

Review Article

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Diseases of White Button Mushroom (*Agaricus bisporus*)- A Potential Threat to Mushroom Industry

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ABSTRACT

Mushrooms have been used by humans for millennia. The commonly cultivated mushrooms include *Agaricus*, *Lentinus*, *Flammulina*, *Pleurotus* and *Volvariella*. In India, Button mushroom (*Agaricus bisporus*) is the most commonly cultivated mushroom followed by *Pleurotus* (Shah *et al.*, 2013). Mushrooms are mainly subjected to bacterial, fungal and viral diseases. The production of fruiting bodies is severely afflicted by fungal, bacterial and viral pathogens that can cause diseases which have an effect on yield and quality (Potocnik *et al.*, 2008). Improper pasteurization of compost and casing soil can be the major source of diseases. Once the disease is introduced in the farm it can be carried out by the different agencies like air, water, machines and workers (Munshi *et al.*, 2010). Fungal diseases commonly occurring in white button mushrooms include dry bubble (*Verticillium* spp.), cobweb (*Cladobotryum* spp.), green mould in compost (*Trichoderma harzianum*) and green mould on casing (*Trichoderma viride*). Over the past two decades, green mould caused by *T. aggressivum* has been the most serious disease of button mushroom. Among bacterial diseases, bacterial blotch (*Pseudomonas tolaasii*) is most common disease of white button mushrooms. Dieback is the most commonly occurring viral disease which is caused by various virus strains (Gupta *et al.*, 2018). These diseases are a major threat to the mushroom industries worth millions as the losses due to these diseases may go up to 100%. Depending upon the stage and severity of the infection, quality of compost and the prevailing environmental conditions, these diseases often cause complete crop failure (Munshi *et al.*, 2010). Considerable losses in cultivation process occur due to lower productivity, decrease in quality and shortened shelf-life. Moreover, mushroom cultivation with its rapidity of cropping makes a suitable environment for augmentation of pathogen inoculum and thus makes its control more difficult (Todorovic *et al.*, 2012).

Keywords

Button mushroom,
Crop failure,
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Introduction

Agaricus bisporus (Lange) Imbach is the most commonly cultivated mushroom species. Mushroom industry in India is overwhelmingly focused on white button mushroom which is a highly sophisticated and capital-intensive activity. Mushrooms are considered as a potential substitute of muscle protein on account of their high digestibility (Pavel, 2009). Though mushroom production in Asian countries started 1000 years ago, cultivation of mushrooms is relatively new phenomenon in India.

Mushrooms such as *Auricularia*, *Flammulina* and *Lentinula* were most likely cultivated for the first time around the year 600- 800 AD in China and other Asian countries (Chang and Wasser, 2017). Scientific cultivation, however, started only at the beginning of the 20th century when pure cultures of mushroom were prepared from spore and tissue. Cultivation in the beginning of the 20th century was focused on button mushroom mainly in USA and Europe. In first half of the 20th century the focus was on cultivation of button mushroom in the West and to a lesser extent on shiitake in the East. In the second half of 20th century, there were rapid changes in rate of growth of mushroom production and number of species brought under commercial cultivation. By the end of 20th century the share of button mushroom in total world production was less than 40 per cent, which in next ten years became around 30 per cent. 21st century, particularly last ten years, have witnessed sudden rapid rise in cultivation of mushrooms other than button. Net result is an exponential growth in world mushroom production. Due to almost unimaginable growth in production of shiitake, oyster mushrooms, wood ear mushroom and *Flammulina*, the contribution of these mushrooms to total world mushroom production has increased tremendously as

compared to button mushroom, which is no more the number one mushroom in terms of share in global mushroom production. Presently shiitake, oyster, wood ear and button mushroom contribute 22, 19, 18 and 15%, respectively in terms of total mushroom production in the world (Singh *et al.*, 2017). The contribution of medicinal mushrooms in world trade has increased over last few decades. The research focusing on validation of medicinal benefits and number of trials on use of novel chemicals derived from mushrooms in cancer research has attracted attention of industry. The recent production data (official data of ICAR-DMR, Solan) showing that, the share of button mushroom in India is maximum amounting to 73% followed by oyster mushroom which contributes about 16%. There are two main types of mushroom growers in India, those who are growing white button mushroom round the year under controlled conditions and seasonal growers who are growing button mushrooms during the winter seasons in north western part of India. The total white button mushroom produced in India from both seasonal and high tech cultivation units is estimated at 94676 metric tons. Out of this, approximately 8500 metric tons of button mushrooms was produced from the seasonal growing units located in Haryana and Punjab which accounted for 9% of total button mushroom production. By effectively utilizing the seasonal variations, the farmers of Punjab and Haryana region have revolutionized the seasonal cultivation process with very less inputs. Initially, white button mushroom production was confined to temperate hilly regions of India. However, with the development of short method of composting and optimization of fruiting conditions using the chilling system, there has been a remarkable change in its production scenario and spread to all the corners of the country. At present, highest production of button mushroom is registered from the Punjab

followed by Haryana and Maharashtra. These three states producing 43% of total white button mushroom produced in India. Fungal pathogens such as *Lecanicillium* (*Verticillium*) *fungicola*, *Mycogone* *perniciosa*, *Cladobotryum* (*Dactylium*) spp. and *Trichoderma* spp. afflict the cultivated mushroom *Agaricus bisporus* (Lange) Imbach, causing its most serious fungal diseases: dry and wet bubble, cobweb disease and green mould, respectively (Potocnik *et al.*, 2008a, 2008b, 2010a, 2010b; Kosanovic *et al.*, 2013).

Several diseases of cultivated mushrooms are caused by bacteria and viruses (Grogan, 2008; Geels *et al.*, 2008). The most common bacterial disease, distributed worldwide, is the bacterial brown blotch caused by *Pseudomonas tolaasii* (Milijasevic-Marcic *et al.*, 2012; Todorovic *et al.*, 2012). Forty years ago, wet and dry bubble diseases caused losses in *A. bisporus* production in the amount of 9 million dollars a year in Pennsylvania, US (Forer *et al.*, 1974), while losses in the UK were up to 5% of total yield (Gaze and Fletcher, 1975). With cobweb disease outbreaks in epidemic proportions in the mid-1990s, yield losses significantly increased up to 40%. The greatest damage was reported in the Republic of Ireland, the UK and the US (Gaze 1996, McKay *et al.*, 1998).

Brown blotch disease was found responsible for 8-10% losses worldwide (Olivier *et al.*, 1997). More recently, major *A. bisporus* diseases have been caused by the mushroom virus X complex (Grogan, 2008) and various *Trichoderma* species, fungi that are the causal organisms of green mould (Kosanovic *et al.*, 2013). They both account for approximately 25% of the total production value, and are the major pathogens of all three cultivated mushroom species (Sokovic and van Griensven, 2006). Mushrooms are mainly subjected to bacterial, fungal and viral diseases. The production of fruiting bodies is

severely afflicted by fungal, bacterial and viral pathogens that can cause diseases which have an effect on yield and quality (Potocnik *et al.*, 2008).

Fungal Diseases

There are four important fungal diseases viz., dry bubbler, wet bubble, cobweb and green mould, particularly referring to *Agaricus bisporus* (Sharma, 1995).

Dry Bubble

The disease is caused by *Verticillium fungicola*. The disease was reported for the first time by Malthouse in 1901. The disease is the most widespread disease of commercial mushroom production worldwide. If the disease gets out of control it can cause crop losses as high as 20 per cent or more, but 1-5 per cent losses are common (Grogan *et al.*, 2009). A poor understanding of how the disease spreads within and between mushroom crops has been a contributing factor in persistence of dry bubble problems. The pathogen can be spread by means of dust, flies, mites, debris, containers, watering and pickers.

Symptoms

Disease symptoms include bubbles (undifferentiated spherical masses), bent and/or split stipes known as blowout, and spotty caps (Fletcher and Gaze 2008; Largeteau and Savoie 2008; Berendsen *et al.*, 2010). Initially fungal growth appears on casing which later spread and turn greyish yellow. Later on, light brown superficial spots appear on caps which finally coalesce to become large brown blotches. The disease is usually transmitted by contaminated compost, casing soil (Kumar *et al.*, 2014). If the infection takes place in the later stages, the stipes are distorted and tilted caps are formed.

Management

Management strategies rely mainly on hygiene and prevention of introducing inoculum on mushroom farms (Berdensen *et al.*, 2010). The most effective control measure against dry bubble disease is to follow strict hygiene practices. Prevention of mites and flies can help in preventing the spread of the pathogen throughout the crop (Tsarev, 2014). Spray of dichlorvos @30 ml/ 100 lit. water / 100 m³ area after spawning can help in preventing the disease. Care should be taken while preparing and storing casing material to maintain the hygiene. The pathogen has developed resistance to many fungicides over time thus rendering them ineffective (Berendsen *et al.*, 2010). Carbendazim has been found to give the highest inhibition of pathogen followed by thiophanate-methyl and mancozeb (Kumar *et al.*, 2014). Bhat and Singh reported Sporogon (0.075 per cent) to be effective against *V. fungicola*. Efficacy of Bavistin against *V. fungicola* has been reported by Navarro *et al.*, (2011), Sharma and Satish (2012). Use of Dithane Z-78 @ 0.25-0.5% at the time of casing, pin head formation after the crop flushes (Munshi *et al.*, 2010).

Cobweb disease

The disease is caused by *Cladobotryum dendroides* syn. *Dactylium dendroides*. The disease exhibits characteristic coarse mycelial growth over the affected mushroom hence is named as cobweb disease. Mushrooms are attacked at any developmental stage. The pathogen rapidly colonizes mushroom which eventually turns brown and rots. The mycelium colour of pathogen changes to pink or red and the cobweb appearance is replaced by a mycelial mat. Brown or pink-brown spots with poorly defined edge are associated with the disease. The pathogen is a soil inhabiting fungus and may be introduced into casing through soil or through spores or mycelium of

the pathogen spread on debris. Unless the spore inoculum is heavy the disease mostly appears in later flushes of crop (Munshi *et al.*, 2010).

Symptoms

The symptoms first appear as small circular patches of gray is mycelium on the casing surface. As the disease progress, a fluffy white mycelium grows over the mushrooms giving it a cotton ball look. Later these turn brown, begin to rot and die-off. High relative humidity and temperature favors the disease. The primary infection takes place by contaminated casing soil or spores through air. Secondary spread of the disease occurs by air movement, pickers, water splashes, etc (Gupta *et al.*, 2018).

Management

The disease can be managed by thoroughly disinfecting the casing soil by live steam or sterilization of casing mixture at 50⁰C for 4 hours. 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 (Sharma, 1994). Application of Benomyl @ 1 g in 0.5-1.0 L water/m² or prochloraz manganese complex (Sporogon) 1.5 g a.i/m² of bed 9 days after casing (Munshi *et al.*, 2010).

Wet Bubble

The disease is caused by *Mycogoneperniciosa*.

Symptoms

The disease is characterized by the development of white mycelial growth on fruiting bodies of button mushroom. It spreads and covers the entire cap. The sporophores are eventually reduced to a white, soft and foul

smelling mass. The disease is also characterized by the development of distorted mass of mushroom tissues called as “sclerodamoid mass”, which initially are white and fluffy but become brown with age and then decay. Sclerodamoid mass develops as a result of infection at pinhead stage. The characteristic symptom of the disease is also the presence of amber liquid droplets on the surface of distorted mushrooms (Munshi *et al.*, 2010). The early development of the disease can also be attributed with the use of infected casing soil or spawn (Fletcher *et al.*, 1989).

Management

Strict hygiene conditions should be maintained along with the use of sterilized casing soil. Spray of benomyl @ 0.5 g m⁻² immediately after casing has been found very effective for protecting the crop (Munshi *et al.*, 2010). A spray of 0.8 per cent formalin on to casing surface, has been found effective against the wet bubble disease (Gupta *et al.*, 2018).

Green mould

Green mould caused by *Trichoderma* spp. is a devastating disease in mushroom crop production. It has been reported to cause serious crop damage in India (Shah *et al.*, 2013). *Trichoderma* spp. have created havoc in the mushroom houses of Kashmir valley.

Symptoms

This mould disease appears as thick cushioned white patch with greenish fungal growth on spawned and cased bags which gradually change to bluish green in colour. *Trichoderma* spp. in its initial stage, produces a dense pure white mycelium which resembles the mushroom mycelium, thus making it difficult for growers to distinguish between the two

(Shah *et al.*, 2013). If this fungus attacks the spawned trays, the spawn-run is affected. If it appears on casing soil, the pin-head formation of mushrooms is retarded. The green mould fungus is a vigorous colonizer of organic material and dead mushroom tissue. Improper phase II composting and high humidity are also responsible for the spread of this disease. The spores of this fungus are carried away by air, water and careless handling (Munshi *et al.*, 2010).

Management

Shah *et al.*, (2013) evaluated five fungicides viz., Carbendazim, Bitertanol, Hexaconazole, Captan and Mancozeb *in vitro* against green mould (*Trichoderma harzianum*) and found that the maximum average inhibition of *Trichoderma harzianum* occurred in Carbendazim (90.8 %), followed by Bitertanol (40.0%), Captan (36.6%) and Hexaconazole (16.1%). The least inhibition (11.7 %) was exhibited by Mancozeb. Certain bacteria, including *Bacillus* species that naturally exist in casing are efficient antagonists of aggressive *Trichoderma* strains, therefore they have the potential to be used for management of green mould disease (Gupta *et al.*, 2018).

False truffle disease

False truffle disease of mushroom is caused by *Pseudobalsamia microspora* or *Diehliomyces microspore*. This disease is more prevalent in summer.

Symptoms

The fruiting body of this fungus appears in mushroom beds as a round, cream-coloured, wrinkled and convoluted surface depicting brain-like appearance. The mushrooms in bed and top of casing soil are characteristically small (resembling fused pinheads). These bodies on maturity turn reddish brown and

release spores. Lack of ventilation and high humidity are the main factors favouring the appearance of this disease. The only control measures are to minimize temperature fluctuations and provide adequate ventilation. The spawn run temperature and cropping bed temperature should not exceed 22°C. High humidity in mushroom houses should be avoided (Munshi *et al.*, 2010).

Management

Avoid high temperature (26-27 °C) during spawn-run and after casing. Remove affected truffles and apply formaldehyde @ 2% solution on the affected patches (Munshi *et al.*, 2010).

Bacterial Blotch

The brown blotch disease of the button mushroom (*Agaricus bisporus*), caused by the bacterium *Pseudomonas talaasii* (Gill, 1995) was observed for the first time in some mushroom farms in the United States of America (Tolaas, 1915) and its etiology was defined a few years later (Paine, 1919).

Symptoms

Under favourable environmental conditions the lesions, initially are small and separated, coalesce affecting large areas of the pileus which may gradually decay with the formation of a strong and disagreeable smell. The pathogen spreads through splashing of water drops from infected to healthy sporophores, picker implements, flies and mites. The disease can develop at any stage of mushroom growth or development on the outer surface of a mushroom- on cap or stem or both. The bacterial blotch disease is strongly influenced by environmental and surface-moisture conditions. Thus the disease control requires inhibiting the pathogen's reproduction on the mushroom surface.

Management

Lowering of humidity to 80 per cent and running fans immediately after watering to dry the caps prevent bacteria to spread on the growing sporophores. Spray the beds with 100 ppm bleaching powder (Gupta *et al.*, 2018).

Viral Diseases

Mushrooms are attacked by a number of viruses which cause diseases like La France, watery stripe, die back, X-disease or brown disease, and have the potential to cause severe crop failure. Different viruses have been reported to infect mushrooms on the basis of size and shape of particles and are known as virus 1, 2, 3, 4 and 5. The viral diseases were not reported in India, but it has been reported in Bangalore recently.

Most common symptom includes the elongation of the stalk with a small, tilted cap (drumstick). Deterioration of the mycelium (die back) is common which increases with the time resulting in bare patches of the crop.

Sometimes small brown mushrooms develop which often open prematurely. Affected fruiting bodies have a water soaked appearance (watery stripe) which are found to be totally water logged when squeezed (Gupta *et al.*, 2018).

Management

Strict hygiene conditions inside the farm and proper ventilation along with the use of filtered air inside the peak heating spawn running and cropping rooms. Mushrooms should be picked before they open. All wooden parts of growing units should be thoroughly cleaned and sterilized to kill any mushroom mycelium from the earlier crop. Tolerant or resistant strains should be used (Gupta *et al.*, 2018).

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