ISSN–0974–0759 | ●●● Popular Article ●●● |Visit us : *www.researchjournal.co.in*|

Mushroom pests : Symptoms and management

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Mushrooms are highly nutritious and environment friendly crops that carry numerous medicinal benefits. The intensive cultivations of edible mushrooms can often be affected by several bacteria, moulds, pathogenic fungi, viruses, nematodes, insects and mites that rather frequently cause dramatic production loss. The details of symptomatology of different mushroom pests and their management are given under.

Fungal competitors moulds : While some fungi, bacteria and viruses directly attack mushroom fruit bodies causing pathogenic diseases, a large number of harmful fungi are encountered in compost and casing which may not be directly pathogenic, but may cause harm to the crop during spawn run and cropping stages. These are known as competitor moulds as they compete for food with mushroom mycelium or "indicator moulds" as presence of each mould indicates some deficiency or fault in compost or casing and also called as "weed fungi" because of their undesirable occurrence. The established vectors of contamination are air, mycelium or spawn, substrate or the compost, casing materials, growers or workers hands, equipment, containers and tools, water, insects and animals.

Green mould (*Trichoderma* spp., *Aspergillus* spp. and *Penicillium* spp.) : Green patches appear in compost, spawn, on casing surface and also sometime on the mushroom surface, engulfing the fruit bodies with its white and greenish mycelium causing Trichoderma blotch disease. The pathogenic species of Trichoderma like *Trichoderma harzianum* infect the fruit body, otherwise green moulds try to spread rapidly and cover entire compost structure depending upon the quality of compost and environmental conditions. The appearance of green mould indicates poor quality compost, unhygienic cropping conditions and low compost pH.

There should be complete hygiene inside and around the mushroom farm, compost ingredients should never come in contact with the soil particles; proper turnings, conditioning and pasteurization of compost is a must, use of foot dips at the doors of cropping rooms, lesser use of formalin sprays, proper cleaning of equipment and tools, use of clean and washed clothes, early removal of infected bags etc.; are some of the recommended methods of control. Spray of some fungicides like 0.1 % Carbendazim, Thiabendazole, Mancozeb (0.2 %) etc. on cropping beds have been found effective in controlling the mould.

Olive green mould (*Chaetomium olivaceum* and *C. Globosum*) : The initial signs of fungus consist of appearance of greyish - white aerial mycelial growth in the compost just after spawning confused with the growth of mushroom mycelium. These mycelial structures later on give rise to small, round, military green or grey green cockle burr (1/16-inch diameter) structure in the compost strictly adhering to the straw. In case of pasteurization process, the peak heat or kill should be done at 58 – 59 ºC for 3-4 hours in the presence of fresh air or aerated steam. Carbendazim (0,05 %) and Dithane Z-78 (.2 %) have been found to be effective in controlling the mould only in case of minor damage of the compost.

Brown plaster mould (*Papulospora byssina*) : The mould appears as white mycelial growth on the surface of compost during spawn run stage and also on the casing surface slowly changing colour from white to light brown to cinnamon brown and finally changed to rusty in appearance. Good hygiene and preparation of good quality compost removes the chances of its appearance and further development. Addition of good quality gypsum is recommended and proper turning of compost with attentive pasteurization procedures help in preventing this mould. Sometimes spray of some fungicides like Carbendazim, TPM, TBZ (0.05 %) and Dithane Z78 or Dithane M-45 (.025 %) have been recommended for its control.

White plaster mould (*Scopulariopsis fimicola*) : The

mould appears as white patches in between or on the compost surface during spawn run stage or also in the casing layer. It inhibits the growth of mushroom mycelium causing yield loss to the extent of 5 – 30 per cent. Mixing of compost ingredients in recommended quantities, proper wetting and turning of compost under hygienic conditions have been highly recommended. Removal of mould from the compost layer and spray of benomyl or Carbendazim (0.05 %) are recommended for its control. In case of high pH and moisture content of compost, delayed turning or conditioning and addition of gypsum is recommended.

Ink cap or coprinus (*Coprinus* spp.): Long stemmed mushrooms with small caps are often seen coming out of the compost which soon turn black, collapse and get decomposed. Maintenance of hygienic conditions, mixing of quality ingredients while preparing compost at proper ratio, proper turning and pasteurization of compost is necessary Addition of too much nitrogenous material and water should be avoided.

Yellow mould (*Chrysosporium luteumis*): Since a number of fungi produce yellow mycelial growth in the compost (yellow Mould) or beneath the compost in the form of yellow layer (mat) or in the form of circular colonies (confetti) or distributed all over the compost, these are known by different names. Proper hygiene, removal and burial of mould affected spent compost at a distant place, proper turning and pasteurization of the compost and casing mixture, use of light and misty water spray technique, covering the windows and ventilators with fine wire mesh, use of filtered air and spray of Benomy l (400-500 ppm) and Blitox (0.25%) have been found effective in controlling the disease.

Sepedonium yellow mould (*Sepedonium chrysospermum* and *S. maheshwarianum*): This mould is found growing in between the compost layer or at the bottom layer. The fungus is initially white but turns yellow or tan coloured at maturity. Strict hygiene followed by proper pasteurization of compost at 59 – 60º C for minimum four hours is recommended. Use of filtered air with high efficiency filters in the cropping rooms and cook out of compost at the end of the crop with steam at 70ºC for 10–12 hours are recommended. Sterilization of chicken manure with 2 % formalin and 0.5 % Carbendazim prior to composting has been found to give good result.

False truffle (*Diehliomyces microspores*): The mycelial colour is initially white at the start and hence difficult to differentiate with the growth of the mushroom mycelium, but soon turns creamy yellow at later stage. It appears as small, wefts of white cream coloured mycelium in compost and casing soil, mainly below the casing. The mycelium becomes thick and develops into whitish, solid, round to irregular, wrinkled fungal masses resembling calves' brain which are the ascocarps of the fungus.

The compost should never come in contact with the soil, hence, it is always better to have a cemented composting yard, covered with a roof with slight gradient. Proper pasteurization of compost (59ºC for 3-4 hours), systematic turning and conditioning is very much essential for complete elimination of the fungus. The casing soil should be sterilized at 65±1ºC for 6-8 hours. The bed temperature during spawn run and cropping should be maintained below 18ºC as it is a very critical situation. Cook out at 70ºC for 10-12 hours will eradicate the fungus as the thermal death point of the fungus has been reported to be 70ºC for 1 hour (ascospores) and 45ºC for 30 minutes (mycelium).

Lipstick mould (*Sporendonema purpurescens*): The mould is noticed as pink mycelial growth on the casing at several crackings or in loose areas of casing. Because of its pink coloured spores, it is known as Lipstick mould. It first appears as a white crystalline mould not differing from white mushroom mycelium in the spawned compost. Proper hygiene and pasteurization of compost at proper temperature eliminates the fungus.

Oedocephalum mould (*Oedocephalum fimetarium*): The mould appears as irregular, light silver grey patches on the compost surface during conditioning and at the time of filling or spawning. During spawn run the mould appears light grey in colour which soon changes to dark tan or light brown with the maturation of spores. It also appears on the casing surface. Hygienic measures and proper pasteurization of compost has been found to eliminate the mould.

Cinnamon mould (*Chromelosporium* spp., *Tel. Peziza ostracoderma*): Due to its cinnamon brown colour in the compost or casing layers in the form of circular white mycelial patches, it is known as Cinnamon Brown Mould. It appears as circular white patches of white mycelium which changes its colour to light brown, then light golden brown and ultimately to cinnamon with granular appearance. Proper hygiene and sterilization of casing avoiding bed temperature above 65ºC, proper composting and pasteurization will eliminate the fungus. Dithane Z-78 and Dithane M-45 sprays (0.2 %) have also been found to control the mould.

Pathogenic diseases :

Dry bubble (*Verticillium fungicola*) : Numerous localized, light brown depressed spots appear on the mature

sporophores. After coalition, these spots form irregular brown blotches with white fungal spore mass or grey mouldy fuzz covering the surface giving a dirty look. Use of properly sterilized casing mixture, cook out of spent compost with steam at 71º C for 8-10 hours and its disposal at a distant place, isolation and removal of infected sporophores from the cropping room, spray of fungicides like Dithane M-45 (0.2%) or Carbendazim (0,05 %) on cropping beds at 10 days interval, complete hygiene, proper pasteurization of compost etc., have been recommended.

Wet bubble (*Mycogone perniciosa*) : The pathogen appears as a white mould attacking primordia and turning them into a soft whitish ball of mycelia. Early infection causes formation of sclerodermoid masses or forms whereas late infection causes production of mushrooms with thickened stipes and deformation of gills. At the later stage amber coloured fluid containing spores and bacteria ooze out from the brown and rotting interior of these bubbles sometime giving bad odour. Proper sterilization of casing soil with live steam or formalin, use of plastic pots or common salt for early covering of the infected fruit bodies so as to prevent further spread of the disease, complete hygiene, cook out of the cropping beds / bags at the end of the crop with live steam at 71ºC for 10–12 hours, fumigation of the cropping room with formaldehyde and spray of fungicides like Bavistin or Mertect (0.5%) immediately after casing etc.; are the measures recommended for controlling this disease.

Cobweb disease (*Cladobotryum dendroides*) : It is cobweb like in appearance which appears as small, white patches on the casing soil and then spreads to the nearest mushroom by a fine grey white mycelium. Floccose white myceliums covers the stipe, pileus and gills eventually resulting in decomposition of entire fruit bodies and change to slightly pinkish cover .at a later stage. Complete hygiene, careful removal of cut mushroom trashes and young dried mushrooms; proper sterilization of casing mixture, covering of infected pinheads with plastic cups or common salt is recommended.

Bacterial yellow blotch (*Pseudomonas tolaasii* and *Pseudomonas agarici*) : Circular but irregular, yellowish spots appear superficially on or near margin of the cap of a wet mushroom which enlarge rapidly under high humidity conditions and coalesce to form bigger rich chocolate brown spots that are slightly depressed and slimy. Avoid heavy water sprays during rainy season, introduce fresh air immediately for about one hour after water spray and ensure that water droplets do not remain on the cap surface, remove all the diseased fruit bodies and spray bleaching powder (0.015 %) on the cropping beds at 7 days interval.

Viral diseases : The viral diseases are not detectable during spawn – run stage; the initiation of pinheads is inhibited and vigour of mycelium severely reduced; yield is drastically reduced, mushrooms appear with distorted shape, delay occurs in appearance of first flush, sporophores with elongated stem and small caps giving drum stick like appearance and tilted towards one side appear, mushrooms appear in patches, premature opening of veils, watery stipe and streaking in the stipe. In case of oyster mushroom, dwarfing or elongation of stem has been observed whereas, no detectable symptoms appear in infected *Volvariella* sp.

Complete hygiene, use of disease free spawn, frequent disinfection with formaldehyde, aeration strictly through high efficiency filters, cook out of exhausted compost at the end of the crop with live steam at 70-71ºC for 10-12 hours, regular disinfection of equipment, wearing clean and changed clothes every time while entering a mushroom house, harvesting of mushrooms before opening when the veil is intact, visitors to be discouraged, wooden trays and shelves to be washed regularly with 4 % sodium pentachlorophenate solution, growing of resistant strains like *A.arvensis* and *A . bitorquishave* been recommended.

Insect-pests, nematodes and animal pests of mushrooms :

Mushroom flies : Mushroom flies and midges are present in nature wherever fungi are found. Attracted by the odour of the decomposing manure and vegetable matter as well as smell of the growing mycelium, the adult female enters the composting yard or the mushroom farm and lay eggs on the compost, near the mycelium or fruiting bodies. Mainly three types of flies phorid fly or dung fly (*Megaselianigra, M. halterata*), sciarid fly or big fly (*Lycoriellasolani, L. mali, L. auripila*) and cecids or gall midges (*Heteropezapygmiae, Mycophilaspeyeri*) are known to infest mushroom beds.

The larvae of flies that emerge from the eggs laid in the mushroom beds, mainly cause the damage as they directly feed on the white mycelium spread in the compost and casing layer and also feed on the mushroom fruit bodies making tunnels through the stems. Mushrooms from the infested mushroom beds are found blackened from inside and infested with white larvae. Mushrooms infested at the pinhead stage become brown and remain stunted. Infested oyster mushrooms remain stunted, wrinkled and bent downwards with a large number of larvae and pupae

lying embedded inside the tissues. Adult flies are the carriers of mites and mushroom pathogens such as spores of *Verticillium, Trichoderma, Mycogone* etc. attached to their hairy body parts. Following practices can be used for control of flies.

– Strict hygiene in the mushroom house.

– Proper turnings during composting process.

– All the doors, windows, exhaust vents and fresh air intake openings should be fitted with fine wire mesh / mosquito netting.

– All the implements and tools should be cleaned and disinfected.

– Proper pasteurization of the compost at Phase –II with aerated steam at 58-59ºC for 3-4 hours and the conditioning at 50-55º C till ammonia is eliminated.

– Dry mixing of the casing materials, proper prewetting and its sterilization with steam at 65± 1ºC for 3-4 hours or with 5 % formalin solution.

– Use of light traps and sticking bands.

– Storage of raw materials in dry and ventilated rooms.

– The spent compost, after the end of the crop, should always be thrown away at a distant place.

– Growing rooms, all containers and equipment / implements should be cleaned with water and disinfected every time before and after the crop is over.

– Spraying beds with safe insecticides like malathion (0.05 %) or DDVP (0.025 %) one week before harvest.

Mushroom mites : Mites are very small, spider like in appearance that live and breed in decomposing vegetable matter feeding on moulds present therein. They differ from the insects in that the mites have four pair of legs instead of three pairs. The environmental factors like moist and warm atmosphere (20–30ºC) and closed area support their exponential growth and a rapid succession of generation.

Mites have the chewing type of mouth part with which they eat mycelia and the mushrooms. They devalue the crop causing certain spots on the surface and crawl into the pickers' body causing discomfort. Following practices can be used for control of flies.

– Complete hygiene and sanitation

– Proper pasteurization of compost and casing materials

– Drenching mushroom houses and premises with endosulfan, diazinon or dicofol (0.1%)

– Use of fresh polythene bags and chemical sterilization of empty trays and trolleys

– Burning sulphur in the empty rooms @ 2-3 lbs / 1000 cu.ft.

– Cook out of the exhausted compost with live steam at 71ºC for 8–10 hours

– Disposal of spent compost at a distant place

– Spraying beds with safe insecticides like chlorfenvinphos, fenitrothion (1ga.i/m² bed area) or malathion (0.05 %)

Springtails : Adults are silver grey to ground colour with light violet band along the sides of the body and black cellular fields present on the head. Body length is 0.7 to 2.25 mm and abdomen 4-6 segmented. Antennae are 3-6 segmented. *Lepidocyrtus* sp., *L. cyaneus*, Seirairicolor, Achorutesarmatus etc. are the main species damaging mushrooms.

Springtails cause damage to the oyster, button and shiitake mushrooms. Staying in groups in the dark, they feed on mycelium in the compost resulting in disappearance of mycelium from spawn – run compost. Fruiting bodies of button mushrooms are also attacked causing slight pitting or browning at feeding sites. In oyster and shiitake, they feed on gills destroying the linings and also eat out the mycelial strands at base of the stipes.

Preventive measures like clean cultivation, proper pasteurization of compost and casing materials, proper disposal of spent compost, raising the crop above floor level etc.; should be followed. Use of 0.05 % malathion as spray for disinfection, mixing Diazinon 30 ppm in compost at the time of filling and spray of insecticides like malathion or Dichlorvos at 0.025 – 0.05 % conc. during spawn run and cropping have been recommended for their control.

Beetles : Some beetles (*Staphylinus* sp, *Scaphisomanigro fasciatum*) have also been found to cause serious damage to the oyster mushroom crop. These tiny insects are dark brown in colour with short elytra and large membranous hindwing and tip of the back culled over its body. The beetle *Scaphisomanigro fasciatum* is deep amber coloured, with its head hypognatus and top of the abdomen not fully covered with elytra.

The grubs are found to feed voraciously on the mycelium and spawn, making tunnels in the stipe, pileus and gills of mushrooms. The infested fruiting bodies turn into abnormal shape and rotten masses. Grubs are seen hiding in between the gills of oyster mushrooms. The insect has been found to complete its life cycle within three weeks. Strict hygiene, proper pasteurization of straw and application of chlorinated water or bleaching powder on cropping beds can control the beetles effectively.

Mushroom nematodes : Nematodes, especially the myceliophagous nematodes are the most numerous and harmful creatures. Also known as eelworms, these are

microscopic, thread like roundworms which live in soil, decomposing organic matter, fresh or salt water, also living on host plants, fungi, insects and animals. Compost ingredients like wheat straw, chicken manure, horse manure, saw dust, pig manure, cotton cake; farm soil, air, water; casing materials like FYM, spent compost, moss pea, forest soi; wooden trays, shelves and other containers etc.; can be the primary source of infestation. Once these nematodes get entry into the mushroom house, they further spread through air, faulty spray of water, workers' hands, implements, mushroom flies, mites etc. Two types of nematodes *viz.,* mycophagous or myceliophagous and saprophagous nematodes are occurred in mushroom.

Myceliophagous nematodes *(Aphelenchoides* spp and *Ditylenchus myceliophagous)* feed directly on mushroom mycelium and the fruit bodies. They are provided with a special type of mouth part *i.e.* stylet or needle with which these parasites puncture the hypha, inject digestive juices and suck the cellular contents leaving hyphal cell damaged which soon dies as it is drained of its cytoplasm. Since they have the capacity to multiply rapidly, these tiny pests millions in number, attack the mycelium moving from cell to cell and destroy the whole mycelial network in the compost within no time. The nematodes can reproduce 30 – 100 fold in about two weeks at 70 – 75º F. Myceliophagous nematode infested compost showed sinks on surface, mycelium grows sparsely in patches and turns stingy and the white mycelium starts disappearing from the infected mushroom compost leaving only the coarse strands showing black compost mass. Compost becomes soggy and foul smelling due to build -up of high population of bacteria. The pinheads turn brown, watery and remain stunted. The fruit bodies appear in patches in the beds. Due to reduction in flush pattern and crop duration, the yield is drastically reduced.

Saprophagous nematodes (*Rhabditis* spp., *Panagrolaimus* spp. and *Diplogaster* spp.) having a tube –like mouthpart instead of a stylet through which they suck the nutrient particles of the substrate, including mushroom compost, suspended in fine films of water. Since bacteria are present in large number in mushroom compost as well as in the casing, these materials provide excellent breeding grounds for saprophagous eelworms. Presence of saprophytic nematodes indicates improper hygiene, faulty pasteurization of compost or the casing mixture and imbalanced growing conditions. With their tube like mouthparts, they are structurally incapable of causing any direct damage to mushroom mycelium. Due to their faecal materials, the *Rhabditids* not only spoil the structure and quality of composts in cropping beds emitting foul smell, but also cause inhibition of mycelial growth, reduction in yield due to disturbed flush pattern, reduction in crop duration and quantitative loss of the sporophores etc. Following practices can be followed for control of nematode infestation. The practices can be used for control of nematodes are as follows.

Complete hygiene :

– Proper pasteurization of compost and casing materials

– Drenching mushroom houses and premises with some disinfectants

– Use of fresh polythene bags and sterilization of empty trays or trolleys with formalin or other disinfectants

– Use of nematode free spray water

– Workers should wear clean overalls, including hand gloves and first harvest the healthy sporophores carefully and only then the older infected ones

– Cook out of the exhausted compost at 71± 1ºC for 8 – 10 hours

– Disposal of spent compost at a distant place

– Growing resistant mushroom varieties like *Agaricus bitorquis*, *Pleurotus sajor-caju*, *Strophariarugoso annulata* etc.

– Nematode trapping fungi like *Arthrobotrys oligospora*, *A. superba*, *A. robusta* and several species of *Pleurotus* can be used as bio- control agents against mushroom nematodes.

– Mixing of plant extracts of neem, castor, groundnut, karanj etc. in compost at the time of spawning or cropping.

Rats: Apart from the Insect-pests and nematodes, some animal pests like rats also cause the damage. In fact they feed on the cereal grains used as substratum for spawn production, but they disturb and damage the beds a lot. Rat proof rooms and use mouse traps are control of rats.

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Fig. 1: Green mould in compost spawned with button mushroom spawn

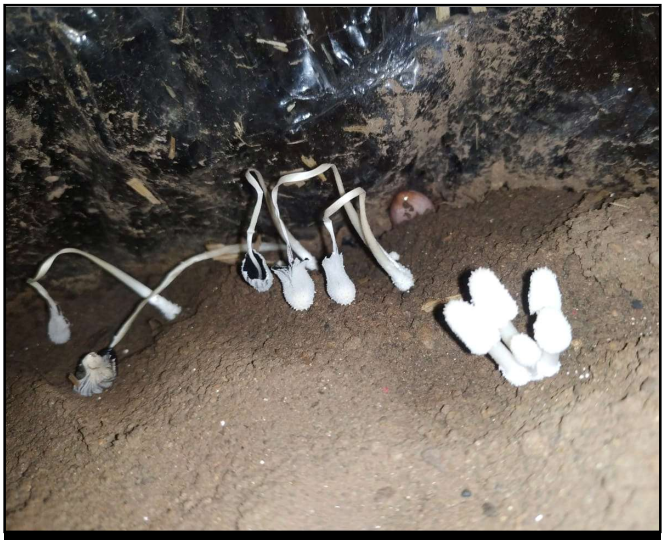

Fig. 2: *Coprinus* weeds in compost spawned with button mushroom spawn

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Received : *02.08.2021* ***Revised :*** *05.10.2021* ***Accepted :*** *09.11.2021*