf spot of brinjal (Pandey et al., 2000).

Constant application of synthetic chemicals to eradicate the pathogens was found to be effective in the improvement of various crops as disease management, several of these chemicals have been found to display side effects which lead to carcinogenicity, teratogenicity, environmental pollution and also other toxicity problems among mankind and other living organisms.

The use of chemicals not only eradicate the pathogens but on constant application pathogens become resistant and also eradicate non-target beneficial organisms. To avoid these problems people are looking for natural plant products with antimicrobial properties, use of which would not cause any pollution and adverse effects. The use of plant extracts and plant products is gradually finding its place in plant disease management in place of chemical control.

The presence of naturally occurring substances in plant species has been shown to play a major role in defense mechanism as well as plant products. The possible use of natural plant products as plant protection agents is gaining momentum especially with the ever increasing cost and pollution hazards of pesticides. In recent years attempts were made to screen the antifungal properties of different plants against plant pathogenic fungi (Grayer and Harborne, 1994).
Considering these, the present study has been undertaken to study the effect of leaf extracts of some naturally occurring plants against teak powdery mildew fungus. All the plant extracts tested inhibited the conidial germination \textit{U.tectonae} (Table-17). Out of nineteen plant extracts \textit{Azadirachta indica} showed complete inhibition. \textit{Strychnos nux-vomica}, \textit{Sterculia urens}, \textit{Melia azadirach} and \textit{Bixa orellana} were effective whereas \textit{Mirabilis jalapa} showed least inhibition of conidial germination.

The difference in the activity of leaf extracts may be due to variations in the composition of antifungal compounds in different plants (Shetty et al., 1989). \textit{A. indica} has been found effective against powdery mildew of pea and powdery mildew, leaf spot and leaf rust of mulberry by Singh et al., (1991) and Biswas et al. (1995). The leaf extract of \textit{Azadiracta indica} has already been recorded as a strong inhibitor of \textit{Curvularia lunata} (Bhowmick and Vardhan, 1981); \textit{Phytophthora capsici} (Anandaraj and Leela, 1996); \textit{Curvularia tuberculata} and \textit{Alternaria alternata} (Srivastava and Lal, 1997); \textit{Rhizoctonia solani} (Kurucheva et al., 1997). \textit{A. indica} was proved to be highly toxic to \textit{Fusarium oxysporum} (Bansal and Gupta, 2000). It was most effective and caused cent percent inhibition against conidial germination of \textit{Colletotrichum capsici} (Javed and Charaya, 2003). The effectiveness of \textit{A. indica} may be due to the presence of oil in plant parts (Singh and Dwivedi, 1990).
Strychnos nux-vomica was found to be more inhibitory to Alternaria alternata (Bavaji, 2003). Bixa orellana have been reported earlier to reduce the growth of Colletotrichum capsici, Fusarium pallidoroseum, Botryodiopsidium theobromae, Alternaria alternata, Penicillium citrinum, Phomopsis caricae papayae and Aspergillus niger (Suhail Mohammed et al., 1996).

Melia azadirach was the most effective inhibitor to Alternaria tenuis, Helminthosporium sp. and Curvularia penniseti (Shekhawat and Prasad, 1971). Melia azadirach showed inducing effect on conidia of Colletotrichum capsici (Gomathi and Kannabiran, 2000).

The present study revealed that the leaf extracts of A. indica, Strychnos nux-vomica, Sterculia urens, Melia azadirach and Bixa orellana can be used as potent fungicides against the teak powdery mildew fungus.