IDENTIFICATION AND MANAGEMENT OF PESTS AND DISEASES OF OYSTER MUSHROOM

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DECLARATION

I hereby declare that this thesis entitled "**Identification and management of pests and diseases of oyster mushroom**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

Certified that this thesis entitled **"Identification and management of pests and diseases of oyster mushroom"** is a record of research work done independently by Ms. Deepthi. S. (2001-11-23) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Dedicated to
My
Achan, Amma and Chettan

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LIST OF ABBREVIATIONS

%	per cent
µm	Micro metre
@	At the rate of
^{0}C	Degree Celsius
CD	Critical difference
cm	Centimetre
CRD	Completely Randomised Design
et al.	And others
Fig.	Figure
g	Gram
h	Hour
kg	Kilogram
l	Litre
m	Meter
mg	Milligram
ml	Millilitre
PDA	Potato Dextrose Agar
ppm	Parts per million
spp.	Species
viz.	Namely

INTRODUCTION

1. INTRODUCTION

Mushrooms are valuable food materials praised for their delicacy, flavour and nutritional qualities all over the world. The medicinal and bioremediation properties of mushrooms are also well recognized. Mushroom farming is now considered as an intensely managed form of food production.

The huge amount of available agricultural wastes and the congenial climatic conditions prevailing provide scope for mushroom cultivation in Kerala. The mushroom industry is slowly gaining momentum especially among the unemployed youth and rural women under self help groups. Many growers cultivate mushroom seasonally under low cost technology and hardly pay any attention to hygiene and sanitation. As a result a large number of pests and pathogens gain easy access to mushroom farms and take heavy toll of crop every year. One of the major limiting factors in mushroom cultivation is the lack of sustainability due to pests and diseases (Verma, 2002).

In addition to insects and pathogens, the competitor moulds also pose problems. Sometimes farmers are even forced to abandon mushroom cultivation after growing two or three crops due to pests and diseases

Realizing the impact of pests and diseases in mushroom cultivation it is inevitable to work out and suggest a complete package of practices to the growers to safeguard the crop against pests and diseases. Mushrooms have several peculiarities, which make the crop protection operations difficult. Mushrooms are indoor crops having very short shelf life and are consumed as such. Hence application of chemicals may lead to residue problem. *Trichoderma* and other contaminants noticed in mushroom beds are fungi and application of fungicides against them often adversely affects mushroom growth. Mushrooms are highly sensitive and even a

slight alteration in their niche will drastically affect their growth and development. The above factors limit the use of many pest and disease management practices in mushroom cultivation.

In this context, the present study entitled "Identification and management of pests and diseases of oyster mushroom" was undertaken with the following objectives:

1. Identification of pests infesting oyster mushroom
2. Identification of diseases and competitor moulds of oyster mushroom and
3. To evolve suitable pest and disease management strategies to make mushroom cultivation sustainable and profitable

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The literature pertaining to the pests and diseases of oyster mushroom *Pleurotus florida* Eger, their nature and symptoms of damage and management is briefly reviewed below.

2.1 PESTS OF OYSTER MUSHROOM

2.1.1 Pests

Cultivated mushrooms are attacked by an array of insect pests commonly known as springtails, mushroom flies and beetle pests.

2.1.1.1 Springtail (Order : Collembola)

Several species of springtails *viz.*, *Lepidocyrus cyaneus*, *L. lanuginosus*, *Achorates armatus*, *Proisotoma simplex*, *Proisotoma minuta* and *Xenylla mucronata* were reported to infest oyster mushroom (Atkins, 1972). Springtail, *L. cyaneus* in oyster mushroom was first reported by Bhandari and Singh (1983a) from Udaipur. *Lepidocyrtus* sp. was also reported damaging button and oyster mushrooms (Thapa and Seth, 1983). Another species of springtail, *Seria iricolor* was found damaging the mycelium and sporophores of button, oyster and tropical mushrooms (Gill and Sandhu, 1994). Balakrishnan (1994) reported the occurrence of spring tails in the oyster mushroom beds of Kerala.

2.1.1.2 Mushroom Flies (Order : Diptera)

Among the dipterans, flies belonging to families Phoridae, Sciaridae and Cecidomycidae were the commonly reported pests.

2.1.1.2.1 Phorid Flies

Phorids commonly known as manure flies are one among the principal pests in mushroom houses. Various species of phorids found

attacking mushrooms include *Megaselia nigra*, *M. agari*, *M. flavinervis* and *M. halterata* (Atkins, 1972). Shandilya *et al.* (1975) described phorid flies as one of the most important pests of mushrooms in India. Szudyga (1978) reported severe occurrence of these flies on *Pleurotus sajor-caju* (Fr.) Singer. Krishnamoorthy *et al.* (1991) reported for the first time the occurrence of phorid flies (*Megaselia* sp.) on oyster mushroom in India. According to Johal and Disney (1994) cultivated oyster mushroom was attacked by the larvae of two species of phoridae *viz.*, *M. pleurota* and *M. scalaris*. Mohan *et al.* (1995) identified the occurrence of larvae of *M. tamilnaduensis* as a pest of the mycelium of cultivated mushroom *Pleurotus citrinopileatus* Singer. Geels (1998) reported *M. halterata* as one among the major insect pests of cultivated mushroom. Disney and Durska (1999) reported a new subspecies polonica of *M. tamilnaduensis* as pest of *Pleurotus ostreatus* (Jacq.ex.Fr.) Quel in Poland. Kumar and Sharma (1999) reported that throughout the world phorids were observed as major pest of mushrooms. Phorid flies were found to attack oyster mushroom beds of Kerala (Balakrishnan, 1994).

2.1.1.2.2 Sciarid Flies

White (1982) reported sciarid flies, *Lycoriella auripila* and *L. solani* as major pests of mushrooms. The attack of sciarid flies on cultivated mushroom was also recorded by Fletcher *et al.* (1986). Chakravarthy *et al.* (1987) reported the occurrence of *L. auripila* damaging oyster mushroom in West Bengal. Occurrence of *Bradysia paupera* on *P. osteratus* was reported by Gnaneswaran and Wijayagunasekara (1999). *L. solani* was found to attack the oyster mushroom *P. ostreatus* (Lewandowski *et al.*, 1999). Balakrishnan (1994) reported the occurrence of sciarid as a pest of oyster mushroom in Kerala

2.1.1.2.3 Cecidomyiid Flies

Cecid flies or gall gnants have for long been regarded as serious pests in mushroom crop. Various types of cecid flies *viz.*, *Hetropeza pygmea*,

Mycophila speyeri, *M. barneri* and *Lestreia cinerea* were found to infest mushroom (Atkins, 1972). White (1982) reported the occurrence of cecidomyiids *H. pygmea*, *M. speyeri*, *M. barnesi* and *L. cinerea* in cultivated mushrooms. *H. pygmea* was found in substrate used for oyster mushroom cultivation (Lewandowski *et al.*, 1999). Lucchi and Santini (1993) reported the epidemiology, injuriousness, prevention and control of *M. speyeri* in Tuscany. Johal and Kaushal (1991) reported for the first time in India the occurrence of an unidentified larva of cecidomyiidae damaging oyster mushroom *P. sajor-caju* at Jind (Haryana) and Chandigrah, which was later, identified as *Heteropezeana cathistes* (Johal and Kaushal, 1994). *Mycophila* sp. was found to infest oyster mushroom (SoungRyul *et al.*, 1999).

2.1.1.2.4 Other Flies

Gnaneswaran and Wijayagunasekara (1999) identified *Drosophila funebris* as a pest of oyster mushoom. SoungRyul *et al.* (1999) confirmed the occurrence of *Cobboldia fuscipes* in oyster mushoorms.

2.1.1.3 Beetle Pests (Order : Coleoptera)

According to Ashe (1990) among gilled mushrooms, adults of staphylinid beetle, *Pleurotobia tristigmata* fed only on *Pleurotus* spp. *Staphylinus* sp. was earlier reported to damage oyster mushroom in Thiruvananthapuram district of Kerala by Asari *et al.* (1991). Balakrishnan (1994) reported that severe attack of staphylinid beetle in oyster mushroom sporocarps. Hanley and Goodrich (1994) reported the adults of *Oxyporus stygicus* inhabited mature fruiting bodies of a variety of fungi including *P. ostreatus*.

Gnaneswaran and Wijayagunasekara (1999) found out that there were severe infestation of *Cyllodes* bifacies in mushroom farms of Sri Lanka. Johal *et al.* (1992) reported the occurrence of larvae of

cucujoid beetle *Cyllodes whiteii* infesting oyster mushooom at Chandigrah.

Johal and Kaushal (1993) reported for the first time the occurrence of the beetle *Alphitobius laevigatus* as a pest of oyster mushroom from India.Muzumber *et al.* (2001) recorded for the first time *Scaphisoma* (Coleoptera : Scaphidiidae) as a pest of oyster mushrooms.

2.1.1.4 Nature of Damage

2.1.1.4.1 Springtails (Order: Collembola)

Thapa and Seth (1983) recorded that the springtails generally feed on gills which resulted in destruction of gill linings. According to Balakrishnan (1994) the adults of springtails usually remained in between gills. The crawling of insects over the first harvested beds inhibited the second and third flush development. Gill and Sandhu (1995) reported that springtails feed mostly on the lower surface of the sporophores, while feeding on upper side was more on beds placed at ground level. Mignucci *et al.* (2000) reported that the springtails caused deterioration of *Pleurotus* basidiocarps

2.1.1.4.2 Mushroom Flies (Order : Diptera)

2.1.1.4.2.1 Phorid Flies

Kneebone (1968) reported that mushroom flies and their larvae reduced the yield. Phorid larvae are known to cause damage by feeding mainly on mycelium but occasionally tunneled into the mushrooms (Atkins, 1972). Flies were attracted by smell of mushroom and laid eggs in the cylindrical beds in close proximity to vents (Krishnamoorthy *et al.*, 1991). The maggot fed on mycelium forming clear wet rotten area around the vents. Bacterial decay of grain spawn and substrate was also observed. Beds when attacked in the early stage of spawn run decayed completely. Positive correlation between damaged area of the beds and yield of mushroom was also indicated. Balakrishnan (1994) found out that a large

number of phorid larvae feeding on the growing mycelium arrested its growth and substrate started decaying in 7-10 days of incubation.

2.1.1.4.2.2 Sciarid Flies

Sciarid larval infestation resulted in patches without mushroom mycelium on the beds (Zaayen, 1978). After sporophore formation, larvae of sciarid entered the mushroom through the stipe in large numbers and the feeding forme tunnels within stipe. They also fed on the gills resulting in the poor development of pin heads (Goltapeh, 1991). Balakrishnan (1994) reported that the sciarid larvae feeding on growing mushroom mycelium arrested its growth and the substrate decaying started within 7-12 days. In cropping room larvae penetrated into the fleshy part of sporocarps and tunneled inside it. Kumar *et al.* (2001) found out that the damaging stage of the pest was the larvae, which fed extensively on mushroom mycelium and sporocarps.

2.1.1.4.2.3 Cecid Flies

According to Atkins (1972) cecid larvae fed on mushroom mycelium and made slowly up the stalk and into the gills without burrowing through the center. Cecids caused vertical grooves in the stipe, tiny pustules of black fluid on stipe and reduction in mushroom mycelium (Sharma, 1997).

2.1.1.4.3 Staphylinid beetles

Asari *et al.* (1991) reported that the emerging grubs of *Staphylinus* sp. fed on the soft gills and crawled over the beds and made irregular holes in the hymenium and even in the stipe. Balakrishnan (1994) reported that the grubs made injuries beneath the pileus and fed on gills. The adults were found to make holes on the stipe and pileus surface and caused rotting. Hanley and Satsuda (1999) reported that adults of *Oxyporus japonicus* fed on mature basidiocarp of *P. ostreatus*.

2.1.1.5 Pests of Mushroom as Vectors

Pests infesting mushrooms were also known to act as vectors of competitor moulds as well as pathogens.

Sciarids are known to spread many mushroom diseases (White, 1986). Phorid as well as sciarid acted as vectors of weed moulds.Adults spring tails were found to spread bacteria and mycopahtogens (Balakrishnan, 1994). Kumar and Sharma (2001) reported that under laboratory conditions, *Megaselia* sp transmitted *Trichoderma viride* to the extent of cent per cent. They further reported that phorids also acted as vectors of mite.

2.1.1.6 Extent of Damage

Zaayen (1978) recorded an yield reduction of 50 per cent due to sciarid attack. Sandhu and Brar (1980) observed 32.7 per cent infestation of mushroom beds in Punjab by Sciarid flies. White (1986) reported that the economic threshold level for the sciarid, *L. auripila*, was virtually zero. Chakravarthy *et al.* (1987) reported that yield loss in oyster mushroom due to *L. auripila* infestation varied from 30.0 to 34.5 per cent. According to Gnaneswaran and Vijayagunasekhara (1999) *C. bifacies* was distributed in about 96 per cent of farms visited and damage was upto 82 per cent. The cecid *Heteropezina cathistes* was known to cause 19 per cent loss to *Agaricus* cultivation (Sharma, 1997). Under protected cultivation sciarid, cecid and phorids were found to cause 17-26 per cent, 26-23 per cent and 46 per cent loss in yield respectively (Sandhu, 1995; Clift and Terras, 2000). Cent per cent reduction of yield in oyster mushrooms particularly during rainy season by phorids was reported by Kumar and Sharma (2000).

2.1.1.7 Periodicity of Occurrence of Pests

Flegg (1992) reported that sciarids were present throughout the year while phorids were common in summer. Gill and Sandhu (1995) reported

that *S. iricolor* remained active throughout the year but its maximum activity was during hot and humid conditions in July- August on tropical mushrooms. Compared to button mushroom, springtails preferred oyster mushroom and feeding was more on beds at ground level. Under conditions prevailing in Solan, peak population of sciarid were observed during the months of February followed by March and April when temperature ranged from 11-20^{0}C. SoungRyul *et al.*, 1999 monitored the pest species belonging to families cecidomiadae and scolopsidae and reported that the pattern of occurrence was dissimilar depending on the survey period and region. *L mali* was reported to occur year round, *C. fuscipes* occurred in summer months and M*ycophila* sp caused severe damage during October to November. Novarro *et al.* (2000) reported the occurrence of higher population of phorids *M. halterata* than that of sciarid *L. auripila* in two villages of Spain. The highest number of flies was recorded in spring, although the phorid populations increased in autumn. From July to October, very low population of sciarids was observed when temperature was in the range of 18-26^0 according to Kumar and Sharma (2001). They also reported that the mushroom flies remained in the mushroom houses for their entire life cycle and were distributed in all mushroom farms at all the seasons of the year and phorids were observed in the temperature range of 11.2- 25 ^{0}C.

2.2 DISEASES OF OYSTER MUSHROOM

2.2.1 Competitor Moulds Infesting Oyster Mushrooms

Fungi occurring in the substrate and competing with mushroom mycelium for space and nutrition include *Arthrobotrys* sp, *Aspergillus niger, A flavus, A fumigatus, Cladosporium* sp *Coprinus* spp., *Cochliobolus* sp; *Drechslera, Fusarium moniliformae, Mucor* sp., *Penicillium* sp., *Rhizopus* sp., *Stachybotrys* sp., *Stibum* sp, *Stysanus medius, Sclerotium rolfsii, Sordaria fumicola, Oedocephalum* spp.,

Trichoderma viride, Trichurus sp and *Phialospora* (Sharma and Jandaik, 1980, 1981a and 1981b; Doshi and Singh, 1985; Singh and Saxena, 1987).

Houdeau and Oliver (1989) reported the occurrence of antagonists and mycoparasites *viz.*, green moulds- *Trichoderma* spp; *Gliocladium* spp; *Penicillium* sp., *Aspergillus* sp.; *Chaetomium* sp. black moulds *Stysanus* sp., *Dorutomyces* sp. and *Trichurus* spp. and other moulds like *Neurospora*, Mucor sp. etc. during *Pleurotus* cultivation. The maximum of 19 fungal species were recorded at various stages of substrate preparation and mushroom production. Majority of fungal flora belonged to deuteromycetes with *Cladosporium oxysporum* dominating (Pandey and Tewari, 1989). Many fungi, mainly species of *Trichoderma*, *Aspergillus*, *Penicillium, Mucor*, *Rhizopus*, *Chactomium* and *Coprinus* were found constantly attacking the beds of oyster mushroom in Kerala (Das and Suharhan, 1991).

During the cultivation of oyster mushroom *Pleurotus eöus* (Berk) Sacc. the important contaminants observed were *Aspergillus flavus* Link ex Gray *A. niger* and *T. harzianum* (Anandh *et al.*, 1999b). According to Thakur *et al.* (2001) the population of mycoflora during different stages of *P. florida* cultivation showed an increasing trend starting from spawning till third flush. Common mycoparasitic moulds observed in oyster mushroom bed and spawn in different farms in Coimbotore were *A. niger*, *A. flavus*, *Neurospora crassa*, *T. viride*, *C. comatus*, *Penicillium* spp and *Sclerotium oryzae* (Krishnamoorthy *et al.*, 2002). Siddique *et al.* (2002) reported microbial contamination of oyster mushroom beds as one of major hinder ness to increase yield of *P. sajor caju.* Several moulds *viz.*, *Aspergillus* spp, *Pencillium* spp, *Rhizopus* spp, *Mucor* spp and *Trichoderma* spp were observed as common contaminants in Hissar during 1999-2000 and 2000-2001 spawn production (Singh *et al.*, 2002).

Das *et al.* (1993) reported that *T. viride* was the most virulent competitor mould both in spawn bottle and in mushroom beds in

Vellayani, Thiruvananthapuram. Torta (1993) reported that due to the presence of green mould there was limited development of mycelium of *P. ostreatus* and wide dark zones in the substrate. The infestation due to *Trichoderma* sp was the most severe problem faced by growers of oyster mushrooms (Balakrishnan, 1994). The most common and harmful green mould was stated to be species of *Trichoderma* in all mushroom-growing countries of the world (Thapa and Sharma, 1994). Domondan and Poppe (2000) reported that among the various pests and diseases the most notorious was *Trichoderma*, which was resistant to pasteurization. Mignucci *et al.* (2000) reported *T. harzianum* competed with *Pleurotus* spp. Several weed moulds viz. *Trichoderma* spp, *Penicillium* spp, *Aspergillus* spp, *Chactomium* spp and *Copunus* spp were found to infest button mushroom (Sharma, 1995). Pani (2000) reported that in *Volvariella volvaceae* (Butt. Ex. Fr.) Singh the incidence of *Trichoderma* sp was the highest (23 per cent) followed by *Sclerotium rolfsi*. Kumar *et al.* (2002) reported *T. harzianum* as a predominant contaminant occurring in majority of the farms causing 80 per cent reduction in a survey conducted during 2000-2001 in 20 mushroom farms in and around Coimbatore.

Aspergillus niger caused problems during cultivation of *Agaricus bisporus* and *Pleurotus* spp resulting in yield loss (Panwer *et al.*, 2002).

Devi (1982) reported the occurrence of *Coprinus lag*opus as weed fungi in the paddy straw beds. Balakrishnan (1994) described the occurrence of *Coprinus* spp as a weed mould in oyster mushroom beds

2.2.1.1 Characterization of Competitor Moulds

2.2.1.1.1 *Trichoderma* spp

Rifai (1969) identified nine species of *Trichoderma* which is an authenticated record of the characterization of genus. The species

description of *T. harzianum*, *T. viride* as proposed by Rifai is presented below.

Characters	*T. harzianum* (Rifai)	*T. viride* Pers.ex S.F.Gray
Colony	Rapid growth, smooth surfaced which turned hairy later, dull green	Rapid growth, smooth at first which turns hairy later
Pigmentation	No pigments	No pigments
Hyphal diameter (µm)	1.5 – 12	1.5 – 12
Chlamydospore	Intercalary or terminal	Formed often
Conidiophore	Much branched dendroid and form loose tuft	Compact to loose tufts form continuous or broken ring
Phialides	In false verticils, short skittle shaped 5-7 x 3 – 3.5 µ	In false whorls 8 – 14 x 2.4 - 3 µ
Spore	Subglobose smooth walled 2.8 – 3.2 x 2.5 – 2.8 µ	Globose or obvoid, rugose wall 3.6 – 4.5 µ

2.2.1.1.2 *Coprinus* spp.

Buller (1958) studied the developmental stages and spore liberation of *C. lagopus* in detail. Geetha (1982) described in detail the characters of *Coprinus lagopus* (Fr.) Fr. as pileus cylindric oval latter turning pointed and stipe with length 1 to 5 cm at first, latter 10 to 15 cm and spore size. 12.5 x 5.5- 7µm.

Purkayastha and Chandra (1985) described *C. comatus* as follows:

Sporophores showing singly, scattered or in clumps, centrally stipulate, usually oblong, characterized by shaggy appearance of the pileus, almost white at maturity, fruiting body auto digesting. Pileus 6.0 – 15.0 cm long, 2.5 – 5.0 cm wide, cylindrical or oblong when young and tan or

purplish tan when old. Surface covered with distinct shaggy brown scales, pileus splitting at the margin. Gills distinctly formed, crowded, free, white when young, then pink, finally black, rather broad, cap and gill deliquescing into an inky fluid. Stipe centrally placed, tapering at the top, 3.5 – 8.0 cm long, 0.6 – 1.5 cm thick, whitish, smooth, hollow with a thin loose ring around the stipe disappearing quickly without volva. Flesh white, fragile. Basidiospores black, smooth, elliptical, 12.0 – 17.0 x 6.0 – 7.0 µm. Spore print black.

Reeja (2002) described *Coprinus comatus* (Mull. Ex Fr) SF Gray having pileus 2.5 –3 cm in long, stipe 3.5 to 8cm long and spores 12-17 x 6-7 µm in size.

2.2.1.1.3 *Aspergillus* spp.

Domsch and Gams (1980) described *Aspergillus flavus* Link ex Gray and *A. niger* Von Tighem in detail.

2.2.1.2 Nature of Damage Caused by Competitor Moulds Infesting Oyster Mushroom

2.2.1.2.1 *Trichoderma* spp.

Das *et al.* (1993) described in detail the symptoms due to infestation by *Trichoderma*. The growth was reported to start on beds 5-10 days after spawning as dark green patches, which spread over the entire substrate as white fluffy growth and suppressed spawn run. Balakrishnan (1994) reported the infestation of *Trichoderma* spp on mushroom beds during spawn run phase.

2.2.1.2.2 *Coprinus* spp

Coprinus spp occurred as a secondary parasite in beds where other competitor moulds had already established (Das and Suharban, 1991; Balakrishnan, 1994).

2.2.1.3 Extent of Damage

Loss in yield in different *Pleurotus* spp by the competitor mould was about 70 per cent (Sharma, 1995). Poppe *et al.* (1985) reported 30 per cent annual loss of *Pleurotus* yield due to *Trichoderma.* Inoculation of *T. viride* in steam-pasteurized substrate at spawning and 20 days later resulted in the highest and the lowest yield respectively. The extent of yield loss in *P. sajor caju* and *P. ostreatus* on steam pasteurized substrate varied from 16 to 17 per cent and 18 to 19 per cent respectively and that of *P. ostreatus* on chemically sterilized substrates varied from 5 to 45 per cent (Sharma and Vijay, 1996). *Trichoderma* spp were known to cause 81 per cent and *Coprinus* 94.4 per cent loss to *Agaricus* cultivation (Sharma, 1997). In studies conducted by inoculating the contaminants, the yield reduction of *P.eöus* by *A. flavour*, *A. niger* and *T. harzianum* ranged between 17.23-77.27, 8.5 –70.91 and 11.77-74.04 per cent respectively (Anandh *et al.*, 1999a). Prakasam *et al.* (2002) reported an yield reduction of 79.31, 83.61 and 84.04 per cent in case of *A. flavus*, *A. niger* and *T. harzianum* respectively.

2.2.2 Fungal Diseases

Some fungal species were reported to attack *Pleurotus* spp. in India. Sharma and Jandaik (1983) found that *Sabrina fungicola* infected oyster mushroom and resulted in rot. *Cladosporium* spp. (Sohi and Upadhyay, 1986; Upadhyay *et al.*, 1987; Goltapeh *et al.*, 1989), were found to cause cobweb disease in oyster mushroom. *Gliocladium* spp were found to cause brown rot (Bharadwaj *et al.*, 1987; Sharma and Jandark, 1987). Ganeshan (1987) reported *Arthrobotrys pleuroti* infection on oyster mushrooms.

2.2.3 Bacterial Diseases

Different species of *Pseudomonas* were reported to attack oyster mushrooms. Femour (1986) reported *Pseudomonas tolaasii* caused brown blotch

symptoms in oyster mushroom. *P. alcalegens* caused rot of mushroom (Biswas *et al.*, 1983). *P. agaricii* resulted in yellowing of oyster mushroom (Besette *et al.*, 1985). Infection of *P. flurescens* produced fist shaped fruiting bodies in oyster mushroom (Poppe *et al.*, 1985). Femour (1986) reported that *P. tolaasii* caused brown blotch symptoms in oyster mushroom. Mellesha and Shetty (1988) reported brown spots in oyster mushrooms due to infection by *P. stutzeri.*

2.2.4 Virus Diseases

In India, virus and virus like diseases have been reported in oyster mushroom by Reddy *et al.* (1983). Symptoms induced in *P. florida* include upward curling of pileus, swollen stalks and greatly distorted basidiocarps. Premature spore shedding and elongation of stalk are the typical symptoms of the disease (Sharma, 1995).

2.3 EFFECT OF PESTICIDES ON GROWTH OF *PLEUROTUS*

Kumar and Sharma (2002a) reported that Nuvan @ 0.05 per cent and malathion @ 0.05 per cent can caused about 100 per cent inhibition to *A. bisporus*. Cypermethrin @ 0.05 per cent, fenvalerate @ 0.05 per cent, Neem shield @ 0.1 per cent, Neemax @ 0.1 per cent, Micrin @0.1 per cent Electra @ 0.1 per cent and Nimca @ 0.1 per cent proved safe for *P. sajor-caju.*

2.4 EFFECT OF FUNGICIDES ON GROWTH OF *PLEUROTUS* AND CONTAMINANTS

Under *in vitro* conditions, carbendazim at 25 ppm concentration initiated inhibition of spore germination of contaminants (*A. flavus*, *A. niger*, *T. harzianum*) and at 150 ppm spore germination was completely inhibited. At 25 ppm of carbedazim the mycelial growth of contaminants was completely inhibited whereas the growth of *P. eöus* was unaffected even at 100ppm (Anandh *et al.*, 1999b).

2.5 MANAGEMENT OF INSECTS USING PHYSICAL METHODS AND BOTANICALS

2.5.1 Physical Methods

Sandhu and Arora (1990) found that mushroom flies could not pass through the nylon nets of 14 mesh/cm. Screening of door and ventilator openings of mushroom house with nylon wire nets of 14-16 mesh/ cm was effective in checking the entry of flies into the mushroom house. Balakrishnan (1994) reported that among the various management practices tested, the maximum yield could be obtained from the beds without any holes but provided with a cotton plug at the top, which showed no incidence of pests.

2.5.2 Baits

Chakravarty *et al.*, 1987 evaluated different types of baits and found that poison baiting of sciarid fly with Baygon diluted in water at 1.10 ratio with addition of sugar was effective. Kumar and Verma (1997) reported that the biopesticides, Electra at 1:10 dilution with sugar and Leaf pep at 1: 10 dilution with sugar controlled sciarid and phorid respectively when used as poison baits.

2.5.3 Botanicals

As sprays, smokes or as aerosols Pyrethrin had been commonly used against mushroom flies because of its low residual toxicity (Hussey, 1961; Brand, 1964). Neem seed powder at 0.5, 1.0, 1.5 per cent incorporated in compost and casing material reduced the larval and pupal populations of the sciarid fly *Bradysia tritici*. Higher dosage reduced spawn run (Baba, 1990). Bhat *et al.*, 1997 reported the effect of two neem based products. Rakshak (Azadirachtin 0.15 EC) at 0.3 per cent and Neemark (Azadirachtin 0.03 EC) at 0.02 per cent sprayed after spawning and other after opening of bed. Rakshak significantly increased the yield and reduced pest population by 77 per cent and fruit body infestation by 78 per cent.

Kumar and Verma (1997) reported the response of mushroom flies towards biopesticides like Ecosulf, Leaf pep, Neemex and Micrin and pointed out that mushroom flies *viz.* phorid and sciarid had different responses towards biopesticides.

2.5.4 Chemicals

Malathion @ 0.01 per cent applied as drench in between flushes after picking was effective against larvae of sciarid (Hussey and Gurney, 1968). Malathion @ 0.025 per cent concentration was recommended during cropping in between flushes with a waiting period of five days (Garcha, 1980). Bhandari and Singh (1983b) evaluated the efficacy of dichlorvos, malathion, endosulfan and carbaryl @ 2.5, 5.0, 10.0 and 15.0 ppm concentration respectively by soaking in the maize straw in their suspension for the control of *L. cyaneus* on oyster mushroom and found dichlorvos 5 ppm and endosulfan 10 ppm effective. The residues on the mushroom due to this treatment were far below the tolerance limit permitted for human consumption. Thapa and Seth (1983) used malathion for spraying against springtails in the mushroom house. An automatic spraying system with dichlorvos (DDVP) at regular intervals @ 1.4 mg/l gave good control of the phorid population in spawn run and precropping stages (White, 1983).

Among malathion, fenetrothion, primiphos methyl, phoxim, dichlorvos, trichlorphon and deltamethrin evaluated as adulticide against sciarids (Sandhu and Brar, 1982; Brar and Sandhu, 1989 and Sandhu and Arora, 1990) dichlorvos was found to be most effective one for the knockdown effect and least persistent activity. Malathion (0.01 per cent) spray on mushroom beds seven days after spawning was effective for controlling sciarid fly, *L. auripila* maggots infesting. *Pleurotus* bed (Chakravarthy *et al.*, 1987).

Sandhu and Bhattal (1989) evaluated the toxicity of malathion, fenitrothion and found dichlorvos, trichlorphon and deltametrin @ 1 $\mu g/cm^2$

against phorid adults and found dichlorvos as the most effective one. Arora and Sandhu (1991) reported that in mushroom house, dichlorvos as ultra low volume (ULV) spray was effective for controlling mushroom flies @ 22.5 g ai/ 100 m^2 dosage and in the case of knapsack sprayer, higher dosage of 30g was effective. Balakrishnan (1994) reported that in a spray schedule consisting of dichlorvos (0.02 per cent) spray in incubation at three day intervals + dichlorvos (0.02 per cent) spray in cropping room at 10 day intervals, mean per cent of bed damaged during incubation was zero. Sandhu (1990) recommended application of malathion or dichlorvos at 0.025- 0.05 per cent concentration respectively. Sandhu (1995) further recommended the use of dichlorvos 76 EC 30 ml/100 m^3 in mushroom house and ceiling but pointed out that direct spraying on mushroom bed should be avoided.

Veire (1988) reported that incorporation of diflubenzuron in the substrate @ 6.25 ppm gave control of larvae for at least nine weeks, leaving only traces of the product in oyster mushroom and that depending on cultural practices surface sprays (0.02 per cent a i) between croppings were also effective. Further Veir (1990) reported that befenthrin and tefluthrin @ 10 ppm were very effective against *Heteropeza pygmea* on *Pleurotus ostreatus*. Residue analysis showed that the pyrethroids were not observed by the fruiting bodies. In studies carried out in Korean Republic when mixed with compost substrate Dursban (chlorpyrifos) and Primicid (pirimiphos- ethyl) both at 50 ppm gave effective control of the flies in a mushroom house. When applied only to the surface of compost chlorpyrifos gave the best control of adult flies and was not phytotoxic chlorpyrifos and pirimiphos ethyl both at 0.11 g ai/m^2 gave the best control and resulted in the highest yields of mushroom sporophores (Jhune *et al.*, 1990). They further found that treatment with diflubenzuron at 4 g/m^2 gave 91.4-93.7 control the flies. Balakrishnan (1994) found that at a spray schedule, Roger (0.1 per cent) in the premises of the mushroom house at 10 day intervals combined with dichlorvos (DDVP) 0.02 per cent

spray in both incubation and cropping rooms (between flushes) at three and 10 day intervals respectively was effective in checking the pest population completely.

2.6 MANAGEMENT OF DISEASES OF OYSTER MUSHROOM USING CHEMICALS

2.6.1 Management of *Trichoderma* spp.

Among the various pasteurization methods tested, carbendazim @ 75 ppm in combination with formaldehyde @ 500 ppm gave complete inhibition of green moulds resulting in the maximum yield (Gokulapalan *et al.*, 1987). Balakrishnan (1994) steam pasteurization was equally good as chemical in controlling competitors. He also reported that adjusting the pH of the substrate soaking water by addition of pure lime powder to a pH range of 7.0 to 9.0 was the most congenial for minimizing the green mould and also for obtaining a steady and reasonable yield.

Competitor moulds have been reported to be completely inhibited under *in vitro* and/ or *in vivo* conditions by benomyl (50 ppm), carbendazim + blitox (100 ppm each) and thiram (100 ppm) (Bano *et al.*, 1975; Sharma and Jandaik, 1980; Doshi and Singh, 1985). Sharma (1997) recommended the use of Benomyl, Chlorothalonil and Thiabendazole as fungicides against mushroom pathogens and competitors. The use of sanitizers like calcium hypochlorite, chlorine gas and sodium hypochlorite was also effective.Five ppm carbendazim completely inhibited *T. viride* and stimulated *P. sajor caju*. At 5-10 ppm carbendazim stimulated *P. sajor caju* but completely inhibited *P. sajor caju* at a concentration of 100 ppm (Rai and Vijay, 1992). Spot application of lime effectively controlled *Trichoderma.* (Balakrishnan, 1994)

Weekly sprays of Dithane Z.78 (0.2 per cent) or Bavistin (0.1 per cent)or TBZ 0.2 per cent or calcium hypochlorite (15 per cent) gave effective control of *Trichoderma.* Formalin two per cent was also

effective (Sharma, 1995). Domondan and Poppe (2000) reported that benomyl 1000, 500 and 250 ppm Prochloraz 1000 ppm and imazalin 1000 ppm and 500 ppm inhibited the growth of *Trichoderma* and Kresoxin- methyl and azoxystrobin inhibited sporulation of *Trichoderma* for a few days.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The facilities available in the mushroom house of the Instructional Farm, College of Agriculture, Vellayani were utilized for spawn production and studies on pests and diseases associated with mushroom.

3.1 PREPARATION OF PURE CULTURE OF OYSTER MUSHROOM

Tissue isolation technique was used for obtaining the pure culture of *P. florida* from its sporocarp.

Sporocarps of medium maturity (two day old sporocarp) were selected for tissue culture. The pileus as well as stipe were surface sterilized with 95 per cent ethyl alcohol. Bits were cut out. These bits were then placed on Potato Dextrose Agar (PDA) in Petri dishes and incubated at room temperature. Once initial growth was observed bits from the peripheral region was aseptically transferred on to PDA slants. The isolate was then purified by hyphal tip method and maintained by subculturing periodically on PDA slants.

3.2 SPAWN PRODUCTION

The spawn required for the experiments was prepared following the method of Sinden (1934). Rice grains (husked) were used for spawn production. Grains were boiled with equal quantity of water until the grains just split out. Excess water was drained off and the grains were air dried for some time and mixed with three to five per cent calcium carbonate thoroughly before filling in glass bottles. Glass bottles of 500 ml capacity were filled with grains. Seven to eight centimeter space at the top of the bottle was left unfilled. The bottles were then sterilized at 1.02 kg cm^2 for two hours. The sterilized grains were then inoculated with a seven day

old culture of *P. florida* and were then incubated in a dark and cool place at room temperature for 14 days. This was used for preparation of mushroom beds.

3.3 ASSESSMENT OF PESTS AND DISEASES OF OYSTER MUSHROOM, *P. FLORIDA*

3.3.1 Layout of Mushroom Beds

Mushroom beds were prepared following the standard compact poly bag method of mushroom cultivation (Bhaskaran *et al.*, 1978) using paddy straw as the substrate. The substrate was chemically sterilized using a mixture of carbendazim (75 ppm) and formaldehyde (500 ppm) (Gokulapalan *et al.*, 1987)

Paddy straw pre-soaked overnight in water containing the above chemicals was made into small twists after draining excess water. Polythene tubes of 30 cm diameter were cut into pieces of 60 cm length and these were used for laying the beds. About nine holes were made on each polythene tube for air circulation and the bottom was tied. Treated straw was then placed inside the cover up to a height of 10cm. This layer was spawned using rice grain spawn and the second layer of straw was placed over it and spawned. In this way the whole cover was filled layer by layer and cover was made as compact as possible and tightly tied to a compact mass. The beds were then kept on bricks laid on a 10 cm high layer of river sand and incubated at room temperature for a period of 12-15 days (spawn run period). In order to maintain 80 per cent relative humidity in the mushroom house, water was sprinkled on the sand during morning and evening hours.

3.3.2 Pests Infesting Oyster Mushroom

One hundred beds were laid out in the mushroom house during August – September 2002. The beds were daily examined for the presence of

insects. Observations were recorded on type of pests, nature and extent of damage.

3.3.2.1. During Incubation

Pests occurring during the incubation period were daily collected. At the end of the incubation period destructive sampling of beds was done. One in every four beds was selected for destructive sampling to collect the insects present inside the bed. The collected insects were preserved in 90 per cent ethyl alcohol for identification.

3.3.2.2. During cropping

The beds laid out for examining the pest incidence during incubation were also used to find out pests associated with sporocarps.

3.3.2.3 Nature of Damage

The nature of damage on mushroom beds and sporocarps were recorded daily.

3.3.2.4 Extent of Damage by Pest Infesting Oyster Mushroom

3.3.2.4.1 During Incubation

Fifteen days after incubation the extent of damage of beds by insects was quantified. For this the area damaged by pests was marked on the polythene tubes of the bed with a marker pen. The polythene tubes were then carefully removed and the area damaged in each bed was measured using graph paper and the percentage area damaged was worked out. Based on this the grading was done (Plate 1).

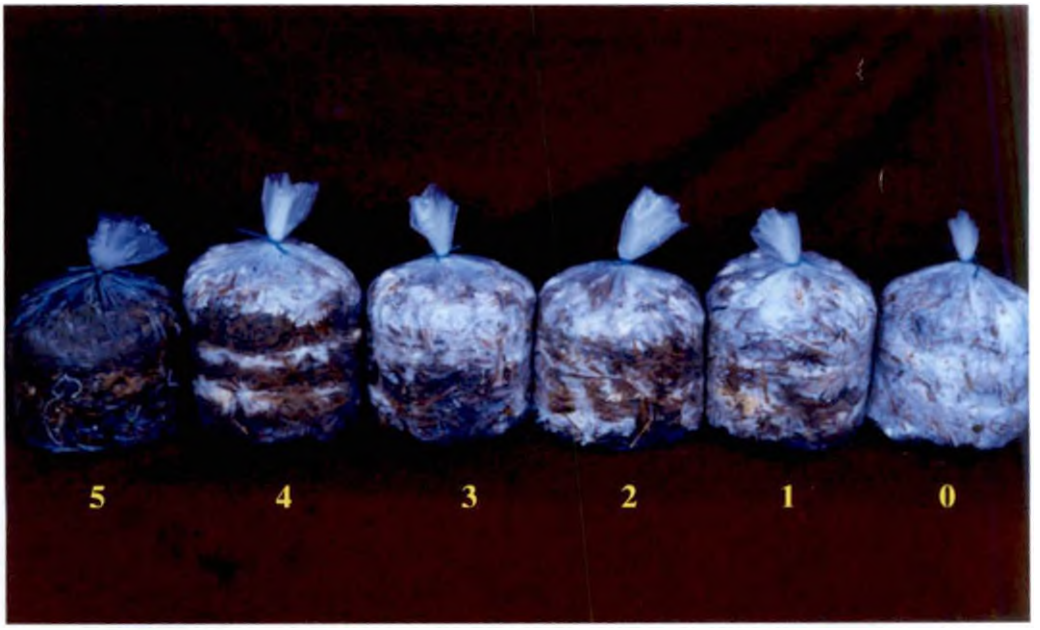

Plate 1 Mushroom bed damage, grade 5 – 0

Damage grade index (DGI-I)	Percentage of area damaged
0	Undamaged bed *i.e.*, complete coverage with mushroom mycelia
1	1 – 20
2	21 – 40
3	41 – 60
4	61 – 80
5	> 80

3.3.2.4.2 During Cropping

Ten beds were randomly selected and the total number of healthy and infested sporocarps per bed was counted. For assessing the intensity of pests the following damage indices were used.

Damage grade index (DGI-II)	Percentage of sporocarp damaged with insects
0	< 10– mild infestation
1	11 to 50– Moderate infestation
2	51 – 75– High infestation
3	> 75– Severe infestation

3.3.3 Periodicity of Occurrence of Pests in Oyster Mushroom House

Yellow light traps were used for studying the periodicity of pest in mushroom house (Plate 2). Yellow bulb of 15 w placed in between two cardboard pieces (15 x 15 cm size) coated with mustard oil was placed among the beds at a height of 60 cm from the ground. One day in a month the bulb was switched on from 5pm to 8am. On the next day cardboard

Plate 2 Light trap in mushroom house

pieces with the insects sticking on it were brought to the laboratory and the insects were identified and counted separately. Data were analyzed and the correlation between weather parameters and pest population was worked out.

The periodicity of occurrence of *Staphylinus* sp. was counted from individual sporocarps at monthly intervals and mean number of beetle / sporocarp was recorded. Observations were recorded from May 2002 to April 2003.

3.3.4 Assessment of Occurrence of Competitor and Pathogenic Moulds in Oyster Mushroom (*P. florida*)

One hundred beds were laid out during June-July 2002. The beds were examined daily for the occurrence of pathogenic and competitor moulds. Observations were recorded on the type of competitor moulds, nature of damage, number of beds infested and yield.

3.3.4.1 Identification and Characterization of Competitor Moulds

Contaminants observed in mushroom beds were isolated following serial dilution technique (Johnson and Curl, 1972) and purified by hyphal tip method. The most commonly observed contaminants were *Trichoderma*, *Aspergillus* and *Coprinus.*

3.3.4.1.1 Characterization of *Trichoderma* spp.

Characterization of *Trichoderma* spp. was done by adopting the methodology of Chowdhary (1997). *Trichoderma* was inoculated on 9 cm Petri dishes plated with PDA and incubated for one to two days at room temperature. Observations were recorded on growth and colour of colonies. For detailed examination of branching system of conidiophores and phialides, slides were prepared before the colony reaching its ultimate colouration. Spore size was measured using micrometer.

3.3.4.1.2 Characterization of *Coprinus* sp.

The identification of *Coprinus* sp. was done following the procedure outlined by Devi (1982).

Characterization of *Aspergillus* sp.

The identification of *Aspergillus* sp. was done based on colony characters and conidial morphology.

3.3.4.2 Nature of Damage Caused by Competitor Moulds

Beds were daily checked and observations regarding the signs of competitor moulds were recorded

3.3.4.3 Extent of Damage by Competitor Moulds

All the beds were observed 15 days after incubation and extent of damage by competitor moulds and damage grade index was worked out as described under 3.3.2.4.1

3.4 EVALUATION OF FUNGICIDES AND DISINFECTANTS

The fungicides were evaluated against the growth of *T. harzianum* and *P. florida* under *in vitro* conditions.

T_1 – Carbenbazim @ 50 ppm (Bavistin 50%WP)

T_2 – Mancozeb @ 250 ppm (Dithane M-45 75%WP)

T_3 – Fresh lime powder @ 500 ppm

T_4 – Sodium hypochlorite @ 500 ppm

T_5 – Sodium chloride @ 500 ppm

T_6 – Control

Double strength concentration of fungitoxicant / disinfectant in sterile water were aseptically added to sterilized double strength potato dextrose agar medium to obtain the final concentration of active ingredients. Colony diameter was measured at every 24 h until the colony in the control covered the Petri dish. Percent inhibition in growth was calculated as follows:

$$\text{Per cent inhibition} = \frac{C - T}{C} \times 100$$

Where C = growth in control
T = growth in treatment

3.5 EVALUATION OF INSECTICIDES

The effect of following insecticides was evaluated against the growth of *P. florida* as per details given under 3.4.

T_1 – Dichlorvos @ 0.01 per cent (Nuvan 76%EC)

T_2 – Dichlorvos @ 0.02 per cent (Nuvan 76%EC)

T_3 – Malathion @ 0.025 per cent (Tagthion 50%EC)

T_4 – Malathion @ 0.05 per cent (Tagthion 50%EC)

T_5 – Malathion @ 0.1 per cent (Tagthion 50%EC)

T_6 – Nimbecidine 2ml/l (Nimbecidine contains azadirachtin 0. 03% EC)

T_7 – Nimbecidine 4ml/l (Nimbecidine contains azadirachtin 0. 03% EC)

T_8 – Nimbecidine 6ml/l (Nimbecidine contains azadirachtin 0. 03% EC)

T_9 – Control

3.6 MANAGEMENT OF PESTS USING PHYSICAL METHODS AND PLANT EXTRACTS

An experiment was conducted during October – November 2002 to study the effect of different techniques for management of insect pests infesting mushroom beds. Experiment was conducted in CRD with four replications. Treatments were as follows:

Treatments

T_1 – Pinpricks on polythene tubes (instead of holes)

T_2 – Holes covered with cotton

T_3 – Installing baits

T_4 – Garlic extract (2 %) spray

T_5 – *Hyptis suaveolens* extract (10 %) spray

T_6 – *Andrographis paniculata* extract (10 %)spray

T_7 – Control (water spray)

3.6.1 Setting of Bait Traps

Banana fruits were used as baits. Ripe palayamkodan fruit was cut into three pieces and cut ends were dipped in Furadan 3 G granule and placed in coconut shells. These coconut shells were placed among the beds. One such trap was placed at the centre of four beds. They were installed during incubation period only so as to avoid contamination during cropping.

3.6.2 Preparation of Plant Extracts

Ten per cent water extracts of *Hyptis suaveolens* and *Andrographis paniculata* were prepared by crushing 100 g plant parts with a little quantity of water. The extracts thus obtained served as stock solution.

This was further diluted to obtain 10 per cent concentration. Five gram of ordinary bar soap was added per litre of the extract.

As extracts of *H. suaveolens* and *A. paniculata* resulted in heavy growth of contaminants the treatments were given only two days after spawning on the surface of beds. Observations were recorded on the extent of area damaged by pests at the end of incubation period, number of sporocarps damaged by insects and yield.

3.7 MANAGEMENT OF INSECTS USING CHEMICALS

An experiment was laid out in CRD with nine treatments and three replications during March – June 2003 to assess the effect of chemicals in the management of pests attacking mushroom.

Following treatments were evaluated.

Experiment -1

T_1 – Dichlorvos spray (0.01 per cent) (Nuvan 76 EC) in incubation room at three day intervals + dichlorvos spray (0.01 per cent) in cropping room at 10 day intervals

T_2 – Dichlorvos spray (0.02 per cent) (Nuvan 76 EC) in incubation room at three day intervals + dichlorvos spray (0.01per cent) in cropping room at 10 day intervals

T_3 – Malathion spray (0.025 per cent) (Tagthion 50 EC) in incubation room at three day intervals + malathion (0.025 per cent) spray in cropping room at 10 day intervals

T_4 – Malathion spray (0.05 per cent) (Tagthion 50 EC) in incubation room at three day intervals + malathion (0.02 per cent) spray in cropping room at 10 day intervals

T_5 – Malathion spray (0.1 per cent) (Tagthion 50 EC) in incubation room at three day intervals + malathion (0.1 per cent) spray in cropping room at 10 day intervals

T_6 – Nimbecidine 2ml/l (Nimbecidine contains azadirachtin 0. 03% EC) spray in incubation room at three day intervals + Nimbecidine 2ml/l spray in cropping room at 10 day intervals

T_7 Nimbecidine 4ml/l (Nimbecidine contains azadirachtin 0. 03% EC) spray in incubation room at three day intervals + Nimbecidine 4ml/l spray in cropping room at 10 day intervals

T_8 Nimbecidine 6ml/l (Nimbecidine contains azadirachtin 0. 03% EC) spray in incubation room at three day intervals + Nimbecidine 6ml/l spray in cropping room at 10 day intervals

T_9 Water spray

Since the yield obtained in the above experiment was low due to inhibition of mushroom by the insecticide another set of experiment was laid out using changed dose and the schedule of treatment of insecticides was given below.

Experiment 2

T_1 – Dichlorvos @0.01% (Nuvan 76 EC) spray in incubation room three days after spawning

T_2 – Malathion @0. 025% (Tagthion 50EC) spray in incubation room three days after spawning

T_3 – Nimbecidine 2ml/l (Nimbecidine contains azadirachtin 0. 03% EC) spray in incubation room three days after spawning

T_4 – Control (water spray)

3.8 MANAGEMENT OF DISEASES USING CHEMICALS

Trichoderma was the commonly occurring competitor mould. So studies on management of *Trichoderma* was undertaken.

Experiment was laid out in CRD with nine treatments and replications during January – February 2003. Treatments were:

T_1 – Carbendazim @ 50 ppm (Bavistin 50%WP)

T_2 – Mancozeb @ 250 ppm (Dithane M-45 75%WP)

T_3 – Fresh lime powder (spot application)

T_4 – Sodium hypochlorite @ 500 ppm

T_5 – Sodium chloride @ 500 ppm

T_6 – Adjustment of pH of substrate soaking water to 6 by adding lime

T_7 Adjustment of pH of substrate soaking water to 7 by adding lime

T_8 Adjustment of pH of substrate soaking water to 8 by adding lime

T_9 Control (water spray)

The beds were artificially contaminated with *Trichoderma.*

3.8.1 Preparation of Inoculum of *Trichoderma harzianum*

Pure culture of *T. harzianum* multiplied in sterilized rice grains in glass bottles served as inoculum for treating the beds The grain inoculum of *T harzianum* was inoculated @ 20 g/bed at two points three days after bed preparation. Treatments were given five days after inoculation. Beds with water spray served as the control. Observations regarding the spread of contaminants and yield were recorded.

RESULTS

4. RESULTS

4.1 PESTS INFESTING OYSTER MUSHROOM.

The details of the insect pests associated with oyster mushroom in Agriculture College, Vellayani are presented in Table 1. The insects observed during incubation period comprised of springtails, flies and beetle pests. The larval, pupal and adult stages of these insects were found in mushroom beds.

The springtail *Seira* sp. was the most predominant pest among the three. The mushroom flies belonging to the family Phoridae and Sciaridae respectively were also identified. The beetle pests infesting oyster mushroom were identified as *Staphylinus* sp., another beetle pest (unidentified) belonging to the family Staphylinidae and subfamily Scaphidiinae was also observed in incubation room.

All these groups of pests *viz.*, springtails, flies and beetles were encountered during cropping also. Coexistence of all these pests was noticed through out the course of study.

4.1.1 Characters of Insects Infesting Oyster Mushroom

4.1.1.1 Springtails (Seira sp.)

Juveniles and adults showed the characteristic jumping movement using the springing organ when disturbed. The adults 2.5 – 3.0 mm long were blackish brown with bands along the sides of body (Plate 3 and 4). The antennae could be seen prominently and two black ocellar fields were present on the head.

4.1.1.2 Phorid Flies (Megaselia sp.)

Larvae 3.0 mm long, creamy white, apodous, narrow at anterior and pointed head and posterior end blunt. The pupae were 2-3 mm long

Table 1. Pests infesting oyster mushrooms

Common name	Order	Family/Subfamily	Genera
Spring tail	Collembola	Entomobryidae	*Seira* sp.
Phorid flies	Diptera	Phoridae	*Megaselia* sp.
Sciarid flies	Diptera	Sciaridae	Unidentified
Staphylinid	Coleoptera	Staphylinidae	*Staphylinus* sp.
Staphylinid beetle	Coleoptera	Staphylinidae Subfamily : Scaphidiinae	Unidentified

blackish brown. The adults 3 mm long dark brown, hump backed and with inconspicuous antennae (Plate 5).

4.1.1.3 Sciarid Flies

Larvae 6-8 mm long dirty white with visible longitudinal black streaks. The pupae 4 mm long and yellowish brown. Adults were 2.5 mm in length and with prominent antennae.

4.1.1.4 Beetle Pests

4.1.1.4.1 *Staphylinus* sp.

Grubs were long whitish cylindrical with tubular terminal segment. Adults 3-5 mm brown insects with short elytra and large membranous hind wing. The tip of the abdomen was seen curled over the back (Plate 6).

4.1.1.4.2 Staphynilid Beetle (Unidentified)

The grubs of unidentified beetle was0.4 to .8 cm long and blackish in colour with creamy white intersegments. The adults were deep amber coloured, head hypognathus, top of abdomen not fully covered by elytra (Plate 7a, 7b and 8).

4.1.2 NATURE OF DAMAGE BY PESTS INFESTING OYSTER MUSHROOM

4.1.2.1 Springtails

Numerous springtails were seen inside the mushroom beds during spawn run period. The initial infestation was observed with in five days after spawning. The feeding of these insects resulted in reduced spawn run.

Large numbers of springtails were also seen associated with the mushroom sporocarps. Even though the entire sporocarps were found infested, the insects were mainly seen crowded on the lower portion of the sporocarps and where the stipe joins the gills. They hide in between the gills and were very difficult to remove them from the gills. This in turn

Plate 3 Adult springtail

Plate 4 Adult and nymph of springtail

Plate 5. Adult Phorid fly

Plate 6 Adult Staphylinid beetle

Plate 7a Adult of Staphylinid beetle (unidentified)

Plate 7b Adult of Staphylinid beetle (unidentified) in sporocarp

Plate 8 Grub of Staphylinid beetle (unidentified)

reduced the market value of the mushrooms. When the sporocarps were severely infested they became discoloured and deformed (Plate 9). It was also noticed that crawling of insects in beds after first harvest restricted further flush development.

4.1.2.2 Phorids and Sciarids

The nature of damage of phorids and sciarids was identical. The attack of mushroom flies started at early spawn run stage normally five to six days after spawning. The larvae were found feeding on mycelium arresting its growth. This resulted in the decaying of the substrate. Often these areas were contaminated by weed moulds. The larvae also fed on decomposed spawn grains. When the infestation was severe the beds decayed completely emitting a foul smell (Plate 10).

During cropping stage the larvae made tunnels in the stipe resulting in discolouration and decay of the fruiting bodies. Adults were also seen on the sporocarps (Plate 11). The larvae hide inside the pileus and gills and crawl out and when the fruiting bodies were harvested. These were seen inside the plastic packets in which the mushrooms were marketed.

4.1.2.3 Beetle Pests

4.1.2.3.1 *Staphylinus* sp.

The infestation of staphylined beetle was not prominent during incubation.

The young sporocarps were highly vulnerable to infestation by the insects. The grubs crawled into the surface of fruiting beds and sporocarps. They were found to feed voraciously, making tunnels in the stipe as well as on the gills and lower portion of pileus. The adults were found to make holes all over the fruiting bodies (Plate 12). The infestation was first seen in mature sporocarps but later infested younger stages also. The infestation ultimately resulted in rotting of sporocarps.

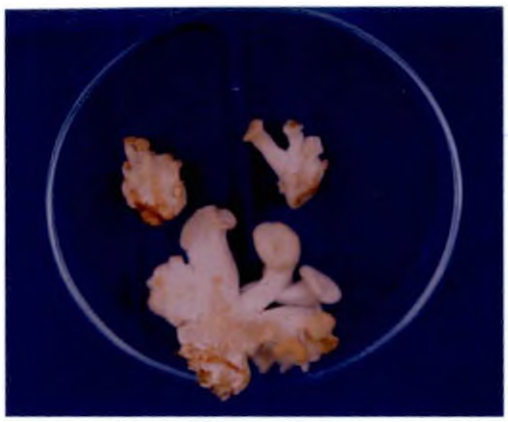

Plate 9a

Plate 9b

Plate 9 a & b Mushroom damaged by springtail

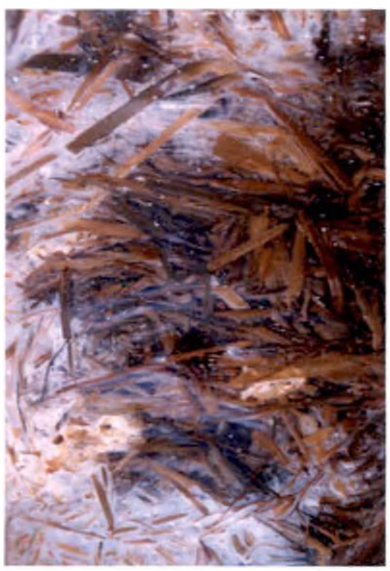

Plate 10 Mushroom bed damaged by phorid fly

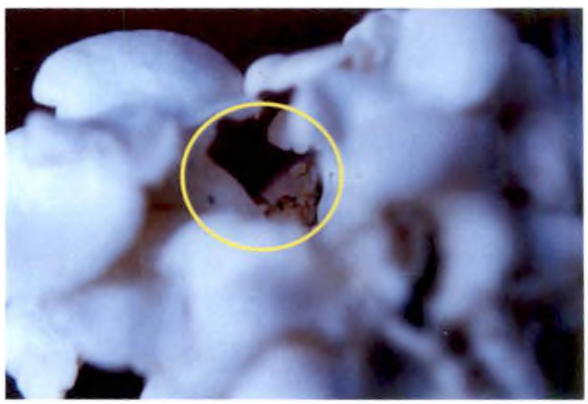

Plate 11 Mushroom damaged by phorid fly

4.1.2.3.2 Staphylinid Beetle Unidentified

The grubs and adults of this beetle were found to feed on the mushroom mycelium during the spawn run stage.

The grubs were found hiding in between the gills. The grubs as well as adults voraciously fed on the stipe and pileus and made irregular holes and destroyed the edges of the sporocarps. The heavily infested fruiting bodies were totally deformed (Plate13a & 13b).

4.1.3 Extent of Damage

4.1.3.1 During Incubation

The extent of damage caused to mushroom beds by the entire pest complex was assessed using the DGI-I as described under 3.3.2.4.1 and presented in Figure 1.

Twenty one per cent of beds were free of pest attack. Thirty-three percent of the beds belonged to DGI 1 where the damage ranged from 1-20 per cent. This was followed by the index 2 under which 23 beds were damaged. More than 80 per cent infestation by insect pest was noticed in 12 per cent of the beds (DGI-5).

4.1.3.2 During Cropping

Each sporocarps was individually assessed to find out the presence of insects. Beds were categorized according to DGI-II as described under 3.3.2.4.2

Sporophores in 15 per cent of the beds were free from insect attack. (Figure 2) while more than 75 per cent of the sporocarps in 20 per cent of the beds were found infested by insect pests. Majority of the beds (42 per cent) belonged to DGI 2 where the insect damage to sporocarp ranged from 11-50 percent.

Plate 12 Sporocarp damaged by *Staphylinus* sp.

Plate 13a Mushroom bed damaged by Staphylinid beetle (unidentified)

Plate 13b Sporocarp damaged by Staphylinid beetle (unidentified)

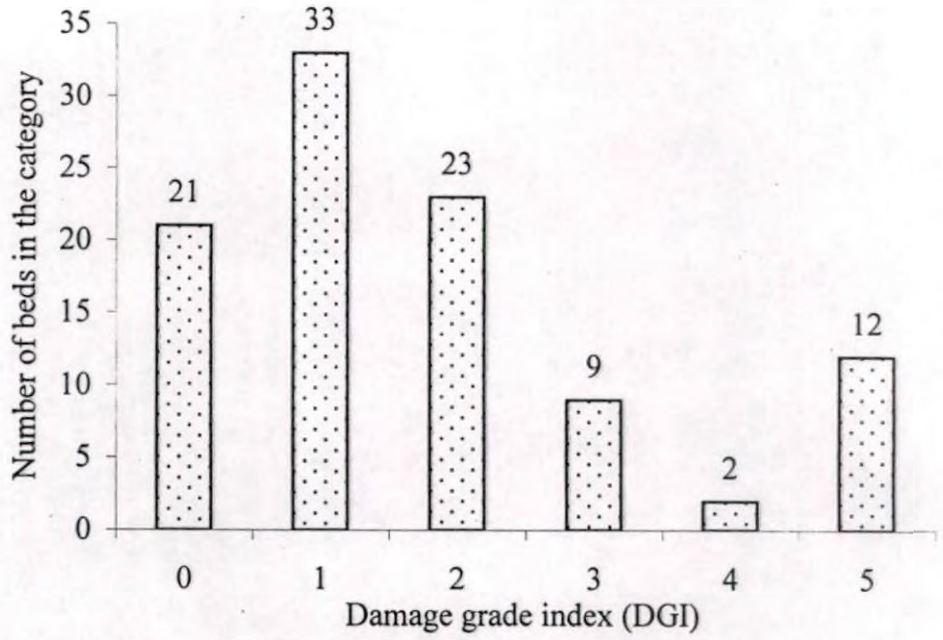

Fig. 1 Extent of damage due to insect pests during incubation

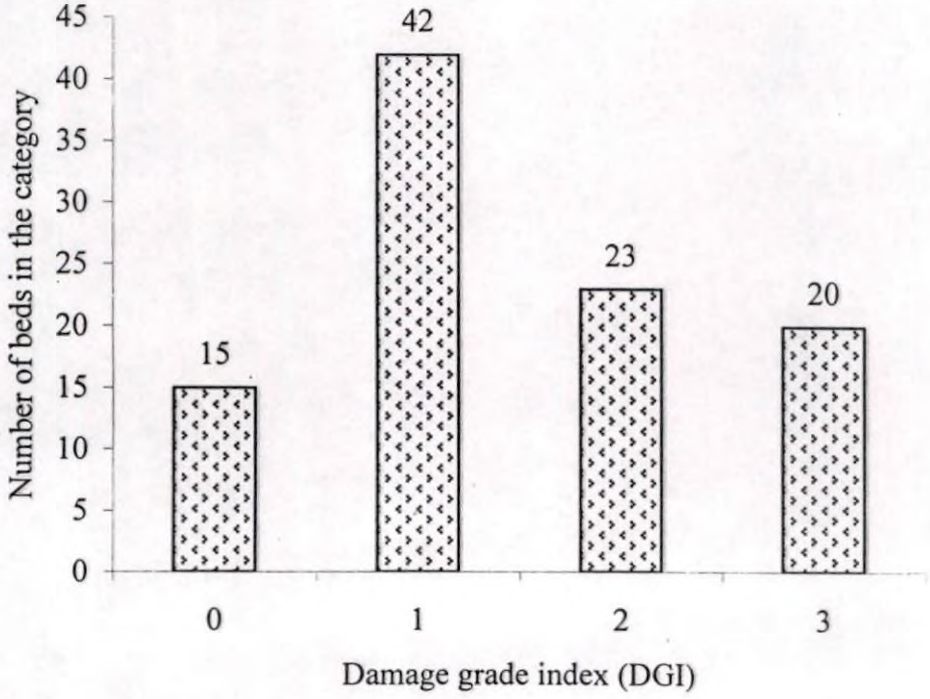

Fig. 2 Extent of damage due to insect pests during cropping

4.1.4 Correlation between Percentage Area of Bed Damage and Yield

The yield obtained from the beds was correlated with intensity of pest infestation in each bed (Table 2 and Fig. 3).

A negative correlation (b-0.9652**) was observed between percentage of bed damaged and yield (Table 2). When the percentage of area damaged was less than 5 per cent (4.58) the reduction in the yield over control was only five per cent. When the damaged area ranged from 11.05 to 17.07 the percent reduction in yield over the uninfested bed ranged from 11.14 to 30.15. More than 50 per cent of the reduction in the yield was noticed when 34 per cent of the area was damaged. Compared to 315 g of mushroom in uninfested bed only 50g was obtained when 78 per cent of the surface of the bed were damaged by insect pests.

4.1.5 Periodicity of Occurrence of Pests in Oyster Mushroom House

The count of insect pests was correlated with temperature (maximum and minimum), relative humidity (morning and evening) and rainfall data (amount of rainfall and number of rainy days) (Table 3) (Fig. 4).

Maximum temperature was found to have a positive correlation with number of phorid flies (b = 2.1178**). The population of phorids was five or more than five during December to May when maximum temperature ranged from 31.5°C to 32.8°C. phorids were not observed during the months of June and July when temperature was around 30°C. In general less number of phorids were observed when the number of rainy days were more.

A negative correlation was observed between evening relative humidity and phorid population. During December-April the evening relative humidity ranged from 57.6 to 67.2. During that period the population of the phorid in mushroom house was maximum. Similarly when humidity level ranged from 64.9 to 78.5 during May to November the population of phorid showed a decreasing trend (5-0).

Table 2. Correlation between percentage area damaged per bed and yield

Percentage area damaged/bed	Yield (g/500 substrate)	Per cent reduction over uninfested
0.00	315	0
4.58	300	5.00
11.05	260	17.46
11.18	240	23.80
17.41	230	26.98
17.07	220	30.15
34.30	150	52.3
43.98	110	65.07
78.71	50	84.13
100.00	0	100

b=–0.9652

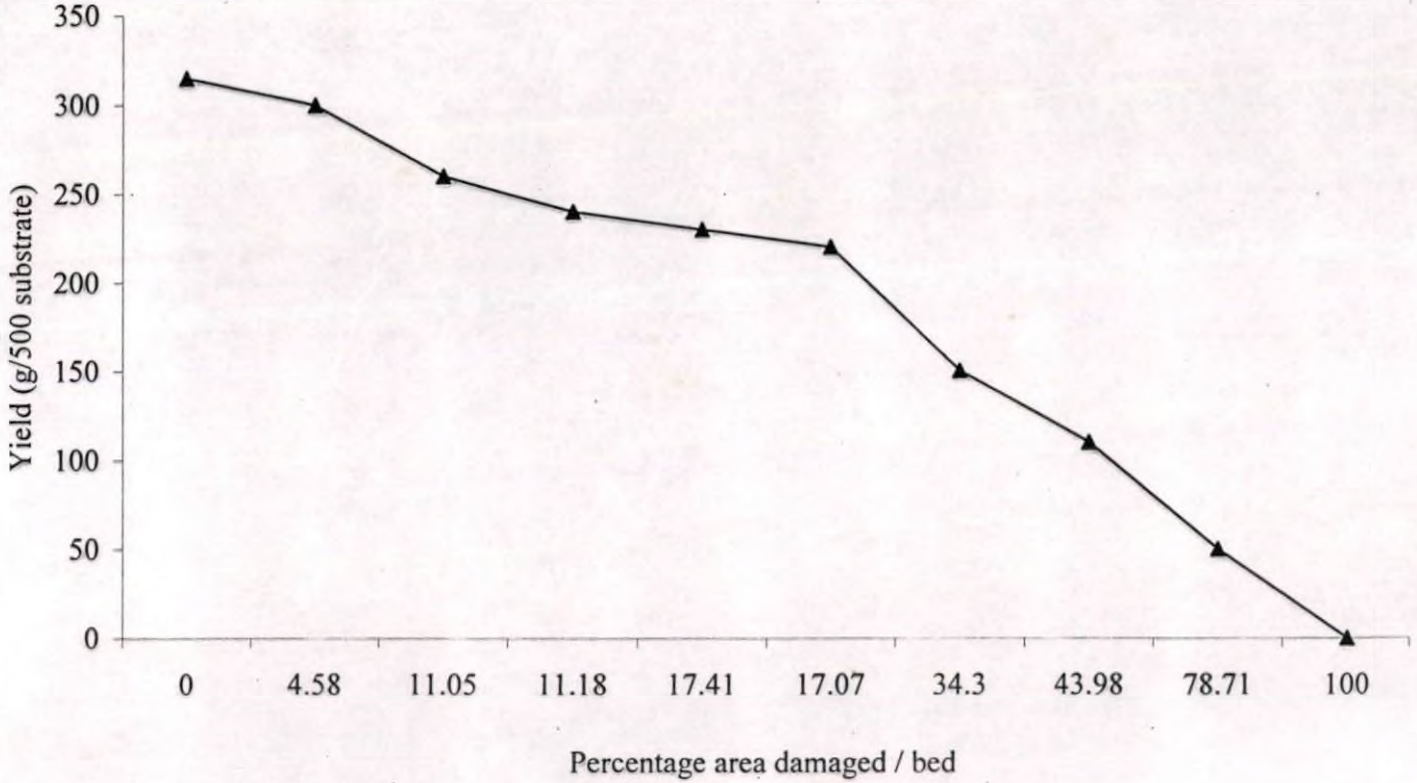

Fig. 3 Correlation between the percentage area damaged per bed and yield

Table 3. Correlation between pests counts and weather parameters

Month	Temperature		Relative humidity		Rainfall		Population count		
	Maximum	Minimum	Morning	Evening	Amount	No. of rainy days	Phorid flies/ 225 cm^2	Spring tails/ 225 cm^2	Staphylinus sp./ sporocarp
May 2002	31.5	25.0	91.8	73.0	200.1	17	5	75	5
June 2002	30.5	24.1	90.0	73.3	161.1	13	0	210	1
July 2002	30.4	23.9	91.5	73.1	33.2	10	0	250	5
Aug. 2002	29.9	23.4	90.9	72.4	101.4	12	2	200	3
Sept. 2002	31.2	22.3	86.1	64.9	32.4	4	3	75	4
Oct. 2002	30.1	23.3	94.1	78.5	416.5	25	4	60	1
Nov. 2002	30.2	23.4	95.9	75.0	92.5	13	3	50	1
Dec. 2002	30.9	21.5	90.4	65.1	3.2	1	5	75	3
Jan. 2003	31.5	21.4	93.0	57.6	1.6	1	6	125	3
Feb. 2003	31.7	22.8	93.4	61.6	68.3	3	7	175	4
March 2003	32.5	23.5	91.7	62.1	69.0	6	7	40	5
April 2003	32.8	24.7	89.5	67.2	80.2	7	7	26	6

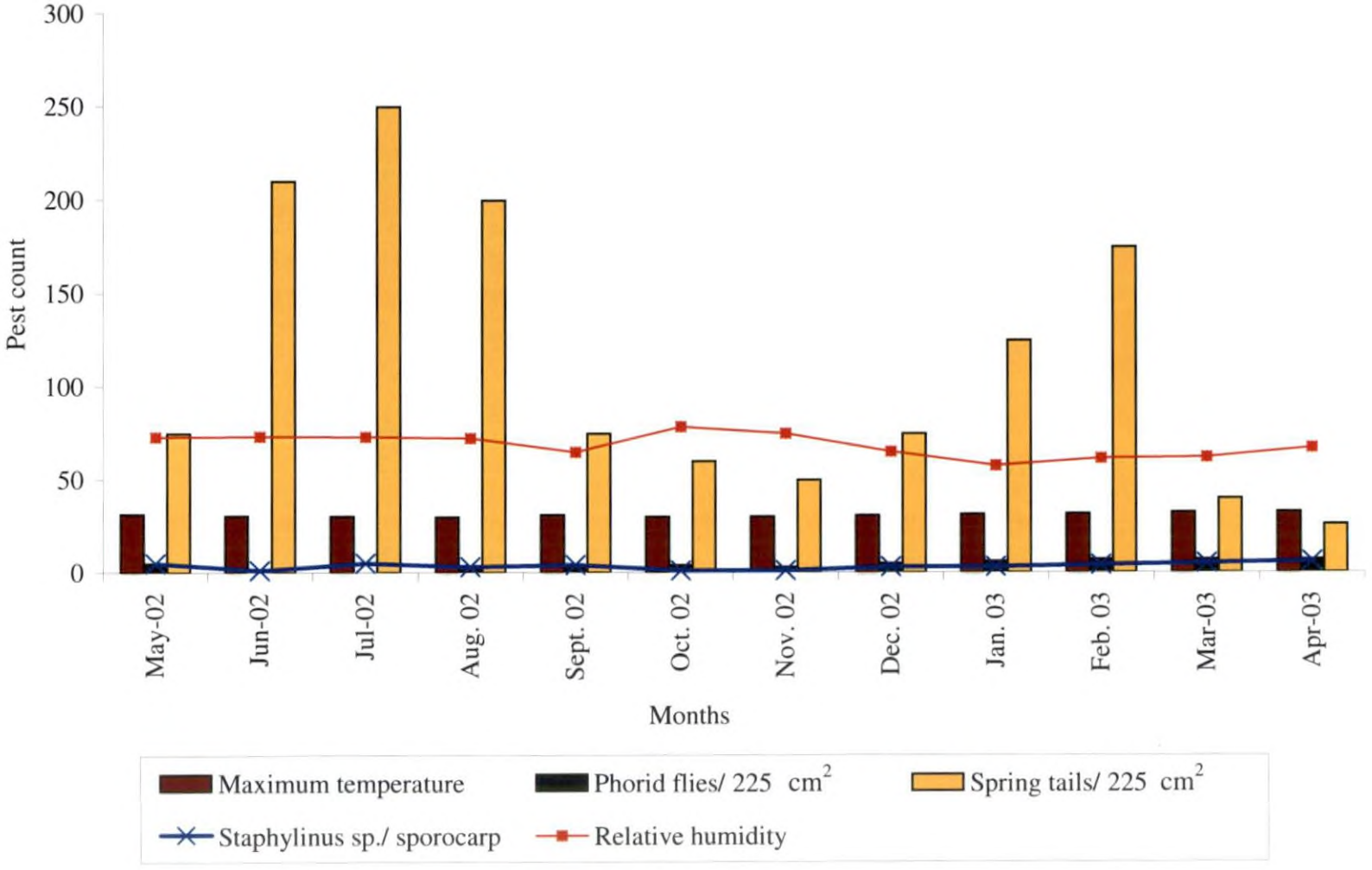

Fig. 4 Correlation between the pest counts and weather parameters

The number of springtails during the experimental period ranged from 40(March) to 250 (July). Unlike in case of phorids no correlation was noticed between the springtail and external climatic conditions.

The population of *Staphylinus* sp. during the experimental period ranged from one to six numbers per sporocarp. The maximum temperature was found to have a positive correlation with the *Staphylinus* sp. population. The highest population of six *Staphylinus* sp per sporocarp was observed during April when the maximum temperature was also maximum. (32.8^0C)

4.2 ASSESSMENT OF COMPETITOR AND PATHOGENIC MOULDS IN OYSTER MUSHROOM

No pathogenic fungal species was found associated with oyster mushroom throughout the course of the study, but competitor moulds were noticed.

4.2.1 Competitor Moulds Infesting Oyster Mushroom

The competitor / weed mould commonly encountered during the course of cultivation were the green mould (*Trichoderma* sp., *Aspergillus* sp.) and the ink caps (*Coprinus* sp.) (Plate 14, 15, 16).

4.2.1.1 Identification of Competitor Moulds

4.2.1.1.1 *Trichoderma* spp.

T. harzianum and *T. viride* were seen associated with mushroom beds. Characters of theses are given in Table 4. Based on the characters *Trichoderma* isolate-1 was identified as *T. harzianum* and *Trichoderma* isolate-2 as *T. viride*. Among these *T. harzianum* was more frequent than the other.

4.2.1.1.2 *Coprinus* spp.

C. lagopus and *C. comatus* were found associated with mushroom beds. The characters of these are given in Table 5.Based on the characters

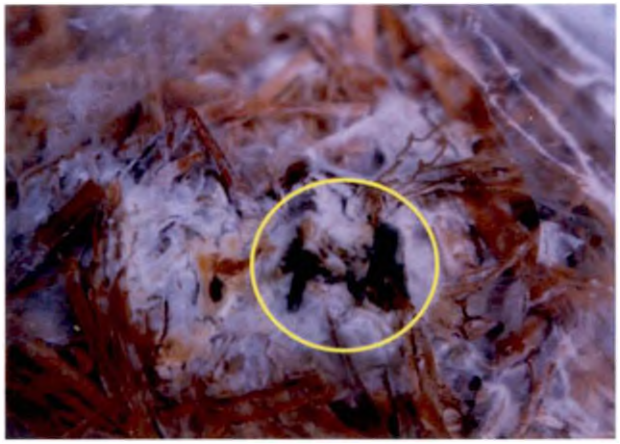

Plate 14 ***Trichoderma*** **in mushroom bed**

Plate 15 ***Coprinus*** **in mushroom bed**

Plate 16 ***Aspergillus*** **in mushroom bed**

Table 4 Characters of *Trichoderma* isolates

Character	**Isolate-1**	**Isolate-2**
Colony character on P.D.A three days after inoculation	Fast growing, completely covered 9cm Petri dish in 2-3 days, colony dull green	Fast growing, completely covered 9cm Petri dish in 2-3 days, colony dark green
Hyphae	Hyaline	Hyaline
Chlamydospores	Intercalary, globase 6.26 – 6.86 µm in diameter (Plate-18)	Intercalary globose 12-14 µm diameter
Conidiophore	Main branch produces numerous side branches. (Plate 17)	Arise in compact or loose tuft, main branches produce several side branches in group of 2-3, all branches stands at wide angle. (Plate-19)
Phialides	Arise in groups upto five, short narrow at the base, attenuated abruptly, sharp pointed neck, 4-5 µm	Main branch produce several side branches in groups mainly at wide angle 7.2 x 3.1 µm
Phialospores	Sub globose smooth surface and pale green 3.0 x 2.2 µm	Globose, minute, roughened wall 3.75 x 1.4 µm

Table 5 Characters of *Coprinus* isolates

Characters	**Isolate- 1**	**Isolate-2**
Pileus	Cylindrical oval at first later conical dirty white with scales, 3 – 4 cm diameter in mature stage. Pileus was splitted radically before autodigestion.	First cylindrical or oblong, companulate or expanded when fully grown, first covered with dense dirty white wooly scales, 2.5 – 3 cm in diameter
Gills	3–4gills per mm length varied with pileus size white at first later turns black	2-3 gills per mm distinctly formed, crowded, free, white when young, then pink, finally black, gills deliquescing into an inky fluid
Stipe	Centrally placed white hollow and slightly hairy a taproot like base, which penetrate the surface, was also present. 4 to 10 cm long and 0.4 to 6 μm thick.	Centrally placed, tapering at the top, whitish, smooth, hollow with 9 delicate white cord of mycelium, 3.5 – 8 cm long and 0.6 – 7 μm thick
Spores	Black 8.74 x 4.374 μm in size, spore print – black (Plate 20,21)	Black, 13 x 6.5 μm in size, spore print - black

Plate 17 Conidiophore and spores of *Trichoderma harzianum* (magnification 1000 x)

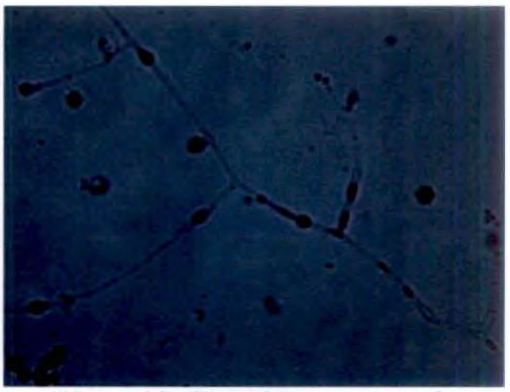

Plate 18 Chlamydospores of *Trichoderma harzianum* (magnification 400 x)

Plate 19 Conidiophore and spores of *T. viride* (magnification 1000 x)

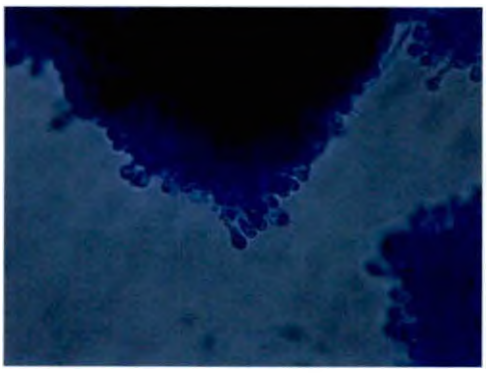

Plate 20 Cystidia of *Coprinus lagopus* (magnification 400 x)

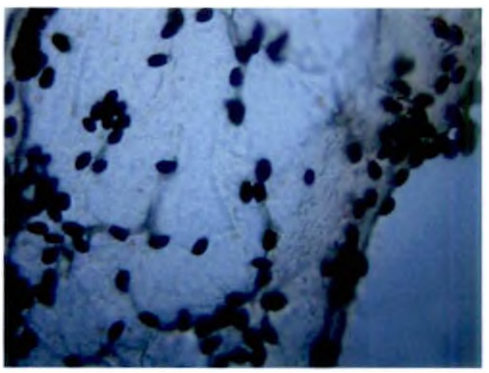

Plate 21 Spores of *Coprinus lagopus* (magnification 400 x)

Coprinus isolate-1 was identified as *C. lagopus* and *Coprinus* isolate-2 as *C. comatus*.

4.2.1.1.3 *Aspergillus* spp.

A. flavus and *A. niger* were commonly seen as contaminants in the mushroom beds. The characters of these are given in Table 6. Based on the characters *Aspergillus* isolate- 1 was identified as *A. flavus* and isolate-2 as *A. niger*.

4.2.1.2 Nature of Damage of Competitor Moulds

4.2.1.2.1 *Trichoderma* spp.

The growth of *Trichoderma* started 3–4 days after spawning as white fluffy growth similar to *Pleurotus*. Hence detection in early stage was difficult. Infected area turned dark green once the fungus started sporulating. The growth rate of *Trichoderma* was faster than that of *Pleurotus* and spread rapidly reducing the spawn run. In certain beds it completely covered the bed and resulted in cent percent yield loss (Plate-22).

4.2.1.2.2 *Aspergillus* spp.

Aspergillus infection was seen only on certain beds. Even in those beds in which *Aspergillus* infection was noticed, the green patches of the fungus was seen distributed unevenly in the beds.

4.2.1.2.3 *Coprinus* spp.

Coprinus infection was seen only in areas damaged by pests and other competitor moulds where spawn run was not proper. At first the growth of *Coprinus* appeared as 4 mm size pinhead like structures and remained like that for two or more days. Gradually it produced tiny button like structures with a stipe length of 2 – 2.5 cm and pileus of diameter of 0.5 – 1.5 cm. At maturity stipe was 10 – 15 cm the pileus expanded and splitted radially. Pileus turned black due to sporulation and

Table 6 Characters of *Aspergillus* isolates

Character	**Isolate-1**	**Isolate-2**
Colony character on P.D.A three days after inoculation	Yellow green colonies appear on PDA plates reaching 9 cm in 4-5days at room temperature	Black powdery colonies appear on PDA plates reaching 9 cm diameter within 4-5 days at room temperature
Hyphae	Hyaline	Hyaline
Conidiophore	Conidiophores and rough walled. Conidial head radiating on larger conidiophore. A layer of metulae supports the phialides.	Conidiophores arising from long, broad thick walled, foot cell. Conidiophores bears metulae and phalides carrying black conidiospores at their tip.
Conidia	Conidia globose to subglobose, finely roughened to echinulate and 3.5 – 4.5 μm in diamter.	Conidia are large radiating heads mostly globose, irregularly roughed 4.0 – 5.0 μm diameter.

Plate 22 Bed damaged by *T. harzianum*

autodigestion. The entire structure collapsed forming black inky fluid with in a day.

4.2.1.3 Extent of Damage of Competitor Moulds

4.2.1.3.1 *Trichoderma* spp.

The intensity of infestation by *Trichoderma* sp. in each beds were assessed using the score chart and details are represented in Figure 5.

Majority of beds (49 per cent) were found free of infestation. In case of 34 per cent of beds the infestation was very low and remained restricted in between the mushroom mycelia. Four beds were totally damaged and showed no spawn run and resulted in complete yield reduction. An important observation was that the beds belonging to score value 0, 1 and 2 yielded similarly.

4.2.1.3.2 *Aspergillus* spp.

Only five per cent beds showed the presence of *Aspergillus* sp. contamination and yielded similar to that of beds free of infestation.

4.2.1.3.3 *Coprinus* spp.

Coprinus sp. appeared only as a secondary infestation in already damaged regions of the bed.

4.3 EVALUATION OF FUNGICIDES AND DISINFECTANTS ON THE GROWTH OF *TRICHODERMA* AND *PLEUROTUS*

Under *in vitro* condition carbendazim @ 50 ppm totally inhibited *Trichoderma* growth and showed significant difference from all other treatments (Table 7). Mancozeb @ 250 ppm and lime @ 500 ppm showed significant inhibition at first, but the growth in Petri dishes were completed within next 24 hours. Addition of sodium chloride and sodium hypochlorite to the medium showed no inhibitory effect on *Trichoderma.*

The *in vitro* evaluation of fungicides and disinfectants on *Pleurotus* was carried out and results are represented in Table 8 (Plate-23, 24).

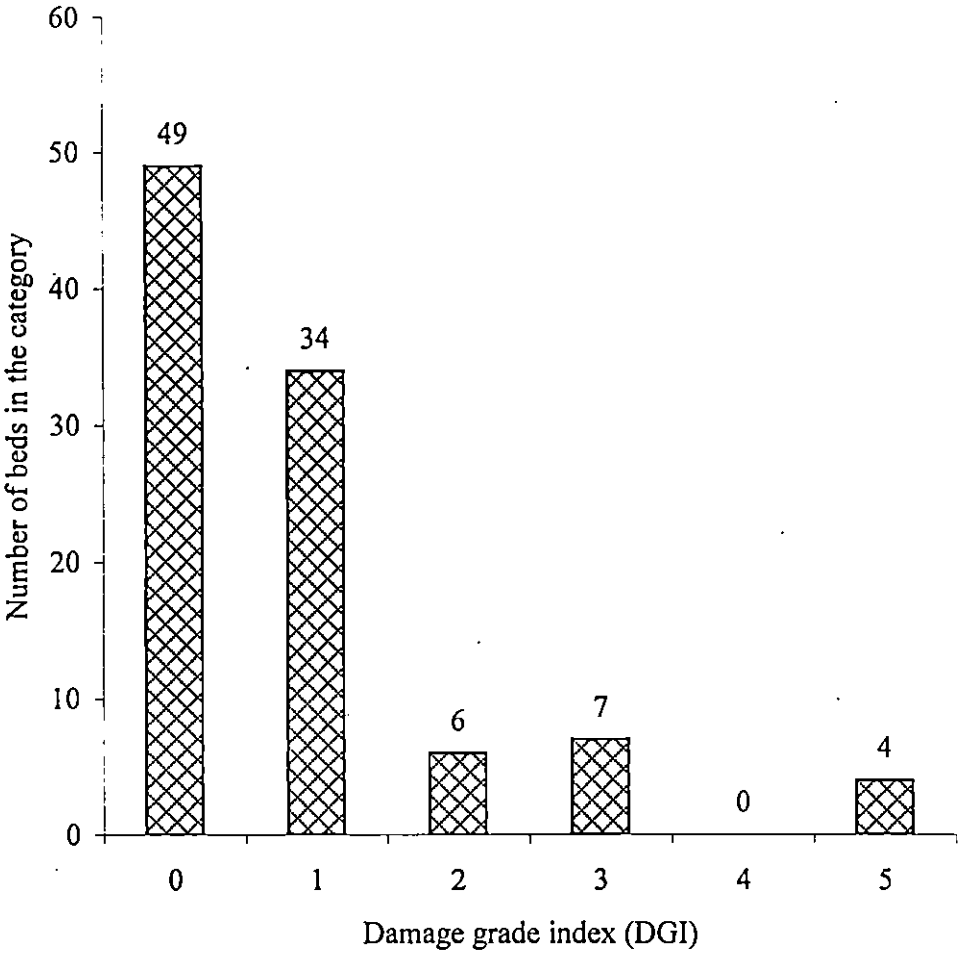

Fig. 5 Extent of damage due to *Trichoderma* spp. during incubation

Table 7. Effect of chemicals* and disinfectants on the growth of *Trichoderma*

Treatments	Colony growth in cm after		Percentage inhibition on mycelial growth
	1st day	2nd day	
T_1 Carbendazim @ 50 ppm	0.5	0.5	100 (10.05)
T_2 Mancozeb @ 250 ppm	1.75	2.33	75.18 (8.75)
T_3 Sodium chloride@ 500 ppm	3.66	9	0(1)
T_4 Sodium hypochlorite @ 500 ppm	2.72	9	0 (1)
T_5 Lime @ 500 ppm	2.95	3.51	60.89 (7.87)
T_6 control	4.47	9	
			CD (0.05):0.18

*Figures in parenthesis are after $\sqrt{x+1}$ transformation

Table 8. Effect of chemicals and disinfectants* on the growth of *Pleurotus*

Treatments	Colony diameter in cm after							Percentage inhibition on mycelial growth
	1st day	2nd day	3rd day	4th day	5th day	6th day	7th day	
T_1 Carbendazim @ 50 ppm	0.50	0.90	1.22	2.13	3.18	6.42	8.77	2.18 (1.78)
T_2 Mancozeb @ 250 ppm	0.05	0.05	0.05	0.05	0.05	0.05	0.05	100 (10.05)
T_3 Sodium chloride @ 500 ppm	0.05	0.96	1.95	2.72	3.5	5.98	8.43	6.24 (2.69)
T_4 Sodium hypochlorite @ 500 ppm	0.50	0.83	1.46	2.05	2.75	5.40	8.5	6.69 (2.79)
T_5 Lime @ 500 ppm	0.05	0.85	0.92	2.5	3.58	6.5	8.82	1.80 (1.67)
T_6 Control	0.5	0.63	2.23	2.7	3.8	6.7	9	
								CD (0.05):0.94

*Values in parenthesis after angular transformation

The results revealed that mancozeb @ 250 ppm was 100 per cent inhibitory to *Pleurotus*. Sodium hypochlorite @ 500 ppm and sodium chloride @ 500 ppm showed slight inhibition on *Pleurotus* carbendazim @ 50 ppm showed no inhibitory effect on P*leurotus*.

4.4 EVALUATION OF INSECTICIDES ON GROWTH OF *PLEUROTUS*

Insecticides, Dichlorvos @ 0.01 and 0.02 per cent and Nimbecidine 2 ml/l, 4 ml/l and 6 ml/l were tested for their effect on growth of *Pleurotus* and details of which are presented in Table 9 (Plate 25a,b and c).

Nimbecidine 2 ml/l showed minimum inhibition to *Pleurotus*. Dichlorvos @0.01 and 0.02 per cent caused 74.6 per cent and 81.7 per cent inhibition to the growth of *Pleurotus*. Malathion @ 0.025 per cent, 0.05 per cent as well as 0.1 per cent proved 100 per cent inhibitory to *Pleurotus*.

4.5 MANAGEMENT OF PESTS INFESTING OYSTER MUSHROOM (*P. FLORIDA*) USING PHYSICAL METHODS AND PLANT EXTRACTS

The data on the effect of physical methods and plant extract in managing the pests infesting oyster mushroom was analysed and presented in Table 10.

In the control beds more than 50 per cent of the area was damaged by the pest and 92 percent of the sporocarps were also infested. The maximum yield of 390g per bed was observed when the holes in the plastic cover was covered with cotton plugs. In this treatment the bed was completely free from insect damage. Even though there was no damage during the spawn run stage 36.15 percent of sporocarp were found infested in this treatment. The pinprick treatment was as effective as covering the holes with cotton during the spawn run stage however a higher rate of sporocarp (50 per cent) were infested at the time of harvest and resulted in 50.31 per cent increase in yield compared to 229.11 percent where holes were covered with cotton. In the treatments were baits were installed 12.71 percent of the beds were damaged in spawn run period. This

ble 9 Effect of insecticides* on the growth of *Pleurotus*

Treatments	Colony growth in cm after						Percentage inhibition on mycelial growth
	1st day	2nd day	3rd day	4th day	5th day	6th dat	
Dichlorvos @ 0.01 %	0	0.3	0.65	1.3	1.67	1.35	75.58 (59.70)
Dichlorvos @ 0.02 %	0.5	0.5	0.5	0.63	1.43	1.65	81.70 (64.65)
Malathion @ 0.025 %	0.5	0.5	0.5	0.5	0.5	0.5	100 (90.00)
Malathion @ 0.05 %	0.5	0.5	0.5	0.5	0.5	0.5	100 (90.00)
Malathion @ 0.1 %	0.5	0.5	0.5	0.5	0.5	0.5	100 (90.00)
Nimbecidine 2 ml / litre	0.5	1.15	1.4	3.33	6.7	8.82	1.93 (7.99)
Nimbecidine 4 ml / e	0.5	1.4	2.1	3.17	5.52	8.52	5.83 (13.35)
Nimbecidine 6 ml / e	0.5	1.6	3.03	4.67	7.92	9	18.31 (25.33)
							CD (0.05):2.97

gures in parenthesis are after $\sqrt{x+1}$ transformation

Plate 23 and 24

1. Bavistin @ 50 ppm. 2. Dithane M. 45 @ 250 ppm. 3. Fresh lime powder @ 500 ppm, 4. Sodium hypochlorite @ 500 ppm, 5. Sodium chloride @ 500 ppm, 0. Control

Plate 25 a

1. Dichlorvos @ 0.01 %
2. Dichlorvos @ 0.02 %
0. Control

Plate 25 b

1. Malathion @ 0.025 %
2. Malathion @ 0.05 %
3. Malathion @ 0.1 %
0. Control

Plate 25 c

1. Nimbecidine @ 2 ml/l
2. Nimbecidine @ 4 ml/l
3. Nimbecidine @ 6 m/l
0. Control

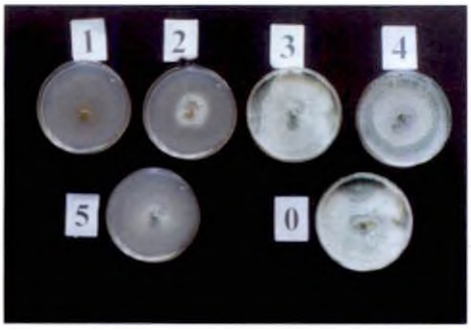

Plate 23 Effect of fungicides and disinfectants on growth of *Trichoderma*

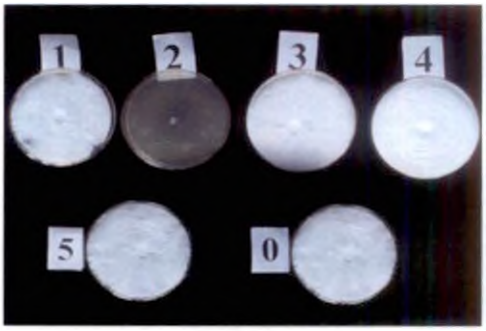

Plate 24 Effect of fungicides and disinfectants on growth of *Pleurotus*

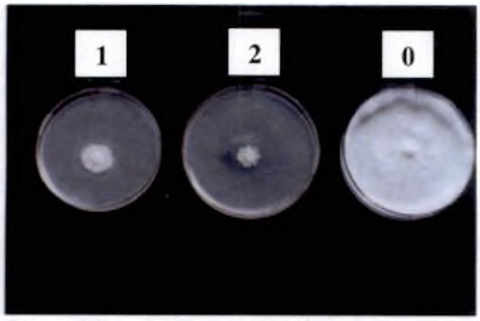

Plate 25 a Effect of dichlorvos on the growth of *Pleurotus*

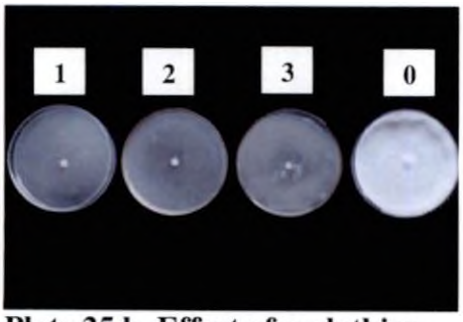

Plate 25 b Effect of malathion on the growth of *Pleurotus*

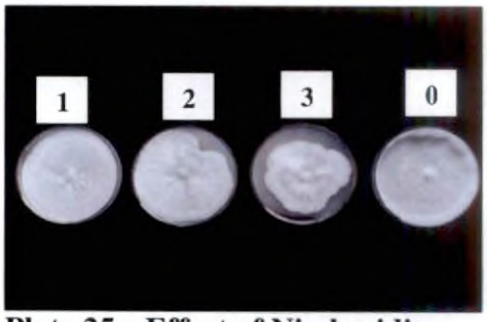

Plate 25 c Effect of Nimbecidine on the growth of *Pleurotus*

Plate 25 a, b & c. Effect of insecticides on growth of *Pleurotus*

Table 10. Effect of physical methods and plant extracts in the management of pests infesting oyster mushroom

Treatment	*Percentage area damaged / bed	*Number of spores produced	**Percentage of sporocarps infested / bed	Yield g/500 g substrate	Per cent change over the control
T_1 Pinpricks only	0 (1)	4.47 (2.34)	50.00 (44.98)	238.50	50.31
T_2 Holes in bed covered with cotton	0 (1)	6.24 (2.69)	36.15 (36.95)	390.00	229.11
T_3 Installing baits	12.71 (3.70)	4.74 (2.40)	47.48 (43.54)	224.50	89.37
T_4 Garlic extract (2%)	21.57 (4.58)	5.49 (2.55)	50.00 (44.98)	260.00	119.4
T_5 *Andrographis panicualta* extract (10%)	29.29 (5.50)	3.24 (2.06)	68.82 (56.03)	173.50	46.41
T_6 *Hyptis suaveolens* extract (10 %)	44.92 (1.99)	2.97 (1.99)	76.68 (61.10)	153.25	29.32
T_7 Control	51.65 (7.26)	3.24 (2.06)	92.12 (73.67)	118.50	
CD (0.05)	61.15	21.16	17.51	51.63	

*Values in parenthesis after $\sqrt{x+1}$ transformation

**Values in parenthesis after angular transformation

treatment enhanced the yield only by 89.37 per cent over the control. When the plant extracts were used the percentage damage in the bed ranged from 21.57 per cent (Garlic 2 per cent) to 44.92 per cent (*Hyptis* 10 per cent). Among these treatments the highest yield of 260g was obtained in garlic (2 per cent) treatment is 119.4 per cent more than the control. In treatments were plant extracts were used more than 50 per cent of the sporocarps were infested at the time of harvest. The treatments T_1 to T_5 were significantly different from control in case of yield. Among the treatments there was no significant difference between the treatments T_1 to T_4 where the number of sporocarps ranged from 4.47 (pin prick only) to 6.24 (holes covered with cotton).

4.5 MANAGEMENT OF PESTS USING CHEMICALS

4.5.1 Experiment I

Two insecticides and one plant product were tried to manage insect pest attacking mushroom bed. In untreated control even though 54.01% of area were damaged and all the sporocarps produced were infested it yielded 133g per 500g substrate (Table 11). Even though Nimbecidine treatment reduced the infestation of the bed significantly compared to the sporocarp infestation and the yield were not significantly different from that of the control. Among the azadirachtin treatment lowest damage in the bed (40.71 per cent) was noticed in treatment number 8 where Nimbecidine 2 ml/l sprayed three day intervals in incubation room coupled with spray at cropping room at 10 days interval. Even though there was 14 per cent reduction in the area damaged from the control the yield was 9.53 per cent less than control.

The least percentage damage of the bed was noticed in treatment. T_4 and T_5 where damage was only less than 10 per cent. In treatment five all the sporocarps produced were free from insect infestation, however the least yield (58.33) and maximum reduction in yield over control was recorded in this treatment. Dichlorovos Treatments T_1 and T_2 were more

Table 11 Effect of chemicals on the management of pests (Experiment 1)

Treatments	**Percentage area damaged / bed	*Number of sporocarps produced / bed	**Percentage of sporocarps infested / bed	Yield g / 500 g substrate	Percentage change over control
T_1 Dichlorvos @ 0.01 % in incubation room at 3 three days interval + Dichlorvos spray @ 0.01 % spray in cropping room at 10 days interval	16.71 (24.12)	3.65 (2.16)	35.80 (36.74)	110	-17.29
T_2 Dichlorvos @ 0.02 % in incubation room at 3 three days interval + Dichlorvos spray @ 0.02 % spray in cropping room at 10 days interval	13.00 (21.13)	2.96 (1.99)	11.68 (19.99)	91.67	-31.08
T_3 Malathion @ 0.025 % in incubation room at 3 three days interval + Malathion spray @ 0.025 % spray in cropping room at 10 days interval	16.10 (23.64)	2.32 (1.82)	93.32 (74.99)	90.33	-32.08
T_4 Malathion @ 0.05 % in incubation room at 3 three days interval + Malathion spray @ 0.08 % spray in cropping room at 10 days interval	9.91 (18.34)	2.0 (1.73)	6.70 (14.99)	76.67	-27.32
T_5 Malathion @ 0.1 % in incubation room at 3 days interval + Malathion spray a@ 0.01 % spray in cropping room at 10 days interval	9.33 (17.78)	1.64 (1.63)	0 (0.00)	58.33	-56.14
T_6 Nimbecidine @ 2 ml /l in incubation room at 3 three days interval + Nimbecidine @ 2 ml/l spray in cropping room at 10 days interval	48.32 (44.02)	4.32 (2.30)	89.57 (71.13)	139	4.51
T_7 Nimbecidine @ 4 ml/l in incubation room at 3 three days interval + Nimbecidine @ 4 ml/l spray in cropping room at 10 days interval	46.03 (42.86)	3.32 (2.08)	97.00 (80.00)	124	-6.77
T_8 Nimbecidine @ 6 ml/l in incubation room at 3 three days interval + Nimbecidine @ 6 ml/l spray in cropping room at 10 days interval	40.71 (39.63)	3.32 (2.08)	86.27 (68.23)	120.33	-9.53
T_9 Control (Water spray)	54.01 (47.28)	3.32 (2.08)	100 (90)	133	
CD (0.05)	2.8468	0.22	29.39	18.05	

*Figures in parenthesis are after $\sqrt{x+1}$ transformation

**Values in parenthesis after angular transformation

effective in reducing the damage caused by insects in the bed reducing the percentage of sporocarp infestation compared to Nimbecidine and control. However supported only less yield than Nimbecidine and control treatments. As the concentration of dichlorvos was increased from 0.01 to 0.02 per cent there was significant reduction in the percentage of insect infestation in bed, number of sporocarp produced per bed and percentage of sporocarp per bed and also yield per bed.

4.5.2 Experiment II

This experiment was conducted to find out the effect of lower concentration of these pesticides on reducing the pest infestation and on yield. Instead of dichlorvos @ 0.01 per cent and 0.02 per cent at a schedule of spraying at three days interval in incubation room and 10 days interval in cropping room in this experiment dichlorvos @ 0.01 per cent was applied only once three days after spawning.

The data regarding the efficacy of three chemicals dichlorvos @ 0.01 per cent, malathion 0.025 per cent and azadirachtin @ 0.00006 per cent a schedule, spraying once three days after spawning is presented in Table 12.

In dichlorvos 0.01 per cent was the percentage area damaged was only 13.39 per cent compared to 37 per cent in control. There was a decrease in percentage of sporocarps infested (56.69 per cent). The yield increase obtained over the control was also significant 24.97 per cent over the control was noted with respect to yield. Malathion spray @ 0.025 per cent and Nimbecidine 2 ml/l were significantly better than control with respect to percentage area damaged. Even though there was significant reduction with respect to area damaged it was not reflected on yield.

4.6 MANAGEMENT OF *TRICHODERMA* USING CHEMICALS

Five chemicals were used for the management of weed mould *Trichoderma* and to assess its effect on the yield of *Pleurotus* sp. (Table 13).

Table 12. Effect of chemicals on the management of pests (Experiment 2)

Treatments	**Percentage area damaged/ bed	*Number of sporocarps produced / bed	**Percentage sporocarps infested / bed	Yield g / 500 g substrate	Percentage change over control
T_1 Dichlorvos spray @ 0.01 per cent once three days after spawning	13.39 (21.46)	4.66 (2.38)	56.69 (43.83)	340.00	24.97
T_2 Malathion spray @ 0.025 per cent once three days after spawning	22.74 (28.47)	4.00 (2.28)	58.68 (49.98)	271.00	5.1
T_3 Nimbecidine 2 ml per litre once three days after spawning	20.87 (27.17)	4.32 (2.30)	89.57 (71.13)	301.67	17.08
T_4 Control	37.00 (37.45)	3.97 (2.23)	89.57 (71.13)	257.67	
CD (0.05)	6.60	0.27	23.56	46.39	

*Values in parenthesis after $\sqrt{x+1}$ transformation

**Values in parenthesis after angular transformation

Table 13 Effect of chemicals* on the spread of *Trichoderma* in bed as well as on yield

Treatment	Lateral spread of *Trichoderma* in cm	Yield g/500 g substrate	Percentage change over control
T_1 Carbendazim @ 50 ppm	0 (1.00)	291.67	41.13
T_2 Mancozeb @ 250 ppm	2.5 (1.87)	118.33	-42.74
T_3 Lime (spot application)	0.42 (1.19)	318.33	54.03
T_4 Sodium hypochlorite @ 500 ppm	3.43 (2.10)	229.67	11.13
T_5 Sodium chloride @ 500 ppm	3.24 (2.06)	228.33	10.48
T_6 Addition of lime to substrate soaking water adjusting pH to 6	3.09 (2.02)	229.67	11.13
T_7 Addition of lime to substrate soaking water adjusting pH to 7	3.33 (2.08)	312.00	50.97
T_8 Addition of lime to substrate soaking water adjusting pH to 8	3.08 (2.01)	355.00	71.77
T_9 Control	5.04 (2.46)	206.67	
CD (0.05)	0.26	45.55	

*Figures in parenthesis are after $\sqrt{x+1}$ transformation

Carbendazim @ 50 ppm completely inhibited the growth of *Trichoderma* in mushroom bed and yielded 291. 67 g of mushroom in 500g substrate, which was 41.13 per cent, more than one observed in untreated control. Treatment of Mancozeb @ 250 ppm even though significantly reduced the infestation of *Trichoderma*, was inhibitory to the growth of mushroom and this treatment resulted in 42.47 per cent reduction in the yield over the control. Spot application of lime was even though less significant than carbendazim in the management of *Trichoderma* it was on par with the Bavistin treatment. The treatment with sodium hypochlorite @ 500 ppm and sodium chloride @ 500 ppm did not differ significantly both in management of *Trichoderma* or in the yield.

The increase in the pH of water used for soaking the straw using lime from 6 to 8 increased the yield from 229 to 355g which is 11.13 per cent and 71.77 pr cent more than the control further these treatments also reduced the spread of *Trichoderma* compared to control.

DISCUSSION

5. DISCUSSION

The cultivated mushrooms are generally attacked by insect pests such as flies, springtails, beetles and mites (Tsai, 1981; Fletcher, 1986; Bhal, 1988; Sandhu, 1990; Balakrishnan, 1994 and Sharma, 1997). A detailed study undertaken to assess the pests infesting oyster mushroom at College of Agriculture, Vellayani revealed that immature stages as well as adults of springtails, flies and beetles caused severe damage to mushroom.

Adult springtail identified as *Seira* sp. was 2.5 – 3 mm long and had a characteristic jumping movement when disturbed. Sandhu (1995) also reported that adult springtails were 2.85 mm in length and moved by jumping with its springtail.

The temperature and humidity inside the mushroom house were 29-32°C and 80 per cent respectively. According to Gill and Sandhu (1995) the maximum activity of this insect was under hot and humid condition. This may be the reason for the high population of springtail observed in this experiment. According to Gill and Sandhu (1995) the activity of springtails were more when the beds are kept at ground. In the present experiment in order to get high humidity mushroom beds were kept on bricks placed on a layer of moist sand. This further enhanced the population of springtail.

The feeding of springtail was more on lower than on upper surface of the sporocarp. Continuous feeding resulted in discolouration and deformation of sporocarps. The yield was considerably reduced during second and third harvests due to the fast multiplication of the springtails. Similar damage by springtails was reported by Gill and Sandhu (1994) and Balakrishnan (1994). According to Gill and Sandhu (1994) the population of springtails is 2 to 3 times more in lower surface of sporocarp.

Among the flies, phorids were more common than sciarids, which made only stray appearance during the entire study. Kumar and Sharma (2001) reported that phorids were observed in the temperature range of 18.5 °C – 25°C. The high temperature prevailed in this location may be one of the main reasons behind the high phorid infestation.

The maggots were found to feed on mycelium, arresting its growth. This resulted in decaying of the substrate emitting a foul smell. They also made tunnels in the stipe resulting in discolouration and its decay. Kumar and Sharma (1999) reported that throughout the world, phorids were observed as major pest of mushrooms. Szudyga (1978) and Krishnamoorthy *et al.* (1991) observed severe infestation of oyster mushroom by phorid flies. The phorid fly identified as *Megaselia* sp. in the present study was with hump back, dark brown and with inconspicuous antennae. Kumar and Sharma (2000) and Krishnamoorhty *et al.* (1991) reported similar flies as *Megaselia* spp. in oyster mushroom beds.

Krishnamoorthy *et al.* (1991) reported that phorid larvae feed on mycelium forming wet rot zone around the holes. Balakrishnan (1994) reported that feeding of phorid larvae arrested the mycelial growth and resulted in substrate decay. Later these areas were contaminated with *Trichoderma* spp., which implied that flies might have acted as vectors of *Trichoderma* spores. This is in conformity with the finding of Kumar and Sharma (2000) who reported that under laboratory condition *Megaselia* sp. was found to transmit *T. viride* to the extent of 100 per cent.

Sciarids were another mushroom fly observed in the mushroom beds. Sciarid flies observed in the beds had 6-8 mm long dirty white larvae with visible longitudinal black streaks. The pupae were 4 mm long and yellowish brown in colour. Adults were 2.5 mm long and with prominent antennae. Sciarid flies have slender bodies and long antennae (Atkins, 1972). The feeding damage of sciarids were found to produce symptoms

similar to that of phorids. As mushroom mycelial growth was arrested by its feeding bare areas were seen in the beds. Sciarid flies were considered as serious pest of mushrooms by many workers. (White, 1982; Chakravarthy *et al.*, 1987; SoungRyul *et al.*, 1999). The adults of sciarid were distinguished from phorids by their prominent antennae. Zaayen (1978) reported the formation of bare patches in mushroom due to the infestation by sciarids. Goltapeh (1991) reported that the larvae of sciarids were found to make tunnels inside the stipe.

Two beetle pests were found very serious, especially during cropping stage. One beetle was dark brown in colour with short elytra and its large membranous hindwing and the tip of the back curled over its body. Asari *et al.* (1991) and Balakrishnan (1994) reported the occurrence of *Staphylinus* sp. in mushroom beds. The beetles identified from the experimental beds were similar to *Staphylinus* sp.

The grubs of *Staphylinus* sp. were frequently seen in growing sporocarps crawling into it, voraciously feeding and making tunnels. This led to rotting of sporocarps. The staphylinid beetle pest belonging to subfamily Scaphidiinaae (unidentified) were found in large numbers inhabiting the sporocarps making irregular holes and destroying the edges of it by continuous feeding and making severe deformation.

The pest damage due to entire pest complex was interpreted as percentage of area damaged in each bed. Twenty-one beds were free from pest attack while 12 per cent were completely damaged. Majority of beds (33 per cent) showed 1 – 20 per cent damage

Krishnamoorthy *et al.* (1991) reported that there was significant negative relationship between area of bed damaged by phorids and mushroom yield. The correlation analysis in the present study revealed that there existed a perfect negative correlation between yield and percentage area damaged by the pest complex. Many workers have

reported varying extent of damage caused by pests. Zaayen (1978) recorded a yield reduction of 50 per cent, Sandhu and Brar (1980) observed an yield. reduction of 32.7 per cent and Chakravarthy *et al.* (1987) reported an yield reduction of 30.4 to 34.5 per cent by sciarid flies. Kumar and Sharma (2000) recorded cent percent loss in oyster mushroom due to phorids. Sandhu (1995) and Clift and Terras (2000) recorded a loss of 17-26 per cent and 46 per cent yield reduction due to sciarids and phorids respectively.

The correlation analysis between the weather parameters and pest population *viz.*, phorid flies, springtail and *Staphylinus* sp. revealed a significant positive correlation between population of phorid flies and maximum temparature. Flegg (1992) reported that phorids were common in summer. The correlation result obtained in the present investigation was in perfect harmony with the report of Kumar and Sharma (2000) that phorids showed positive correlation with temperature. The population of *Staphylinus* also showed positive correlation with temperature. Balakrishnan (1994) recorded *Staphylinus* sp. during hot climate, with a temperature in the range of 26 – 34°C. Gill and Sandhu (1995) reported that the springtails were present active throughout the year except during severe winter. The correlation analysis on the population of springtails in the present study showed no significant relationship with climate. This is mainly due to the fact that extreme temperature variation were not recorded in Kerala as observed in many other parts of India and abroad. Here temperature variation ranged only from 21.4 to 32.5. A negative relationship could be derived between evening relative humidity and population of phorid flies. Balakrishnan (1994) reported that the phorid flies prevailed in dry and hot climatic conditions. The result obtained was similar, as increased evening relative humidity adversely affected the phorid population build up.

Eventhough fungal pathogens of oyster mushroom were reported by early workers (Sharma and Jandaik, 1983; Upadhyay *et al* 1987; Bharadwaj *et al.*, 1987; Ganeshan (1987) they were not detected during the course of the study on oyster mushroom but competitor moulds were observed.

The competitor / weed moulds commonly encountered during the course of study were, *Trichoderma harzianum*, *T viride*, *Aspergillus flavus* and *Coprinus lagopus.*

T. harzianum was the most serious competitor mould noticed throughout the course of study. The infestation due to *Trichoderma* spp. was considered as most severe problem in oyster mushroom cultivation by Thapa and Sharma (1994); Das *et al.*, 1993; Balakrishnan, 1994; Domondan and Poppe (2000). Mignucci *et al.* (2000) reported that *T. harzianum* competed aggressively with *Pleurotus* spp.

As was reported by Das *et al.* (1993) in the present study also infestation of *Trichoderma* started in mushroom beds as white and fluffy mycelial growth, which was similar to *Pleurotus* and made identification very difficult. Later these infected areas turned dark green once *Trichoderma* started sporulating. At few instances the growth spread over the entire surface and resulted in crop failure. But many times it could be noticed that the growth remained restricted and the beds yielded normally.

The data regarding the extent of damage revealed the fact that nearly half the beds were free from infestation (49 percent). Due to *Trichoderma* losses ranging from 16 (Sharma and Vijay, 1996) to 84 per cent (Poppe, 1985) were reported. Only in four per cent beds complete yield loss was observed. The low level of fungal infestation in the present studies may be due to the fact that the substrate used for growing mushrooms were sterilized using chemicals. This shows that chemical sterilization using 500-ppm formalin and 75-ppm carbendazim is a practical method of checking the competitor moulds.

In addition to *Trichoderma* spp., *Coprinus* spp. and *Aspergillus* spp. were also found infesting the mushroom beds. *Coprinus* sp. occurred in areas, which remained uncovered. Houdeau and Oliver (1989) reported the occurrence of antagonists such as *Trichoderma* spp., *Gliocladium* spp., *Aspergillus* spp., *Penicillium* spp. and *Chaetomium* spp. in mushroom beds. During cultivation of *Pleurotus* sp. the important contaminants observed by Anandh *et al.* (1999a) were *A. flavus, A. niger and T. harzianum*

In vitro trails conducted to study the effect of fungicides and insecticides on *Trichoderma* and *Pleurotus* revealed that carbendazim @ 50 ppm could completely inhibit the mycelial growth of *Trichoderma* while it was safe against *Pleurotus*. On the other hand mancozeb @ 250 ppm was highly toxic to *Pleurotus* and less toxic to *Trichoderma*. The response of *Trichoderma* and *Pleurotus* to carbendazim was reported by several workers. Anandh *et al.* (1999b) reported that carbendazim @ 25 ppm completely inhibited competitor moulds while growth of *P. eöus* was unaffected even at 100 ppm.

Among the pesticides tested, malathion at all concentrations were inhibitory to mushroom *P. florida* while mancozeb @250 ppm showed high rate of inhibition. Nimbecidine did not inhibited the growth of *Pleurotus* used at a concentration of 2ml/l. Inhibitory nature of malathion and beneficial role of azadirachtin was reported by many workers. Kumar and Sharma (2002) reported that Nuvan @ 0.05 per cent and malathion @ 0.05 per cent caused about 100 per cent inhibition to *Agaricus bisporus* and neem product like neem shield @ 0.1 per cent, Neemax @ 0.1 per cent, Nima @ 0.1 per cent and Micrin @ 0.1 per cent proved safe for *P. sajor-caju.*

To study the impact of treatments on the pest management, results were analysed in terms of their ability to reduce the bed damage and sporocarps infestation and ultimately their efficacy for improving the

yield. *Trichoderma* was identified as the major contaminant and the impact of various treatments to reduce it was assessed.

As physical methods and plant extracts have several advantages over chemicals separate experiment was carried out to study the impact on pest incidence.

Physical methods were much better than botanicals in reducing pest population. The beds having pinpricks without holes as well as beds with holes covered with cotton were found to be free of damage by pests. These results are in conformity with the works of Balakrishnan (1994) that in beds without holes and provided with a cotton plug at the top showed no incidence of pest and gave maximum yield. The beds with holes plugged with cotton yielded maximum and beds without holes and with pinpricks showed significant reduction in yield in the present study. The population of flies in the mushroom house was seen throughout period. These flies once gained entry inside the beds resulted in spread of contaminants and consequent yield reduction. These also acted as vectors of fungal spores from infected beds resulting in the spread of contaminants and consequent reduction in the yield. Once the open holes are plugged with cotton the possibilities of flies coming into contact and inoculating the weed fungus into the substrate is restricted. This may be the reason for reduced competitor moulds in the cotton-plugged beds. The reduction in the yield in beds with pinpricks may be due to poor aeration and accumulation of water due to lack of evaporation.

The garlic extract (2 per cent) spray was as effective as pinpricks. Other botanicals such as *Hyptis suaveolens* (10per cent) and *Andrographis paniculata* (10 per cent) as such cannot be recommended because of their poor insect control activity and possible chance of contamination by *Trichoderma* and *Coprinus*. The higher rate of infestation of weed moulds and poor yield in beds treated with botanicals may be attributed to the

unsterilized crude extract used in the trail, which might have contained fungal contaminant, which in turn inhibited the growth of *Pleurotus*.

Malathion spray @ 0.1 per cent at three day interval in incubation room and 10 day interval in cropping room gave high reduction in pest population. But the effect was on par with malathion @ 0.05 per cent at the same schedule, which indicates that higher dose is not necessary. Use of malathion at concentrations ranging from 0.01 to 0.025 per cent has been reported to be effective against the pest by earlier workers (Hussey and Gurney, 1968; Garcha, 1980; Bhandari and Singh, 1983b; Tapa and Seth, 1983 and Sandhu, 1995). Even though malathion could reduce the pest population it also inhibited the yield of *Pleurotus*.

The use of dichlorvos as a safe chemical in mushroom cultivation was recommended by several workers. Dichlorvos both @ 0.01 and 0.02 per cent in the schedule of three day interval in incubation room and 10 day interval in cropping room could significantly reduce pest population but the yield was also reduced considerably. Sandhu (1995) recommended use of dichlorvos 76 EC 30 ml/100 m^2 in mushroom house and ceiling but pointed out that direct spraying on bed should be avoided.

Among the botanicals only Nimbecidine 2 ml/l under the prescribed schedule produced higher yield than control but was not significant. Bhat *et al.* (1997) reported that the two neem based products Rakshak (Azadirachtin 0.15 EC) at 0.3 per cent and Neemark (Azadirachtin 0.03 EC) at 0.2 per cent reduced pest population by 77 per cent and per cent fruit body infestation by 78 per cent. Kumar and Verma (1997) reported that the response of mushroom flies were not similar towards different biopesticides.

Maximum reduction in *Trichoderma* contamination was observed when carbendazim 50 ppm was used. Rai and Vijay (1992) reported that 5 ppm carbendazim completely inhibited *T. viride* and stimulated the

growth of *P. sajor-caju*. According to Sharma (1995) weekly spray of Dithane Z 78 (0.2 per cent) or Bavistin (0.1 per cent), TBZ 0.2 per cent and treatment with calcium hypochlorite (15 per cent) was effective in control of competitor moulds. Sharma (1997) recommended the use of sodium hypochlorite as a safe disinfectant in mushroom house. Significantly higher yield was obtained by increasing the pH of soaking water to eight by addition of lime. This result is in conformity with works of Balakrishnan (1994) that by increasing pH range of soaking water from 7 to 9 it was possible to minimize the green mould infestation and to retain a steady and reasonable yield.

The results of the study revealed that the main constrain of *Pleurotus* cultivation are infestation by insects and competitor moulds. Most common insect pests of mushroom are springtail, flies and beetle pests. Pathogenic fungi were not observed however competitor moulds *viz.*, *Trichoderma*, *Coprinus* and *Aspergillus* were present.

Based on the results it can be concluded that under conditions of very high pest infestation dichlorvos @ 0.01 per cent could be considered because of its pest control activity. However direct contact of the chemical on the bed should be avoided. Nimbecidine 2 ml/l can also be selected as a safe chemical considering its pest control activity and reduced inhibitory effect on the yield. Malathion at doses 0.05 and 0.1 per cent had inhibitory effect hence its use should be avoided.

SUMMARY

6. SUMMARY

The main objective of the study was to identify the pests and diseases affecting *Pleurotus* and to evaluate the various management practices in tackling them.

Springtail, flies and beetles were the main pests found infesting *Pleurotus*. No pathogenic microorganism was found infecting mushroom while competitor moulds were found damaging the crop.

Springtail (*Seira* sp) was the most persistent insect species found throughout the course of the study. The congenial climatic conditions prevailing in the mushroom house as well as the practice of placing beds directly on floor instead of hanging aggravated its infestation. Heavy feeding by these insects resulted in the total deformation of the sporocarps.

The mushroom flies belonging to two different families *viz* Phoridae and Sciaridae were observed in mushroom house. The phorids (*Megaselia* sp.) were more common than the sciarids. The larval stages of these flies feed on the mushroom leading to reduction of spawn run as well as sporocarps.

Among the two beetle pests observed, one belonged to the genus *Staphylinus*. Another beetle pest, which belonged to the family Staphylinidae and subfamily Scaphidiinae, is a new report from Kerala. The grubs as well as the adult stages of these beetles destroyed the sporocarps

Extent of damage by the insects was interpreted on the basis of area damaged by them. Twenty one per cent of beds was free from pest attack and 12 per cent beds were completely damaged. Majority of the beds (33 per cent) showed 1-20 per cent damage. A perfect correlation existed between area of bed damaged and the yield

A positive correlation existed between the maximum temperature and population of phorid flies and beetles while there was a negative correlation between evening relative humidity and population of flies.

No pathogenic microorganism was identified in the study. But competitor moulds were observed. The competitor mould complex found in oyster mushroom was *Trichoderma harzianum*, *T. viride*, *Aspergillus niger*, *A. flavus*, *Coprinus comatus* and *C. lagopus*. Among these *T. harzianum* was the most dominant one. *Coprinus* spp. appeared as a secondary parasite in already damaged areas. Extent of damage due to competitor mould was low which revealed that the chemical sterilization practiced for substrate preparation was effective in reducing the contaminants.

Under *in vitro* conditions, Carbendazim 50 ppm completely inhibited *Trichoderma* but showed no inhibitory effect on *Pleurotus*. Mancozeb @ 250 ppm proved 100 per cent inhibitory to *Pleurotus*. The insecticides such as dichlorvos @ 0.01 and 0.02 per cent, malathion 0.025, 0.05 and 0.1 per cent proved inhibitory to *Pleurotus* whereas Nimbecidine 2 ml/l showed no inhibitory effect. At high concentrations Nimbecidine 4 ml/l and above it was inhibitory to *Pleurotus*

Studies were carried out to evolve a practical management practice to inhibit pests and diseases of oyster mushroom. The practices, which prevented the entry of flies into the mushroom beds such as covering the holes in mushroom beds with cotton and making pinpricks instead of holes on the cover, were effective in controlling the pests. Among the botanicals tested only garlic extract at two per cent proved to be effective.

Malathion at concentrations of 0.025per cent and above in a spray schedule of three day interval in incubation room and 10 day interval in cropping room reduced the pest population but it also reduced yield considerably. Dichlorvos @ 0.01 and 0.02 per cent also showed a similar trend. In a schedule consisting of one time spray in room three days after spawning, dichlorvos @ 0.01 per cent was proved effective. In the same

schedule spraying Nimbecidine @ 2ml/l, 4ml/l and 6ml/l could check the pest population and maintain the yield.

For managing *Trichoderma*, spot application of carbendazim 50 ppm or lime was effective. Increasing pH of soaking water from 6 to 8 considerably increased the yield. This is an effective, cheap and ecofriendly recommendation, which can be practiced by farmers.

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IDENTIFICATION AND MANAGEMENT OF PESTS AND DISEASES OF OYSTER MUSHROOM

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ABSTRACT

A study on "Identification and management of pests and diseases of oyster mushroom" was conducted during 2002-2003 at the College of Agriculture, Vellayani. It was undertaken to investigate on the pests and diseases of oyster mushroom *Pleurotus florida* Eger as well as to evolve ways for tackling them.

Springtail, flies and beetles were identified as pests infesting oyster mushroom. Springtail (*Seira* sp.) was the most dominant pest. Apart from this, mushroom flies, phorids (*Megaselia* sp.) and sciarids were found to cause severe damage. The beetle pest, *Staphylinus* sp. and an unidentified beetle belonging to family Staphylinidae and subfamily Scaphidiinae were also problematic. Pathogenic microorganisms were not observed but competitor moulds *viz.*, *Trichoderma* spp., *Aspergillus* spp. and *Coprinus* spp. were present resulting in a reduction in the yield.

In vitro studies revealed that dichlorvos 0.01 per cent and 0.02 per cent and malathion at 0.025, 0.05 and 0.1 per cent inhibited the growth of *Pleurotus* spp.

The practices, which prevented the entry of flies into the mushroom beds like covering the holes in mushroom beds with cotton and making pinpricks instead of holes on the cover, were effective in controlling the pest. Among the botanicals tested only garlic extract at two per cent proved effective. Chemicals such as dichlorvos @ 0.01 and 0.02 per cent, malathion @ 0.025, 0.05 and 0.1 per cent had inhibitory effect on *Pleurotus* if used in a spray schedule of three days interval in incubation room and 10 days interval in cropping room. Nimbecidine 2ml/l though not very effective in controlling the pest could be recommended, as it proved not inhibitory to *Pleurotus*. A single spray of dichlorvos @ 0.01

per cent three days after spawning can be recommended for controlling the pests affecting oyster mushroom.

For managing *Trichoderma* spot application of carbendazim 50 ppm or lime were effective. Increasing pH of the soaking water from 6 to 8 considerably increased the yield. This is an effective, cheap and ecofriendly recommendation, and can be practiced by the farmers.