

FAQ's on insect-pests

1. What are the major insect-pests of mushrooms?

Ans: Sciarids, phorids, springtails and mites are major pests of mushrooms.

2. Which stage of sciarids and phorids are damaging?

Ans: larvae

3. How larvae damage the mushrooms?

Ans: Larvae feed on compost, mushroom mycelium and mushrooms. Through the consumption of compost by the larvae, pH of the substrate changes which slows down the growth of mushroom mycelium. As the infestation by the larvae is often in groups, bare patches without mushrooms can be seen on the beds. After the sporophore formation, larvae enter the mushrooms and start feeding and tunnel within a stipe. Eventually they reach the pileus and feed vigorously. When larval attack occurs at pin head stage, further development of pinheads completely stops and pin eventually die. *Agaricus bisporus* is more susceptible than *A. bitorquis*. Flies also transport spores of the pathogenic fungi, virus infected fungi, nematodes and mites.



4. What is the Economic threshold level ?

Sciarids are major pests of mushrooms throughout the world. Generally infestation by the pest during spawning or at spawn running time results in greater yield losses than infestation after casing. Economic threshold level for the mushroom sciarid, *L. auripila* is virtually zero making chemical control necessary at very low larval densities.



4. What is the distinct morphological character of sciarid larvae?

Ans: The newly hatched larva has distinct black head. Fully grown larvae are dirty white with visible longitudinal black streaks. Larvae are 5-8 mm in length.

5. What is the distinct morphological character of phorid larvae?

The mature larva is greyish white and measure 2.9-3.9 mm in length. Larva of *Megaselia* sp is creamy white with pointed head and blunt rear end and measure 3-4 mm.



6. What are the control measures?

Ans: Prophylactic measures:

Physical methods

- i) **Hygiene and sanitation:** Hygiene is the primary method of pest control in mushroom farming. It is the foundation upon which success of all other control techniques depends. The objectives of any hygiene programme includes exclusion of pests and diseases from production cycle, elimination of pest and pathogens and destruction of pest and disease present in a crop at its termination. Such measures help to reduce the contamination level and ensure clean start for subsequent crops.

Sanitation focuses on, elimination or killing a pest. Routinely removing stumpage from the rooms where the crop is growing is a sound sanitary practice. Sanitary practices are designed not only to remove mushroom pests but to kill significant crop threats.

- ii) **Screening of doors and ventilators:** Mushroom flies can easily pass through ordinary wire screen and enter the mushroom house to breed on spawned compost and mushroom beds. Screening of doors and ventilators with nylon net of 35 or more than 35 mesh can effectively check the entry of flies in the cropping rooms.
- iii) **Light traps:** Polythene sheets coated with sticky material and attached to a fluorescent strip light in each cropping room help in controlling adult flies. Insects are attracted to white light above 15 °C and to yellow light at lower temperature. Use of light trap (15W yellow bulb and polythene sheet coated with mustard oil) is very effective for monitoring as well as for the management of the flies.
- iv) **Poison baiting :** Poison baiting with Baygon diluted with water (1:10) with addition of little sugar is an effective method of fly control in cropping rooms. Solution of Leafpep and Electra (1:10) with addition of sugar is also effective for controlling flies
- v) **Cookout :** The most heavily contaminated area on a farm is where the older crops are about to be terminated. Elimination of pests that have built up within these crops, is one of the essential step in any effective control programme. Temperature of 71°C held for 2-3 hours effectively kills all stages of pest and pathogens.
- vi) **Disposal of spent compost:** The spent compost and casing material contain the insects, mites and nematodes. Dumping the spent compost and casing material in moist and shady places helps it to become ideal substrate for breeding of pests. Putting this material in the compost pit and covering it with at least 10 cm thick layer of manure helps to check the fly breeding.

Curative methods:

1. When mushroom flies are noticed in cropping rooms, spray 30 ml Nuvan 76 EC at 22.5 g a.i./100 m³ by ULV. After spraying, close the doors and ventilators for 2 hours. Avoid direct spray on mushroom beds. Observe the interval of 48 hours between spraying and picking of mushroom.
2. Flies can be killed by application of Permethrin dust (10g a.i/kg), without any residue problem.

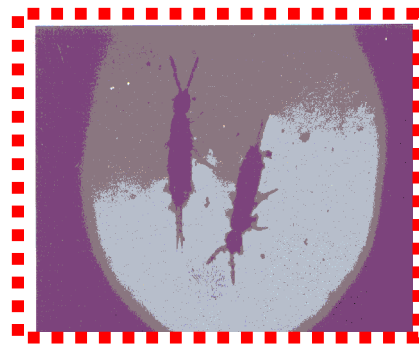
3. Malathion (2-3g/m²) and Diazinon (0.5-1g/m²) can be applied between flushes and near harvest.
4. Malathion (0.01%) spray on the beds 7 days after casing.
5. Spray application of Fenvalerate and Decamethrin (0.05%) on walls, floors and galleries effectively checks the adults. However, continuous application of the same chemical results in the development of resistance in insects. Therefore, care should be taken to rotate the chemicals.

What are springtails?

Ans: These are minute to medium small entognaths. The adults range in length from 0.5mm to 10mm.

How springtails damage the mushrooms?

Springtails damage oyster, button, shiitake and milky mushrooms. The springtails feed on mycelium in compost resulting in disappearance of mycelium from spawned compost. They also attack fruiting bodies of button mushroom and cause slight pitting or browning at feeding sites. In oyster and shiitake they feed on gills resulting in destruction of gill linings. *S. iricolor* scrap the spawn grains making them naked. They also congregate at the base of stipe and eat-out the mycelial strands.

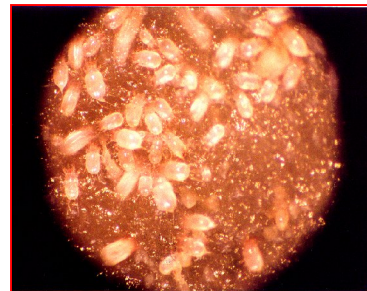


What are the control measures?

Ans: Springtails enter in mushroom houses along with the organic matter. Measures to minimize their infestation are (i) Cleaning of the surroundings and inside of mushroom house. (ii) Proper pasteurization of compost and casing material. (iii) Proper disposal of spent compost. (iv) Raising the crop above the floor level. (v) Disinfect the composting yard and empty growing room with 0.05% malathion. (vi) Mixing Diazinon 30 ppm (15 ml diazinon 20 EC after dilution with water) in 100 kg of compost at the time filling (Sandhu and Arora, 1990). (vii) For controlling infestation during spawn run and cropping period spray malathion or dichlorvos at 0.025-0.05% and observe the waiting period of 2 and 5 days in case of dichlorvos and malathion, respectively.

What is the source of mushroom mites?

The initial infestation of mites in mushroom houses comes through raw material used for the preparation of mushroom beds. *T. dimidiatus*, a major pest of mushroom throughout the world is often present in large numbers in hay, straw, grains and similar materials used for preparation of mushroom beds. Occasionally phorid flies also transport mushroom mites.



How mites damage the crop?

Symptoms/damage caused by the mites vary with the species. *T. dimidiatus* hollows out tiny buttons while in large mushrooms it makes cavities of various sizes on stalk and caps. *T. berlesei*, *T. mycophagus* and *T. longior* make holes on caps. *Calogyphus keameri* and *Oppia nitens* make deep pits on stalk and cap while in some cases buttons are completely hollowed out after tunneling within the stipe. *Tyrophagus putrescentiae* feeds on mycelium and sporophore resulting in small irregular pits on stalk and caps. *Pygmephorus* sp. feeds on mycelium below the casing layer. These mites are also known to cause allergic reactions. Mites, *R. echinopus*, *T. dimidiatus*, *H. heinemanni* and *H. miles* attack *P. sajor-caju*, *P. ostreatus*, and *Volvariella volvacea*. *H. heinemanni* is most injurious inflicting nearly 90% loss. *Brennandania lambi* attacks mycelium of *Auricularia*, *Hericium erinaceus*, *Tremella fuciformis* and *A. bisporus*. *Rhizoglyphus* sp. causes severe damage to *Lentinula edodes* fruit body.

What are the control measures?

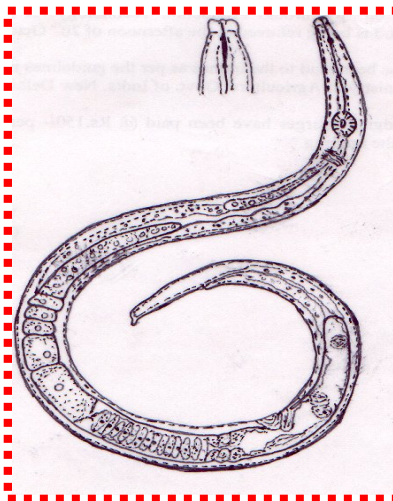
- (i) Proper pasteurization of compost and casing material.
- (ii) Proper hygiene and sanitation.
- (iii) Disinfection of the mushroom houses by spraying 0.1% dicofol.
- (iv) Burning sulfur in the empty rooms @ 2-3 lb/1000 cu. ft.
- (v) Cooking out at 71 C for 1-2 hours, after each crop.
- (vi) Sterilization of empty trays.
- (vii) Disposal of spent compost in pits at least one mile away from mushroom house
- (viii) Applying Propargite (Omite 590 EC) at 0.88 and 0.66 g a.i./m² at spawning and casing gives effective control of *C. berlesei*.
- (ix) Spraying beds with chlorfenvinphos, fenitrothion, fenthion, trithion or Metasystox (1.0 g a.i./m²) immediately after spawning and before casing give satisfactory control of mites without crop reduction.
- (x) Spraying diazinon 20 EC (1.5-2.0 ml/10 lit. of water) in the compost or Dicofol (0.1 %) in mushroom beds, or drenching mushroom houses and all their premises with diazinon is also effective.

What are the mushroom nematodes?

The term nematode (nema= thread+oides= resembling) indicates the external appearance of the organisms. Nematodes are microscopic (upto 1 mm) and can swim easily in the surface film of water in casing and compost. Mycelium of the fungi is favourable source of food for nematodes. Nematodes are one of the most dangerous pests of button mushroom which once enter the beds can not be eradicated completely, until and unless crop beds are destroyed and disposed off completely. Their presence in the beds simply means very poor yield or total crop failure.

How nematodes damage mushrooms?

Myceliophagous nematodes have needle like structure (stylet) in their mouth parts. The stylet is hollow inside and can be moved forward and backward by the contraction



and relaxation of the muscles. Salivary gland is located in the lumen of oesophagus and discharge the secretions in the lumen of buccal cavity. The nematodes secrete strong enzymes. The nematode, *D. myceliophagous* secretes chitinase and invertase, while *A. composticola* secretes strong cellulose, invertase and chitinase. These enzymes act immediately after ejection and help in penetration of stipe and to convert the cell contents in assimilable forms. These nematodes have very fast rate of multiplication (50-100 fold/week). Rate of multiplication is faster during spawn run period (22-28°C) than the cropping period (14-18°C) and beyond 30C these do not reproduce. It has been found that initial infestation with 3 nematodes of *D. myceliophagous*/100 g of compost can entirely destroy the mycelium with in a period of 70 days.

What are the sources of nematode infestation?

Button mushroom is highly susceptible to nematode attack during entire cultivation process. The common source of nematode contamination are damp wheat straw, manures, FYM, garden soil, spent compost, platform soil, irrigation water and contaminated implements. Sometimes flies, particularly sciarids, carry the nematodes from one bed to another.

What are the symptoms of nematode infestation?

Since the growers are reluctant to disturb the beds after casing, the early symptoms of nematodes attack are generally overlooked and yield reduction is the first effect noticed by them. Damage caused by the nematodes is given in Table. 12. Following symptoms of nematode attack appear in infected beds in succession :

1. Mycelial growth is sparse, patchy and mycelium turns stingy
2. The compost surface sinks
3. Whiteness of spawn-run slowly changes to brown.
4. Sporophore flushes are poor and delayed
5. Alternate high and poor yield in successive flushes.
6. Browning of pinheads.
7. Decline in yield.
8. Complete crop failure.

What are the measures for the nematode management?

Prophylactic measures :

1. Cropping should be done in purposely built mushroom houses with proper ventilation.
2. Strict hygienic and sanitation measures should be followed throughout the cropping period.
3. Composting yard must be cemented to prevent the direct contact of compost with the soil. Composting yard must be disinfected with 4% formalin, twenty four hours earlier to compost preparation.

4. All the instruments, walls, floors and galleries should be disinfected with 4% formalin.
5. Composting ingredients should always be stored in clean area.
6. Cleanliness should be maintained inside and in surroundings of mushroom farms.
7. Casing mixture should be properly pasteurized.
8. Manures used for composting should be thoroughly broken and its layers allowed to decay properly.
9. In long method of composting, covering compost with double PVC sheet for 24 hours after third turning gives effective control of nematodes.
10. Foot dips must be installed in front of each cropping room.
11. Irrigation water should be clean.
12. No person or worker should be allowed to enter into the farm without proper disinfection of his/her hands and feet.
13. All the cropping rooms should be fly proof and only recommended insecticides should be sprayed for the control of flies.

What are the factors that cause diseases in mushrooms?

Ans: Biotic and abiotic

What are biotic factors?

Ans: Fungi, bacteria and viruses

What are abiotic factors?

Ans: Air, temperature, nutrition and other environmental factors

Which moulds generally appear in compost?

Ans: Olive green mould (*Chaetomium olivaceum* and other spp.), Ink caps (*Coprinus* spp.) Green moulds (*Aspergillus* spp. *Penicillium* spp. and *Trichoderma* spp.), Black moulds (*Mucor* spp., *Rhizopus* spp.) and other (*Myriococcum praecox*, *Sporotrichum* sp., *Sepedonium* sp., *Fusarium* spp., *Cephalosporium* spp., *Gliocaldium* spp., and *Papulospora* spp.).

Which moulds generally appear in casing soil?

White plaster mould (*Scopulariopsis fimicola*): Brown plaster mould (*Papulospora byssina*), Lipstick mould (*Sporendonema purpurescens*), False truffle (*Diehliomyces microsporus*) and green moulds.

What are the symptoms of dry bubble and how it can be managed?

Whitish mycelial growth is initially noticed on the casing soil which has a tendency to turn greyish yellow. If infection takes place in an early stage, typical onion shaped mushrooms are produced. Sometimes they appear as small undifferentiated masses of tissue upto 2cm in diameter. When affected at later stage, crooked and deformed mushrooms with distorted, stipes and with tilted cap can be seen. When a part of the cap is affected



hare-lip symptom is noticed. Affected mushrooms are greyish in colour. If the infection occurs at later stage, grey mouldy fuzz can be seen on the mushrooms. Sometimes little pustules or lumps appear on the cap. On fully developed sporophores, it produces localized light brown depressed spots. Adjacent spots coalesce and form irregular brown blotches. Diseased caps shrink in blotched area, turn leathery, dry and show cracks. Infected fruit bodies are malformed, onion shaped and become irregular & swollen mass of dry leathery tissue (Sharma, 1994). In *A.bitorquis*, the dark brown blotches caused by *V.fungicola* var *aleophilum* are sometimes covered with a layer of grey coloured mycelium particularly in the centre. In *A.bisporus* it causes minor spotting though in variety Les Miz-60 it causes fruit body deformation. An isolate of *V.psalliole* from *A.bitorquis* causes more confluent brown spots on *A.bitorquis* but could not infect *A.bisporus*

Management:

- a) *V.malthousei* was controlled by Zineb on a large scale, Bercema - Zineb 80 used at 0.1 - 1.2% controlled the disease when used before and between the flushes . *V.malthousei* was controlled by 3 sprays with Dithane Z-78 at 0.25 or 0.50% or Hexathane at 0.30% given at the time of casing, at pinhead formation and after flushes of crop . Application of chlorothalonil as a drench reduced the incidence of *V.fungicola* tolerant to certain benzimidazole fungicides. Disease can be controlled by spraying with carbendazim, benomyl or thiophenate methyl at 100, 150 and 200g/100m², respectively in 100-150 litres of water immediately after casing. Cased beds can also be treated with 0.5% formalin or 100g carbendazim, 150g benomyl or 200g thiophenate methyl in 100-150 litres of water per m² of bed.

What are the symptoms of wet bubble and how it can be managed?

symptoms of wet bubble at different stages of mushroom development have been described by many workers. Two main symptom types are infected sporophores and sclerodermoid masses which is due to infection by *M. pernicioso* at different stages in the development of the sporophores. Thus, when infection took place before the differentiation of stipe and pileus the sclerodermoid form resulted, whereas, infection after differentiation resulted in the production of thickened stipe with deformation of the gills . Infected sporophores may be recognised by two symptoms, one is tumorous form, infected from pin-heads, and other is malformation, infected at later stage. Both types of

infections may exude water drops on the surface of infected sporophores. These water drops later change into amber colour. When young pin heads are infected they develop monstrous shapes which often do not resemble mushrooms. Symptoms also include as short, curly, pure white fluffy mouldy growth of the pathogen on malformed mushrooms which can be easily observed by naked eyes. Cross section of deformed sporophores without cottony growth showed black circular area just beneath the upper layer. Large, very irregular, nodular and tumorous fungal masses are formed and no differentiation or organogenesis of the cell mass takes place. Mycopathogen grew on the surface as fluffy mycelium but was absent deep on the lesions.



Management:

Benomyl spray at 0.5-4g/m² immediately after casing has been reported very effective for protecting the crop. Adequate control of wet bubble can be obtained by benomyl or Thiophanate methyl at 10g ai at casing while TBZ was less affective. Wet bubble disease can be controlled by spraying the crop with carbendazim, benomyl or thiophanate methyl at 100-150 litre water immediately after casing. It was reported that if casing is contaminated control can be achieved by treating it with 1 per cent formalin. Alternatively, a spray of 0.8 per cent formalin on to casing surface, immediately after casing, can be effective. However, this concentration can be injurious if used at a later stage in crop development.



What are the symptoms of cob web and how it can be managed?

Cobweb appears first as small white patches on the casing soil which then spreads to the nearest mushroom by a fine grey white mycelium. A floccose white mycelium covers the stipe, pileus and gills, eventually resulting in decomposition of entire fruit body. As the infection develops, mycelium becomes pigmented eventually turning a delicate pink cover. In severe attacks, a dense white mould develops over casing and mushrooms change from a fluffy cobweb to a dense mat of mycelium. The white colour can turn pink or even red with age. One symptom which can appear and which is generally not associated with the disease is cap spotting. The spots can be brown or pinkish brown. On inoculated fruit bodies, characteristic symptoms appeared within 24 hours of inoculation when mycelial + spore suspension were applied, symptoms appeared 4-12 days after infestation. Younger mushrooms are more susceptible than fully developed ones. Tufts of conidiophers develops on all sides of the



web and growth of engulfed mushroom is arrested. On removal of mycelial felt from affected mushroom, drops of dark brown coloured fluids exudes emitting bitter foul smell
Management:

Terraclor (pentachloronitrobenzene) can eradicate Dactylium mildew even after the well establishment of the disease . Annual disinfection of houses and surrounding areas with 2% bordeaux mixture or with 5% formation solution at 0.5-1.0 L/m² or fumigation with 2.0-2.5 L formation ands 0.5-1.0 kg chlorinated lime/100 m³ for controlling disease. Single application of prochloraz manganese complex (sporogon) at 1.5g a.i./m² of bed 9 days after casing gives satisfactory control of the diseases.

What are the symptoms of green moulds and how it can be managed?

Different species of *Trichoderma* have been reported to be associated with green mould symptoms in compost, on casing soil, in the spawn bottles and on grains after spawning. A dense, pure white growth of mycelium may appear on casing surface or in compost which resembles to mushroom mycelium. Later on mycelial mat turns to green colour because of heavy sporulation of causal agent which is a characteristic symptom of the disease. Thereafter, the mould creeps to surface of casing layer and infects the new parts and developing newly borne primordia. Mushrooms developing in or near this mycelium are brown, may crack and distort, and the stipe peels in a similar way to mushrooms attacked by *Verticillium fungicola* causing dry bubble disease. Some species induce brownish lesions / spots on caps which may cover the entire cap surface under congenial conditions.



Management: Very good hygiene

- b) Proper pasteurization and conditioning of compost.
- c) Sterilizing the supplements before use and mixing them thoroughly preferably after spawning.
- d) Using the correct concentration of formalin (maximum 2%)
- e) Weekly sprays of mancozeb(0.2%) or bavistin (0.1%) TBZ(0.2%) or treatment with zineb dust or Calcium hypochlorite (15%) have given effective control of the disease.

What are the symptoms of false truffle and how it can be managed?

The colour of the fluffy mycelium is white to start with and turns a creamy yellow at a later stage. It appears as small wefts of white cream coloured mycelium in compost and casing soil, usually more conspicuous in the layer where compost and casing mixture meet and also on casing. Gradually the mycelial growth become thicker and develops into whitish, solid, wrinkled, rounded to irregular fungal masses resembling small brains

(ascocarps of the fungus), looking like peeled walnuts. They vary appreciably in size ranging from 0.5 to 3cm in diameter. At maturity they become pink, dry and reddish and finally disintegrating into a powdery mass emitting a chlorine like odour. The fungus does not allow the mushroom mycelium to grow and compost turns dull brown. The spawn in affected patches turns soggy and disappears.

Management:

1. Compost should be prepared on a concrete floor and never on uncovered soil. Because during composting there is rise in temperature which activates the ascospores present in the soil.
2. Pasteurization and conditioning of the compost should be carried out carefully. Maszkiewicz and Szudyga (1999) observed that pasteurization of compost under optimum condition completely eliminated the false truffle incolum in the compso.
3. Temperature above 26-27°C during spawn run and after casing should be avoided. During cropping, temperatures should be kept below 18°C. Under such conditions, it is practically impossible to grow *A. bitorquis* but disease can be managed effectively in *A. bisporus*.
4. Casing soils known to harbour traces of spores should not be used. Young truffles must be picked and buried before the fruit bodies turn brown and spores are ripe.
5. Woodwork, trays or side-boards of shelf-beds should be treated with a solution of sodium-pentachlorophenolate at the end of the crop which was infected with the truffle disease. Air-drying of wood-work for 2-3 months may also eradicate the pathogen.
6. Good cooking out (compost temperature 70°C for 12h.) at the end of the crop should be carried out which will kill mycelium and spores of the pathogen in the compost. Wooden trays should be separately chemically sterilized. Thermal death point of ascospores and mycelium has been reported to be 70°C for 1 hr. and 45°C for 30 minutes, respectively (Sharma 1998).
7. Initial infection can be checked by treating the affected patches with formaldehyde (2%) solution



What are the symptoms of olive green mould and how it can be managed?

The earliest signs of the fungus consist of an inconspicuous greyish-white fine mycelium in the compost or a final aerial growth on the compost surface 10 days after spawning. Frequently initial spawn growth is delayed and reduced. By late spawn run, fruiting structures that look like gray-green cockle-burns-1/16 inch in diameter, develop on straw in isolated spots of the affected compost. The compost will have a musty odour. Compost not supporting spawn growth generally supports the growth of *Chaetomium* and

other several moulds and hence olive green mould is not the exclusive colonizer of black compost. Spawn usually grows into areas occupied by *Chaetomium*, although normal spawn growth is delayed. *C. globosum* is also noticed on spawn bottles.

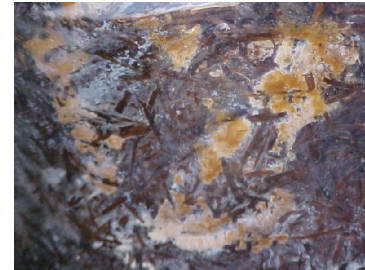


Management:

1. The fermentation period of the compost should not be too short. It is essential to provide an active compost that is not too wet and has a good structure.
2. Do not add nitrogen, ammonium sulphate, urea, chicken manure or similar materials just before filling.
3. There should be sufficient time for peak-heating and sufficient supply of fresh air during pasteurization. Higher temperatures (above 60°C) for longer time should be avoided.
4. Large number of fungicides including Benomyl, Thiophanate methyl, TBZ, Vitavax, Dithane Z-78, Dithane M-45, Thiram and Captan have been found effective under *in-vitro* conditions and sprays of Dithane Z-78 (0.2%) have been recommended for checking the secondary spread .

What are the symptoms of brown plaster mould and how it can be managed?

It is first noticed as whitish mycelial growth on the exposed surface of compost and casing soil in trays as well as on sides in bags due to moisture condensation. This develops further into large dense patches gradually changing colour through shades of tan, light brown to cinnamon brown; ultimately becoming rust coloured. No mushroom mycelium grows on places where plaster mould occurs.



Management:

1. Good hygiene.
2. Composting should be carried out carefully, using sufficient gypsum and not too much water.
3. Peak heating should be of sufficient duration and at proper temperatures. The compost should not be too wet before or after peak heating.
4. Munjal and Seth (1974) recommended localized treatment of infected patches with 2% formalin while Seth and Shandilya (1978) recommended 4% formalin for its control.

5. Large number of fungicides namely, benomyl, carbendazim, thiophanate methyl, vitavax, daconil, MBC, dithane Z-78, dithane M-45, captan, thiram and copper fungicides have been screened under *in vivo* and *in vitro* conditions by various workers .

What are the symptoms of yellow mould and how it can be managed?

The yellow moulds may develop in a layer below the casing (Mat disease), from circular colonies in the compost (confetti) or they may be distributed throughout the compost (Vert-de-girs). In India, *M. lutea* has been reported to induce mat disease. This fungus forms a yellow brown corky mycelial layer at the interphase of compost and casing which is difficult to detect during the impregnation of casing layer by the spawn and even during the first break. It becomes apparent when it develops its stroma like morphology and mushroom production is severely inhibited.

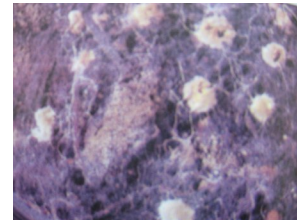


Management:

1. Proper pasteurization of the casing mixture is very essential. Fungus does not survive the exposure for 6 hrs. at 51°C or 4 hrs at 54°C.
2. Benomyl (400-500ppm) and blitox (400ppm) sprays have been found effective to control the disease and increase the yield . Spraying with calcium hypochlorite solution (15%) is effective for eradication of the mould growth .

What are the symptoms of sepedonium yellow mould and how it can be managed?

This mould is mainly observed in the compost and is initially white in colour turning to yellow or tan at maturity. It is generally present in the lower layers of the compost or at bottom of the cropping bags. Various types of distortions in fruit bodies are commonly observed, probably due to the production of volatile substances or toxins. These toxins inhibit the spawn and ultimately mushroom mycelium disappears from the compost.



Management:

1. Strict temperature monitoring and control during compost pasteurization and an adequate post-crop cooking out are essential to eliminate the threat of infestation.
2. Preventing the entry of spores during spawning and spawn-running by installing high-efficiency air filters are essential.

Incorporation of 0.5% carbendazim in compost and sterilizing the chicken manure (for long method of composting) with 2% formalin or 0.5% carbendazim has given good results.

What are the symptoms of ink caps and how it can be managed?

Ink caps appears in the compost during spawn run or newly cased beds and outside the manure piles during fermentation. They are slender, bell-shaped mushrooms. Cream

coloured at first, blueish-black later and are usually covered with scales. This fungus sometimes grows in clusters in beds and has a long sturdy stem which often reaches deep into the compost layer. Several days after their appearance ink caps decay and form a blackish slimy mass due to autodigestion.

Management:

Use properly pasteurized compost and casing soil. Avoid excessive watering. Rogue out young fruit bodies of the weed fungus to avoid its further spread.



What are the symptoms of cinnamon and how it can be managed?

Although *Chromelosporium fulva* (*Ostracoderma fulva*) has been called cinnamon brown mould, its colour ranges from yellow gold to golden brown to cinnamon brown. The mould first appears as large circular patches of white aerial mycelium on the compost or casing. Within few days the spores are formed and the colour changes from white to light yellow or to light golden brown. As the spores mature, the colour changes to golden brown or cinnamon and the colony develops a granular appearance. The fungus produces numerous cup-like fleshy fruit bodies on beds.

Management:

1. Casing soil should not be made completely sterile by steam or formaldehyde. Newly cased beds should be sprayed with dithane Z-78 and maintain proper moisture content in casing layer.

What are the symptoms of lipstick mould and how it can be managed?

The disease first appears in spawned compost as a white crystalline-like mould, rather nondiscernable from spawn. As the spore of the mould mature, the colour changes from white to pink, to cherry red and then to dull orange or buff. White mycelial growth is more in loose areas of casing and can colonize well conditions compost. In crops where there is a serious virus disease, lipstick mould usually occurs as a secondary disease.

Management:

Good hygiene is essential. Good pasteurization and conditioning of the compost will eliminate the pathogen.

What are the symptoms of bacterial diseases and how it can be managed?

Bacterial blotch of white button mushroom is characterized by brown spots or blotches on the pilei and in more severe cases, on the stipes. Circular or irregular yellowish spots develop on or near the margins of the cap which enlarges rapidly under favourable conditions and coalesce to form rich chocolate brown blotches that are slightly depressed. The most characteristic symptom of bacterial blotch is the occurrence of dark brown areas of blotches on the surface of the cap. These may be initially light in colour but may eventually become dark brown. Severely affected mushrooms may be distorted and the caps may split where the blotch symptoms occur. Brown and slightly concaved spots appeared on the surface of the diseased fruit bodies. Light infection of mushroom caps produced a yellow light brown spotting on the surface, but the common symptom associated with infection was appearance of brown, slightly sunken lesions of variable size and mushroom tissues were usually affected to a depth of 1 to 3 mm. Mushrooms

often become infected at a very early stage in their development. The enlargement of the spots on the cap surface is dependent upon environmental conditions and is favoured by temperatures of at least 20°C together with the presence of water film.

Management:

Management

5.1 Ecological management: Manipulation of relative humidity, temperature, air velocity and air movements are of great significance in managing the disease. Temperature above 20°C and relative humidity of more than 85 per cent should be avoided. Additional ventilation and air circulation after watering can ensure quick drying of mushrooms. Temperature fluctuations at higher relative humidity leading of water condensation must be avoided.

5.2 Biological management: Isolates of *P. fluorescens* and other antagonistic bacteria have resulted in 30 to 60 per cent control of bacterial blotch. Many selective bacteriophages have also been found effective against *P. tolaasii* without any significant effect of *P. fluorescens*. Spraying the casing soil with a mixture of *P. fluorescens* and bacteriophage has resulted in more than 80- per cent control of blotch symptoms.

5.3 Chemical management: Application of terramycin 9 mg per square foot, streptomycin (200 ppm), oxytetracycline (300 ppm), kasugamycin and kanamycin has been found effective in managing the disease.

5.4 Physical management: Pasteurization of casing soils by steam/air mixture and short wave length irradiation have been reported effective in eliminating the bacterial pathogen but over-heating should be avoided otherwise biological vacuum will be created and successive invasion of moulds would be very high. The introduction of water retentive acrylic polymers as a component of casing soil mixture is also claimed to reduce the disease.

What are the symptoms of stroma and how it can be managed?

Stroma or Sectors / Sectoring are noticeable aggregations of mushroom mycelium on surface of spawned compost or the casing. Discrete aerial patches of white mycelium from a dense tissue layer on the substrate surface. Stroma can be easily peeled from the surface of compost or casing. Storma form on the compost in small localized areas and the smaller patches can coalesce into larger areas. After casing, stroma may form on the casing above a patch of coalesce into larger areas. After casing, stroma may form on the casng above a patch of compost-borne stroma or on casing where stroma does not exist in the compost. Stroma on casing developes in advance of pinning but rapidly putrefies once watering begins. Mushrooms can develop on stroma, but this is somewhat unusual.

A sector is a portion of spawn that is distinctive when compared to the general appearance of spawn. A sector may be extra-white, extra-dense or extra-ordinary fluffy

and is always different from the normal spawn. Sectors appear on or in the compost and on the casing, and tend to disappear as the crop ages.

Stroma and sectors are related to the genetic character of the spawn but are sometimes induced if spawn is mishandled or exposed to harmful petroleum based fumes or chemicals or certain detergents during preparation, storage, transit or at the farm. Production practices during cropping also affect the appearance of these abnormalities but specific relationship has not been elucidated. Excessive CO₂ and prolonged spawn run period also result in stroma may reduce yield. Large patches of stroma 8 to 12 inches are often removed from the compost or casing surfaces with the hope that next growth of spawn will be normal and bear mushrooms. Removing patches of stroma does not ensure growth of mushrooms in these areas, so removal of stroma is a matter for each farmer to decide. This disorder has been commonly observed in seasonal farms in HP where proper aeration is lacking.

What are the symptoms of Weepers / Strinkers / Leakers and how it can be managed?

Mushrooms described as being 'Weepers' typically exude considerable amount of water from mushroom cap. When small water droplets exude from stem or cap, the mushrooms are called leakers. These water droplets may be few in number and relatively isolated from each other or may be sufficiently numerous to cover the mushrooms. The distinction between a 'leaker' and 'weeper' is that the water droplets remain as droplets on the leaker mushrooms while it actually falls or flows from a weeper. Weepers are usually noticed since they are quite unusual. A weeping mushroom can dissolve into a white foam. Water collects on the casing surface beneath a weeper and the area develops a putrid odour becoming a 'stinker'.

Factors that induce a mushroom to become a weeper are not known but low-moisture compost-less than 64% coupled with high moisture casing is where weepers are frequently seen. The combination of these two conditions often foster weeper mushrooms prior to and during the first break.

Smooth white button mushrooms seems to have some sort of protection against leakers and weepers. Other major types-off white, cream, golden white are susceptible to this malady.

What are the symptoms of Block, Hard cap and Open veil: and how it can be managed?

Flock is a physiologically induced malformation of the mushroom's cap and gill tissue. The cap opens pre-maturely and the gills of the affected mushrooms are rudimentary, poorly developed and have little pigmentation. The flocked mushrooms generally appear in first flush and may disappear in subsequent flushes but in some cases it continues increasing in subsequent flushes.

The mechanism that causes the mushrooms to be flocked is genetic and certain strains have a greater tendency to develop the abnormality. Environmental conditions including diesel exhaust, oil-based point fumes and certain anticorrosive chemicals in steam boilers or certain diseases like die-back, brown plaster mould and false truffle induce flock symptoms. Hard cap is a variation of flock syndrome. With hardcap, cap and gills are as described for flock and the cap tends to be disproportionately small in relation to stem diameter. Hard cap mushrooms are restricted to a limited area on the casing but at times 30% areas may produce hardcaps. Hard cap means a loss of harvestable mushrooms. Open veil is the premature opening of veil with abnormal gill development. Open veil sometimes occurs when a period of water stress of 1 to 3 days – is followed by a generous watering. It also occurs when fumes of certain organic chemicals drift into or are released in a growing room. Overall, if open veil appears, it is safe to conclude that the mushroom had been under stress during its development. This abnormality is of common occurrence in H.P. and Haryana, especially during the termination of the crop or under high temperature conditions.

What are the symptoms of Hollow core and Brown pith and how it can be managed?

These two disorders seem to afflict cream strains much more than other strains, although off-white strains can have hollow core. When the bottoms of the stems are trimmed after harvesting, a circular gap is seen in the centre of the stem. This hole may extend the length of the stipe or it may be shorter. When the hollow cut end portion is brown in colour the sale price is considerably reduced. This abnormality seems to be related to watering and water stress.

What are the symptoms of Purple stem / Black leg / Storage bum and how it can be managed?

Cut stems of the mushrooms develop a deep purple colour within few hours of harvest or after being in cold storage (36UF) overnight. At times colour is closer to black than purple and it occurs in all strains-smooth white, off-white, cream and brown. Generally mushrooms from 3rd break to the end of the crop are most susceptible. Polyphenol oxidase, an enzyme increases in later-break mushrooms and this enzyme influences pigment formation. Conditions that predispose mushrooms to this phenomenon are unknown but the frequency and the amount of water applied before harvest seems to affect its occurrence.

What are the symptoms of Rose Comb and how it can be managed?

Large lumps and swelling are visible on the mushroom cap. The gills often grow in the top of the cap tissue and even on the top of the cap. These mishappen gills make the swellings look spongy. The mushrooms can even burst or split and then turn brown.

The abnormality is caused by gases or vapours coming from solvents, paint or oil products and polluted casing soil.

What are the symptoms of Scales or crocodiles and how it can be managed?

Scales arise through the surface tissue failing to grow while the cap develops further. The main reason for scales being formed is poor climate control, in particular too much drying out or too great air velocities. Strong vapours of formaldehyde or pest control products in excess can also cause the outer layer of the skin of half-grown mushrooms to tear off. As the mushroom continues to grow, the skin bursts and so-called 'crocodile' skin is formed. The off-white and cream mushroom strains are more sensitive to scaly skin than white mushrooms. This is the most common and serious malady affecting button mushroom in seasonal farms in HP.

What are the symptoms of Long stemmed mushrooms and how it can be managed?

The presence of long stems in combination with a number of other symptoms can indicate virus diseases but it is often the result of too high CO₂ concentration so that the stems extend more (drumsticks). With the improvement of aeration such conditions can be avoided.

What are the symptoms of Brown Discolorations and how it can be managed?

Browning of small pin heads or half grown mushrooms is very common on seasonal mushroom farms. This may be caused by high temperature, sprinkling at high water pressure (maximum pressure is 0.4 atm), chlorinating with too high a chlorine rate (maximum rate is 500ml (10%) per 100 litre of water per 100m²) or incorrect use of formalin, e.g. by spraying the mushrooms with a formalin solution.

Problems encountered during mushroom and spawn production

White button mushroom

Problem	Cause	Solution
Spawn grains start turning green	Immature spawn used Temperature too high	Use mature and fresh spawn
Spawn fails to resume any growth in compost	Very old spawn is used	Use mature and fresh spawn
Spawn growth is slow in the compost	Temperature too low	Provide optimum temperature during spawn run
Vegetative growth continued on the top of casing soil or stroma formation is there	Less ventilation and high temperature	Provide sufficient ventilation and reduce the temperature
	Less vigorous spawn has been used	Use reliable spawn
Pins do not develop after casing	High temperature	Reduce the temperature
Onion shaped mushrooms are formed	Less ventilation	Improve the ventilation
Long stemmed mushrooms	Less ventilation	Improve the ventilation
Caps of the mushroom turns scaly	Ventilation at high velocity	Ventilation should be at mild speed

Milky and paddy straw mushroom

Problem	Cause	Solution
Paddy straw mycelia or spawn not growing on the substrate	Bundles too wet	Drain well before spawning or preparing the bed
	Spawn too weak, too old or dead	Use good quality or reliable spawn
	Bundles contaminated with organism competing with <i>Volvariella</i> ;	Use newly harvested straw or do not prepare beds in previously infested area
	Temperature too high or too low	If too hot, remove plastic cover and aerate. If too cool, prepare higher

Problem	Cause	Solution
		beds, beds should be made close together to increase heat
Paddy straw mycelia running but no fruit bodies are formed	Spawn has degenerated	Use reliable spawn
Abundance of primordia are formed in paddy straw but these do not mature in fruits or buttons	Weak spawn and Bundles are prepared too loose so that young mushroom wither or die	Use reliable spawn Tramp straw firmly during bed preparation
Rotting of paddy straw mushroom	Developing mushroom disturbed when other mushroom are picked Onset of bacterial diseases infection on the fruits bodies	Observe care during harvesting and watering Observe sanitation, do not over water
Abundance of ink caps on the bed	Substrate old and exposed to rain	Fresh straw should be used and it should not be exposed to rain
Fruit bodies of milky mushroom bent towards one side	Insufficient light and it is from side of the cropping area	Provide sufficient light from the top of the cropping room

Oyster, Black ear and Shiitake

Problem	Cause	Solution
Mushrooms taking very long time to appear after the bags opened	Temperature too high or too low Mycelium not mature enough Insufficiently humidity Insufficient ventilation	Maintained correct temperature for fruiting Allow to properly mature Maintain at least 85 per cent relative humidity Open ventilators to provide enough aeration
Mushroom are small and do not appear to grow as large as expected	Spawn weak or degenerated Insufficient nutrients Too many fruit bodies developed at the same time Nutrients in the substrate already exhausted after many harvests	Use reliable spawn Increase supplements available in substrate Allow only a few fruit bodies to develop at one time by opening bags only slightly
Rotting of mushrooms	Excessive watering Onset of fungal or bacterial diseases and pest infection	Avoid direct watering on developing fruits Check fungal or bacterial diseases and pest infection
Low production / Few fruit bodies formation	Weak or degenerated spawn Temperature too high or too low	Use reliable and good quality spawn Provide optimum temperature for fruiting
Mushroom long and thin stalked	Insufficient light	Provide adequate light
Obvious insect damage and infection	Insufficient sanitation	Spray insecticides

During Culture/ Spawn Preparation

Problem	Cause	Solution
Agar medium very soft or hardly solidifies	Quantity of agar insufficient i.e. too low	Use proper quantity of agar in medium
Agar surface in the plates not smooth or lumpy	Agar medium partially solidify when poured	Pour agar medium when it is still hot
Contaminants appear after 2-3 days on the surface of the medium after sterilization and before inoculation	Medium not sufficiently sterilized Medium not aseptically poured	Sterilization should be carried for the recommended period and temperature/ pressure

Transferred mycelial bit/ tissue resume no growth	Non viable inoculum/culture Wrong type of medium Incorrect formulation or pH Needle or scalpel used to transfer the culture bit too hot	Medium should be poured aseptically Use viable culture/ actively growing culture Use correct medium Properly check the formulation and pH of the medium Cool the flamed needle before picking the inoculum
Contamination develops on the plugs after 2-3 days	Culture used already contaminated Filters of the laminar flow damaged Incubation too much loaded with air born inoculum	Use fresh/ disease free cultures Filters should be checked or replaced as per recommendation Sterilized incubation rooms from time to time
Resulting mycelial growth slow and fluffy	Strain degenerated	Obtain another culture or retrieve stock culture
Grains contaminated after sterilization and before inoculation	Highly infected seeds Grains not fully sterilized	Use fresh and clean seed Prolong sterilization period
Mycelial growth very thin and hardly penetrates the grains	Grains too dry	Boil the grains sufficiently And adjust proper moisture levels
Mycelial growth does not continue to the bottom	Excessive grain moisture	Adjust proper moisture level
Mycelia growth very thin, hardly penetrate the grains	Grain too dry	Adjust proper moisture level
Mycelia do not grow through substrate or patchy growth	Grains contaminated with bacteria due to improper sterilization Less vigorous strain	Use recommended sterilization time Use vigorous strain
Contamination appears on the surface of the grain or on the mycelia plug which was inoculated	Contamination occurred during inoculation Mycelia plug or culture contaminated	Inoculation should be performed in a more aseptic way and observe complete cleanliness
Mycelia growing very slowly	Unsuitable substrate Incubation temperature not suitable Culture have degenerated	Use recommended substrate Check the temperature requirement Use vigorous culture
