Competitor Moulds and Diseases in Button Mushroom Production and Their Management

A number of harmful fungi are encountered in compost and casing soil during the cultivation of white button mushroom. Many of these act as competitor moulds thereby adversely affecting spawn run whereas others attack the fruit bodies at various stages of crop growth producing distinct disease symptoms. At times there is complete crop failure depending upon the stage of infection, quality of compost and environmental conditions. At any phase of growth an undesirable growth or development of certain moulds can occur and can adversely affect the final mushroom yield. A brief description of diseases in commercially important mushrooms is given below.

Contents

I. Fungus

A. Competitor/indicator/weed moulds

1. False truffle (*Diehliomyces microspores)*

False truffle is a limiting factor in the production of *A. bitorquis* in India because of its higher temperature requirements. The disease is of common occurrence during February or early March in *A. bisporus* in the plains of the Northern India and during summer months in *A. bisporus* and *A. bitorquis* in hilly regions of the country. 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 (Fig.1). 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 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.

Fig.1. False truffle

Epidemiology

Ascospores develop in the truffles in 3 to 6 weeks and are released when the truffle disintegrates. Ascospore production is abundant at 25 and 30°C but not at 15 or 37°C Ascospore germination up to 70% has been recorded at 27°C after giving heat stimulus at 40-50°C for half an hour. The major sources of infection are casing soil and surviving ascospores/mycelium in wooden trays from the previous crops. Ascopores can survive for periods of 5 years in soil and spent compost and mycelium for 6 months and thus serve as the major source of primary inoculum.

Control

i. 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.

ii. Pasteurization and conditioning of the compost should be carried out carefully.

iii. Temperature above 26-27°C during spawn run and after casing should be avoided. During cropping, temperatures should be kept below 18°C

iv. 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.

v. 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.

vi. 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.

vii. Initial infection can be checked by treating the affected patches with formaldehyde (2%) solution.

2. Olive green mould (*Chaetomium olivaceum, C. globosum)*

The earliest signs of the fungus consist of an inconspicuous greyish-white fine mycelium in the compost or a fine 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 (Fig.2), develop on straw in isolated spots of the affected compost. The compost has a musty odour. Spawn usually grows into areas occupied by *Chaetomium*, although normal spawn growth is delayed. *C. globosum* is also noticed on spawn bottles.

Fig.2. Gray-green cockle-burns of olive

Green mould

Epidemiology

The infection usually comes through air, compost and casing soil. It appears due to defective composting in phase-II because of improper pasteurization accompanied by high temperatures in the absence of adequate fresh air. Improper stacking of the compost trays in the pasteurization room which do not allow proper circulation of the air or overfilling of the room causes intensive condensation when wet steam is introduced; result in non-selective compost which harbours *Chaetomium* and other moulds. Spores are resistant to heat and are probably not killed easily during pasteurization. When compost is too wet, penetration of air is less which results in the conversions of nitrogenous compounds in wrong direction. Unfavourable conversions often results in renewed production of anhydrous ammonia which prompts the growth of ammonia. Sometimes the temperature is too high in certain spots of a room, or may be less of oxygen which often results in olive-green mould appearance. Ascospores are spread by air flows, clothes and other materials used in mushroom farm.

Control

i. The fermentation period of the compost should not be too short. It is essential to provide active compost that is not too wet and has a good structure.

ii. Do not add nitrogen, ammonium sulphate, urea, chicken manure or similar materials just before filling.

iii. 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.

iv. Sprays of Dithane Z-78 (0.2%) are recommended for the control of olive green mould.

3. Brown plaster mould (*Papulaspora byssina*)

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 (Fig.3). No mushroom mycelium grows on places where plaster mould occurs.

Fig.3. Brown plaster Mould

Control

i. Composting should be carried out carefully, using sufficient gypsum and not too much water.

ii. Peak heating should be of sufficient duration and at proper temperatures. The compost should not be too wet before or after peak heating.

iii. Localized treatment of infected patches with 2% formalin.

4. Yellow mould (*Myceliophthora lutea, Chrysosporium luteum, C. sulphureum*)

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.

Epidemiology

The major source of primary inoculum is air, chicken manure and spent compost. The secondary spread is mainly through mites, flies, water splashes, picking and tools. The fungus survives easily through thick walled chlamydospores. Disease severity is generally more at high moisture content of the compost and 19-20°C temperature.

Control

i. Proper pasteurization of the casing mixture is very essential.

ii. 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.

5. Sepdonium yellow/ Tikki mould (*Sepedonium* spp.)

This mould is mainly observed in the compost and is initially white in colour turning to yellow or tan at maturity (Fig.5). 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.

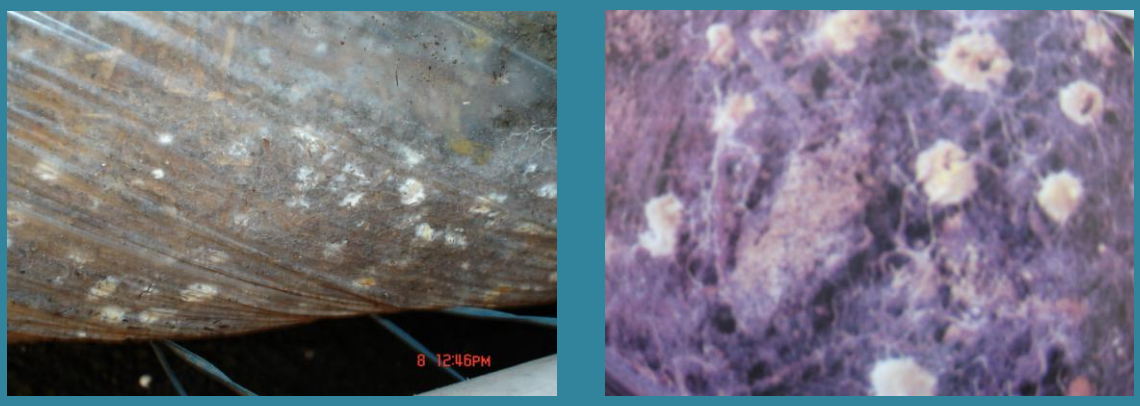

Fig. 5: Tikki mould

Epidemiology

Primary source of inoculum are probably, soil, spent compost, air or improperly sterilized wooden trays. The chlamydospore are thick-walled and resistant to heat and in this spore from, the fungus may survive peak to heat and in this spore from, the fungus may survive peak heat. Spores can be spread to the compost by air currents prior to or during filling operation, during the spawning operation or with unpasteurized or spent compost sticking to wooden trays. Conditions favourable for button mushroom cultivation also favour the *Sepedonium* mould. Higher N content, especially in the form of chicken manure, have been reported to favour the mould development. Its appearance in the lower layers of the compost has been

linked with more wetness. It has been reported very high population of *Sepedonium* spp. in 3-12 months old chicken manure which may serve as the primary source of inoculum in long method of compost.

Control

i. Strict temperature monitoring and control during compost pasteurization and an adequate post-crop cooking out are essential to eliminate the threat of infection.

ii. Preventing the entry of spores during spawning and spawn-running by installing high-efficiency air filters are essential.

iii. 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.

6. Ink caps (*Coprinus* spp.)

Ink caps appear 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.

Epidemiology

The infection generally comes through unpasteurized or particularly pasteurized compost or casing soil or air. Ink caps appear if the compost contains too much N, so if too much chicken manure is used, or if the peak heating period is too short. These are the indicator moulds indicating higher ammonia in compost. Ink caps can also develop if insufficient gypsum is added to the compost or if peak heating has taken place at too low a temperature or if the compost is too wet and poor in texture. Ink caps can directly use free NH_4^+ and can also decompose cellulose very well, in addition to lipids and lignin. They are genuine coprophillic fungi which have an optimum pH of around 8. The large masses of spores released through inking of the caps can very easily infect freshly prepared compost.

Control

i. Use properly pasteurized compost and casing soil. Avoid excessive watering. Rogue out young ink caps to avoid its further spread.

7. Cinnamon mould (*Chromelosporium fulva*, Perfect status: *Peziza ostrachoderma)*

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 (Fig.7). 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. Later on fungus produces numerous cup-like fleshy fruit bodies on beds (Fig.8).

Fig.7: White aerial mycelium

Fig.8: Cup-like fruit bodies

Control

i. 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.

8. Lipstick Mould (*Sporendonema purpurascens)*

The disease first appears in spawned compost as a white crystalline-like mould, rather non-discernable 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.

Epidemiology

Soil, casing mixture and spent compost are the sources of primary inoculum. Water splashes or pickers further disseminate it. The mould is reported to be associated with the use of chicken manure in the compost formula; the litter is said to carry the lipstick fungus.

Control

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

9. Oedocephalum mould (*Oedocephalum fimetarium*)

The mould forms irregular, light silver gray patches on the compost surface during cool down before spawning. After spawning, the mould is light gray but changes to dark tan or light brown as the spore mature. Similar growth also recorded on casing layer. *Oedocephalum* sp. in compost indicates that ammonia and amines were not completely eliminated during pasteurization and conditioning. Spraying or swabbing locally with 2% formalin controls the mould.

11. White plaster mould (*Scopulariopsis fimicola*)

The mould appears as white patches on the compost or casing soil. These patches or mycelial mats may be more than 50 cm under favourable

conditions. The white growth changes to light pink after a week of the formation of the spot. Spawn run is reduced significantly and under severe conditions complete crop failure are also recorded. The pathogen is favoured by under or over composted compost which still retains the smell of ammonia and has high pH (more than 8). Proper composting and addition of optimum quantities of water and gypsum are recommended. Sprays of benomyl (0.1%) and local application of formalin (2%) after the removal of the mat are helpful in controlling the mould.

B. Diseases

1. Wet bubble (*Mycogone perniciosa*)

Wet bubble produced two main symptoms, infected sporophores and sclerodermoid masses which are considered to be the result of infection by *M. perniciosa* at different stages in the development of the sporophores. When infection takes place before the differentiation of stipe and pileus the selerodermoid form resulted, whereas, infection after differetration resulted in the production of thickened stipe with deformation of the gills. The disease also results into white mouldy growth on the mushrooms, leading to their putrifaction (giving foul odour) with golden brown liquid exudates.

Epidemiology

Spread of *M. perniciosa* occurs primarily through casing soil but the introduction of pathogen through other agencies, like spent compost and infected trash, is not ruled out. The infection can be air-borne, water borne or may be mechanically carried by mites and flies Water splash is an important factor for wet bubble spread on the beds. Spread through contact also occurs readily during watering and especially harvesting. Chlamydospores have been reported to survive for a long time (upto 3 years) in casing soil and may serve as the primary source of inoculum. The aleurospores produced on the surface of monestrous structures are probably responsible for secondary infection.

Control

i. Benomyl spray at 0.5-4g/m² immediately after casing has been reported very effective for protecting the crop. Application of carbendazim, chlorothalonil, prochloraz manganese complex (Sportak 50 WP) @0.1% into casing mixture have been reported very effective for the management of wet bubble. Spray of 0.8 per cent formalin on to casing surface, immediately after casing also effective.
ii. Use plastic pots to cover mushroom showing wet bubble symptoms during the cropping season to prevent spread of disease.

2. Dry bubble (*Verticillium fungicola)*

This is the most common and serious fungal disease of mushroom crop. If it is left uncontrolled, disease can totally destroy a crop in 2-3 weeks. 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 (Fig 11). Sometimes they appear as small undifferentiated masses of tissue up to 2 cm in diameter. When affected at later stage, crooked and deformed mushrooms with distorted stipe and with tilted cap can be seen. When a part of the cap is affected hare-lip symptom is noticed. On fully developed fruit bodies 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.

Fig.11. Typical onion shaped mushroom symptoms of dry bubble

Epidemiology

The disease is introduced (primary infection) on to the farm by infected casing soil. Spread is carried out by infected equipments, hands and clothing. Phorid and sciarid flies are also known to transmit this disease. Mites are also known to transmit the disease from infected to healthy mushroom. The fungus is soil borne and spores can survive in the moist soil for one year. It also perpetuates through resting mycelium from dried bulbils and in spent

compost. The optimum temperature for disease development is 20°C. The period from infection to symptom expression are 10 days for the distortion symptoms and 3-4 days for cap spotting at 20°C. The pathogen grows best at 24°C. High humidity, lack of proper air circulation, delayed picking and temperature above 16°C favours its development and spread. It becomes more common when cropping is extended beyond two months.

Control

i. Use of sterilized casing soil, proper disposal of spent compost and proper hygiene and sanitation are essential to avoid primary infection

ii. Two to three sprays of zineb (Dithane Z-78) @0.15% gave good control of the disease. Spraying with carbendazim or thiophenate methyl @ 0.1% immediately after casing is reported to give good control of the disease. Application prochloraz + manganese complex (Sportak 50WP) @ 0.05%, 9 days after casing is also recommended for the effective management of the disease. Use of formaldehyde (2 litre/100 litres of water/100 m^3) immediately after casing is also advocated for the effective management of disease.

3. Cobweb (*Cladobotryum dendroides*)

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 (Fig 12), 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.

Fig.12: Cobweb disease

Epidemiology

High relative humidity and temperature encourage the disease. Spread is mainly by conidia. The pathogen is a soil inhabiting fungus and is normally introduced into the crop by soil contamination, spores, mycelium on crop debris or by farm workers. Spores are easily spread by air movement, workers hands, tools and clothing and by water splash. A high RH and temperature range of 19-22°C resulted in maximum loss in yield.

Control

i. Regular cleaning, removal of cut mushroom stems and young half dead mushrooms after each break and controlling temperature and humidity helps in controlling the disease.

ii. Annual disinfection of houses and surrounding areas with 2% bordeaux mixture or with 5% formalin solution or fumigation with 2.0-2.5 L formalin and 0.5-1.0 kg chlorinated lime/100 m^3 is helpful in controlling disease. Immediate spray after casing with benomyl @ 0.1% also controls the disease. Single application of prochloraz manganese complex (sporogon) at 1.5g a.i/m^2 of bed 9 days after casing gives satisfactory control of the diseases.

4. Green mould *(Trichoderma viride, T. hamatum, T. harzianum, T. koningii, Penicillium cyclopium, Aspergillus spp.)*

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.

Epidemiology

Green mould generally appears in compost rich in carbohydrates and deficient in nitrogen. If the compost is tampled too hard in the beds, or the filling weight is too high, this can make the peak heating difficult. This is certainly the case with compost which has a short texture and which might also have too high moisture content, resulting in improper pasteurization and conditioning of compost. Frequent use of formalin also tends to promote the development of green moulds. Different sources of primary inoculum of *Trichoderma* spp. could be dust particles, contaminated clothing, animal vectors especially the mite, *Pygmephorus mesembrinae*, mice and sciarid flies, air-borne infection, infected spawn, surface spawning, contamination of compost by handling and machinery and equipments at the mushroom farm. High relative humidity accompanied by a low pH in the casing soil also promotes the development of *Trichoderma* spp.

Control

i. Very good hygiene
ii. Proper pasteurization and conditioning of compost.
iii. Sterilizing the supplements before use and mixing them thoroughly preferably after spawning.
iv. Using the correct concentration of formalin (maximum 2%)
v. Weekly spray of carbendazim (0.1%) / mancozeb (0.2%) treatment effectively control the disease.

B. Bacterial diseases

The bacterial diseases have been reported in *A. bisporus and the* symptoms includes blotch, mummy, pit, drippy gill, soft rot and yellowing, however blotch of button mushroom is most important.

Bacterial blotch (*Pseudomonas tolaasii*)

Bacterial blotch of white button mushroom is characterized by brown spots or blotches on the caps and in more severe cases, on the stipe. 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. 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.

Epidemiology

Causing and airborne dust are the primary means of introducing the blotch pathogen into a mushroom house. Even after pasteurization the bacterial pathogen is present in most casing materials. Occurrence of the disease is associated with the rise in the bacterial population on the mushroom cap rather than in the casing. Bacteria present on mushroom surface reproduce in moist conditions especially when moisture or free water film persists for more than 3 hours. Once the pathogen has been introduced at the farm, it may survive between crops on the surfaces, in debris, on tools and various other structures. When the disease is present on the farm, its secondary spread may take place through workers, implements, ingredients, mushroom spores, debris etc. sciarids and mites are also important carriers of the pathogen beside water splashes.

Control

i. 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 more than 90 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.
ii. Application of bleaching powder @ 150 ppm available chlorine has been found effective in managing the disease.