Int.J.Curr.Microbiol.App.Sci (2024) *13*(07): 10-21

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 13 Number 7 (2024)**
Journal homepage: http://www.ijcmas.com

Review Article https://doi.org/10.20546/ijcmas.2024.1307.002

Diseases and Pests in Mushroom Crop and their Management

Nalini Singh[1*], Praveen Singh[1] and J. S. Brar[2]

[1]*Department of Agriculture, Sant Baba Bhag Singh University, Jalandhar, India*
[2]*Department of Entomology, Guru Kashi University, Talwandi sabo, Bathinda, India*

**Corresponding author*

Keywords

Mushrooms, ascorbic acid, pantothenic acid, edible, Diabetic patients

Article Info

Received:
20 May 2024
Accepted:
28 June 2024
Available Online:
10 July 2024

A B S T R A C T

The mushroom has high nutritional value and rich in protein with a substantial content of essential carbohydrates, amino acids, fiber and low in fat. Various vitamins B1, B2, B12, C, D and E are contain by edible mushroom in worldwide. In addition to this mushrooms have been recognised as therapeutic foods that play an important role in preventing diseases such as hypertension, diabetes, hypercholesterolemia and Cancer. Exhaustive cultivation of edible mushrooms is adversely affected by a large number of biotic and abiotic variables of fungal, bacterial, and viral infections nematodes, insects and mites are among the biotic agents that directly or indirectly cause damage to mushrooms which frequently reduce the yield of the crop and production. In this article we are going to discuss about widely affected disease & pests and their management strategies.

Introduction

Mushrooms are categorized as macro fungi which have unique fruiting bodies. They are can be hand-picked adequately (Chang and Miles, 2004; Lakhanpal and Rana, 2005; Chang, 1999). It is used in folklore as fairy egg or witches' egg (Molitoris, 2002).

The mushrooms are considered to be of high nutritive value in reports and indicate that it has found to be an excellent source of vitamin B3 (nicotinic acid) and vitamin B (riboflavin); and good sources of ascorbic acid and pantothenic acid (Ukpebor *et al*., 2007). Diabetic patients as well as obese are encouraged to consume this since it is an ideal food. This is due to the absence of fat and starch in them (Kettawan *et al*., 2011). There are many kinds of mushrooms which are edible, and can also be attributed to medicinal and health promoting properties. In mushrooms, the high percentage of protein is found that why it is popularly called as "poor man's protein" (Pandey, 2004).

These proteins contain all the essential amino acids, especially rich in lysine and leucine and considered as a good source of digestible proteins .the mushroom have contains various vitamins and mineral elements such as potassium, calcium, phosphorous, magnesium, iron, zinc and copper (Singh & Brar, 2024).

Before 5000 years, in search of food human discovered these mushrooms as edible thing. Mushrooms in the genus *Agaricus* (Button Mushrooms and Portabellas), *Pleurotus* (Oyster Mushrooms) and *Volvariella* (Straw Mushrooms) are the fleshy fruiting bodies of edible mushrooms. Depending on their stage of development and variety, mushrooms are highly variable in

appearance. Because of its protein rich content it is suggested to be grown under cultivation. The most commonly cultivated mushroom species is *Agaricus bisporus*. The mushrooms cultivated usually in the dark and controlled rooms. The temperature of various mushroom varieties are cultivated in India are given below.

Microorganisms like of fungi, bacteria, mites, nematodes and viruses cause enormous losses in commercial mushroom farm worldwide. There are various opponent molds and pathogenic fungi found to either grow on or infect different mushroom species in cultivation unit.

Each mushroom species have grown in a specific environment and affected by different pests and diseases. Even a little carelessness in the cultivation of mushroom can cause destruction in the mushroom unit. Improper pasteurization of compost and casing becomes a major source of infection of fungi and bacteria.

Once the disease has been introduced, it attracts mushroom flies, a common pest among cultivated mushroom species, on the smell of decaying mushroom.

Although, not only microorganism attack on mushroom crop, environmental parameters can cause many abnormalities in it. A number of abiotic factors in unfavorable environment resulting the quantitative as well as qualitative loss in the proper growth of mushrooms.

Accumulation with these abiotic factors include low or high moisture in the substrate, pH and temperature, CO_2 concentration in the room, wind velocity, fumes and relative humidity.

Many of these factors make the substrate nonselective for mushroom mycelium and encourage other molds and pests while some interfere with normal mushroom production (Gupta *et al.,* 2018; Francisco and Maria, 2017; Aminuzzaman *et al*., 2022).

The following abiotic disorders are quite frequently observed in worldwide mushroom production. Exhaustive production of edible mushrooms can frequently affected by some bacterial, fungal and viral diseases that, frequently cause loss in production. Mushrooms are a sensitive fungus crop and usually difficult to control the fungal illnesses because the chemicals used to treat the disease can harm the mushroom.

These infections are facilitated by the particular conditions under which the mushroom is commonly carried out, such as warm temperatures, high humidity and low aeration rate.

The unhygienic conditions of mushroom cultivation unit provide a friendly atmosphere for many diseases and pests. Therefore, a clean environment is essential to mushroom production. The room must be lime-washed and the surrounding area must be formalin-clean.

The growth of this fungus can be inhibited by sterilized casing soil, maintained temperature and certain bio-control reagents. In this review we discussed the symptoms and treatment/controls for efficient production of mushrooms. Now days, food industries, export industries and governments should pay greater attention to mushroom production and proper disease management. To encourage Farmers/producers to employ plant-based goods rather than meat based meals. It plays an important role in preserve the ecosystem for the same concern government provides subsidies and initiatives to be enhanced mushroom production.

Author Contributions

Nalini Singh: Investigation, formal analysis, writing—original draft. Praveen Singh: Validation, methodology, writing—reviewing. J. S. Brar:—Formal analysis, writing—review and editing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

Table.1 Various types of mushroom and their temperature requirements

S.no.	Scientific name of Mushroom	Common name	Temperature requirement	
			Spawning	**Cropping**
1.	*Agaricus bisporus*	White button mushroom	22-25	14-16
2.	*Agaricus bitorquis*	Summer white button mushroom	28-30	25-27
3.	*Auricularia sp*	Black ear/ Wood ear mushroom	20-34	12-30
4.	*Lentinula edodes*	Shiitake mushroom	22-27	15-20
5.	*Pleurotus erangii*	Kabul Dhingri	18-22	14-18
6.	*P. flabilatus*	Dhingri (flavillatus)	25-30	22-26
7.	*P. florida*	Dhingri (Florida)	25-30	18-22
8.	*P. sajor caju*	Dhingri	25-32	22-26
9.	*Vovariella volvacea*	Paddy straw/ Parali mushroom	32-34	28-32
10.	*Calocybe indica*	Milky/ Dudhiya mushroom	25-30	30-35

Resource: Data collected from ICAR report

Table.2 Diseases and pests with causal organisms and their management in Mushroom

S. No	Disease Name	Causal Agent	Common Name	Symptoms	Management	References
	Fungal Disease					
1.	**Dry bubble**	*Lecanicillium fungicola* or *Verticillium fungicola*	*Verticillium* disease, brown spot, fungus spot, dry bubble	Muddy brown, often sunken spots on the cap of the mushrooms and greyish, white mouldy growth seen on cap, if infection takes place in an early stage, typical onion shaped mushrooms are produced, remain small. Later stage mushroom becomes dry.	**Mechanical Control** **Proper** pasteurization of compost as well as casing material and control of insect vectors likeflies, mites, nematodes, etc. Chemical control: Dithane Z-78@0.2% 3 times at casing. Di-ethane Z-78, Sporgon, Topsin M may be applied in the stage of infection.	Grogan *et al*., 2009; Kumar *et al*., 2014; Francisco and maria, 2017
2.	**Soft Mildew**	*Cladobotryum dendroides Dactylium dendroides*	Cobweb	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.	Good ventilation and prevention of excess humidity in mushroom house to prevent further development of disease. **Chemical control:** Best control of disease by applying Bavistin + TMTD at 0.9 and 0.6g/m^2 followed by TBZ and Benlate (0.9g/ m2). Di-ethane Z-78@0.2% and disinfection of mushroom house with formalin solution before starting with new crop	Francisco and maria, 2017; Aminuzzaman *et al*., 2022
3.	**Inky Cap**	*Coprinus lagopus* and *Coprinus comatus*	Ink weed	Appearance of long slender stalk with a small slender cap. The slender stalk with thin cap in due course of time dissolves into black inky liquid. Ink caps appear in the compost during spawn run or newly cased beds and outside the manure piles	Physical removal of Coprinus from the cube is the only control measure recommended. Trays of compost should be freed from ammonia Re-pasteurization of spawn trays at 60 ^{o}C for 2hrs and Re-spawned and re-cased.	Francisco and maria, 2017; Aminuzzaman *et al*., 2022

				during fermentation. They are slender, bell-shaped mushrooms. Cream coloured at first, bluish 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 forma blackish slimy mass due to auto-digestion		
4.	**Sepedonium Yellow mould**	***Sepedonium chrysoporium***	Yellow mould	Yellow brown corky mycelium on the interphase of compost and casing are initial symptoms of yellow mould disease which emit a strong metallic smell similar to carbide	**Cultural management practices:** Yellow mold can be prevented through careful attention to maintain hygienic condition and by proper air filtration.	Francisco and maria, 2017; Aminuzzaman *et al*., 2022
5.	**Pink Mould**	*Cephalothecum roseum*	Pink Mould	It appears as white growth during an earlier stage of contamination on the casing soil and later it turns pink	Maintain hygienic condition	Francisco and maria, 2017; Aminuzzaman *et al*., 2022
5.	**Green Mould**	*Trichoderma viride, T. hamatum, T. harzianum T. koningii, Penicillium cyclopium, Aspergillus* spp	Trichoderma spot, Trichoderma blotch, Trichoderma mildew, Green mould	Pure white growth of mycelium 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	Fungus is favoured by improperly pasteurized compost and high humidity in mushroom house, Therefore humidity should be maintained. Very good hygiene, Proper pasteurization and conditioning of compost. Using the correct concentration of formalin (maximum 2%). **Chemical control:** Weekly sprays of Mancozeb (0.2%) or Bavistin (0.1%) TBZ (0.2%) or treatment with Zinebdust or Calcium hypochlorite (15%) have given effective control of the disease.	(Shah *et al*., 2004; Woo *et al*., 2004; Gupta *et al*., 2018).

6.	**False Truffle**	*Pseudobalsamia microspora or Diehliomyces microspores*	Truffle disease	Initially the colour of the mycelium is white, gradually the mycelial growth become thicker and develops into whitish, solid, wrinkled, rounded to irregular fungal masses resembling like Small Brains. At maturity they become pink, dry and reddish and finally disintegrating into a powdery mass emitting chlorine like odour.	Avoid high temperatures (26-27oC) after casing and during the spawn-run. Remove the troubled truffles and treat the troubled patches with a 2 percent solution of formaldehyde.	Gupta *et al*., 2018; Francisco and maria, 2017; Aminuzzaman *et al*., 2022
7.	**Wet Bubble**	*Mycogone perniciosa*	Wet bubble, White mould, bubble, *Mycogone* disease	Fungus covers the mushroom with white mat of mycelium, which look like cauliflower and it becomes creamy brown after few days. Small amber (yellowish brown) to dark brown drop of liquid develops on the surface of the undifferentiated tissue in very high humid conditions. At this stage an unpleasant odour comes out from the infected beds	WBD is controlled using a combination of cultural measures, sanitation, including chemical fungicides. Since fungicide is harmful against a large variety of fungi but ineffective in limiting the growth of Basidiomycetes benzimidazole fungicides, primarily benomyl, were used to control WBD by the mid-1970s. In addition to using sterilized casing soil, strict hygiene conditions should be ensured. Spraying benomyl @ 0.5gm-2 shortly after casing was particularly successful in safeguarding the crop. The wet bubble illness can be prevented by spraying 0.8% formalin on the casing surface. There has been no substantial evidence of resistance occurring among *M. perniciosa* strains to yet, which is exceptional when compared to the data for other mycoparasites.	Glamoclija *et al*., 2009; Zhang *et al*., 2017; Edgington *et al*., 1971; Munshi *et al*., 2010; Gupta *et al*., 2018
	BACTERIAL DISEASE					
1.	**Bacterial blotch**	*Pseudomonas tolaasii*	Brown blotch, bacterial spot.	Brown spots or blotches on the cap, In case of severe infection on the stipes circular or irregular yellowish spots	Sanitation, Lowering humidity, Watering with a 150 ppm chlorine solution (calcium hypochlorite products are used since sodium hypochlorite products may burn caps)	(Wells *et al*., 1996; Gupta *et al*., 2018).

				develop on or near the margins of the cap which enlarges rapidly under favourable conditions and coalesce to form rich chocolate brown blotches		
2.	**Mummy disease**	*Pseudomonas aeruginosa*	**-**	Fruit bodies have tilted caps and curved stalk. Base of the stem enlarged and tissue of the mushroom becomes spongy giving mummified appearance.	Sanitation, Lowering humidity, Watering with a 150 ppm chlorine solution (calcium hypochlorite products are used since sodium hypochlorite products may burn caps)	Gupta *et al*., 2018; Francisco and maria, 2017; Aminuzzaman *et al*., 2022
3.	**Cavity disease**	*Burkholderia gladioli* pv. *agaricicola* (previously *Pseudomonas cepacia*, then *Pseudomonas gladioli* pv. *agaricicola*) (Gill and Cole, 1992).	**-**	Infected sporophores may show symptoms ranging from minor blotching to severe pitting, with enormous extensive cavities reaching from the cap surface to the stipe. The expression of the sickness, according to Gill and Tsuneda (1997), is a combination impact of mushroom tissue-degrading enzymes such as chitinase and -glucanase) and various toxins.	**Management** Cavity disease biological control although utilizing competing microorganisms to preserve mushrooms is a promising method, further research is needed before commercial goods can be developed	Archana and Vaja, 2022
	VIRAL DISEASE					
1.	Brown disease/ watering stipe/ X-disease or dieback disease	*Phorid larvae* and *Tarsenomid mites*	Complex viruses	Reduction in the yield of mushrooms is perhaps the most reliable symptom. The other symptom commonly associated with the infected crop is the slow and depressed growth of the mycelium isolated from the infected mushroom	Prior to opening, the farm should have strict hygiene standards, proper ventilation, and the use of filtered air during peak heating spawn rooms for running and cropping mushrooms. Growing units should avoid using any wooden parts. To get rid of any Mycelium from a previous crop of mushrooms, the mushrooms have been thoroughly cleaned and sterilized. It is best to use strains that are tolerant or resistant.	Gupta *et al*., 2018; Francisco and maria, 2017; Aminuzzaman *et al*., 2022
	PEST DISEASE					
1	**Flies**	*Megaselia halterata*	Sciarid flies,	They lay eggs on the straw or	To check entry of adult flies during the	Gupta *et al*.,

		and *Megaselia tamilnodolensis, Lycoriella malli*	Phorid flies, Cecid flies	mushroom, and the larva emerging from the damage the crop. Larva feed on the mycelium, mushroom and penetrate inside the fruiting bodies making it unfit for consumption.	cropping period, screen the doors, windows or ventilators, if any with 30 mesh nylon or wire net. Use fly- trap or repellent in mushroom house. Use 1.2 to 1.0 g Diaflowbenzoran 25WC or Nimbidiseen (0.03%) 100 ml/ lit. to be added in 13-14 litreof water to mix in 100 kg compost Dichlorovas 76 EC 0.5ml., should be added in one litre of water at the interval of 3-4 days	2018; Francisco and maria, 2017; Aminuzzaman *et al*., 2022
2.	**Mites & Slugs, Snails**	*Tarsonemus myceliophagus* and *T. floriculus*	Tarsonemid mite	These are very thin, small crawling arthropods that appear on the mushroom body. They are not damaging, but annoy the grower when present in large numbers. These pests chew up portion of the mushroom which may later get infected with bacteria and affect the quality of the crop.	Maintain a hygienic condition of the house as well as its surrounding. Use of Diacophal 50 EC 1- 2ml. Kelthane @ 10 litre to be added and should be sprayed from time to time in the compost and on the wall of mushroom house. Remove the pests from the cubes and kill them. Maintain hygienic conditions	Gupta *et al*., 2018; Francisco and maria, 2017; Aminuzzaman *et al*., 2022
3.	**Beetle**	*Sacphiso manigrofaceatum & Sacphiso mapictummotschulsky*	Black beetle and Brown beetle	Golden lines seen on the body of the insect. Both feed on young buds and grown-up mushrooms by scrapping the tissues. They mainly transmit the bacterial blotch disease from one bed to other	Maintain hygienic conditions.	Gupta *et al*., 2018; Francisco and maria, 2017; Aminuzzaman *et al*., 2022
4.	**Nematode Disease**	*Ditylenchus mycelophagus* and *Aphelenchoides composition*.	Nematode	Nematode infestation is more severe in button mushrooms	Maintain hygienic conditions.	Gupta *et al*., 2018; Francisco and maria, 2017; Aminuzzaman *et al*., 2022
5.	**Springtails**	*Lepidocyrtus* sp., *L. cyaneus, Seirairicolor,* etc	*Springtails*	Springtails cause damage to the oyster, button andshiitake mushrooms. Staying in groups	Use of 0.05 per cent Malathion as spray for disinfection, mixing Diazinon 30 ppm in compost at the time of filling and spray of	Gupta *et al*., 2018; Francisco and

				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.	insecticides like Malathion or Dichlorovos at 0.025–0.05 per cent conc. during spawn run and cropping have been recommended for their control	maria, 2017; Aminuzzaman *et al*., 2022

Table.3 Abiotic disorders and symptoms in mushroom cultivation

S. no.	Name of the disorder	Causes of symptoms in mushroom	References
1.	Hard cap orhard gill	Degeneration of spawn cultures and dramatic changes in the temperature of spawn cultures or compost	Amin *et al*., 2021
2.	Crack ormalformation	Fluctuation in humidity and temperature	Amin *et al.*, 2021
3.	Open veil	A period of water stress of 1 to 3 days followed by a generous watering. Changes in temperature also can trigger opening of the veil, as can excessive carbon dioxide levels during cropping	Amin *et al.*, 2021
4.	Stroma	Repeated use of old spawns, Excessive CO2 with high water content in compost, prolonged spawn run	Amin *et al.,* 2021
5.	Weepers or Strinkers or Leakers	Low-moisture compost (less than 64%) coupled with high moisture casing is where weepers are frequently seen.	Gupta *et al*., 2018; Francisco and Maria, 2017; Aminuzzaman *et al*., 2022
6.	Mass pinning	Sudden fall in temperature, excessive aeration or early lowering of CO2 concentration	Amin *et al.*, 2021
7.	Hollow core and Brown pith	Watering and water stress	Gupta *et al*., 2018; Francisco and Maria, 2017; Aminuzzaman *et al.*, 2022
8.	Rose comb	Smoke or gases or vapors of kerosene oil, petrol, and diesel paint or oil products	Amin *et al.*, 2021
9.	Browning discoloration	High temperature, sprinkling at high water pressure, too high a chlorination rate	Amin *et al.*, 2021
10.	Scales or crocodiles	Poor climate control particularly too much drying out or too great air velocities. Strong formaldehyde vapours or excess pesticide.	Gupta *et al*., 2018; Francisco and Maria, 2017; Aminuzzaman *et al.*, 2022
11.	Long stem	Too high CO2 concentration	Amin *et al.*, 2021

References

Amin Z, Wani F F, Gulzar H, Dar W A, Sheikh P A., 2021, Diseases of White Button mushroom (*Agaricus bisporus*)-A potential threat to mushroom industry. Int. J Curr. Microbiol. App. Sci.; 10(02):2076-2085. https://doi.org/10.20546/ijcmas.2021.1002.247

Aminuzzaman, F. M. Smirti Shahi, Sudip Thapa and Kallol Das, 2022, Mushroom Diseases and Their Management: A Review, in Recent Advances in Mushroom Cultivation Technology and Its Application Vol. – 2, ISBN: 978-93-92804-20-5

Archana T. S and Sonal Vaja, 2022, A Review on Diseases of Button Mushroom (*Agaricus* spp.): A Potential Hazard to Mushroom Cultivation, Vol. – 2, ISBN: 978-93-92804-20-5

Chang S T, Miles P G., 2004, Mushrooms: Cultivation, Nutritional Value, Medicinal Effect and Environmental Impact, CRC Press, Boca Raton, Fla, USA, 1st edition, 2004

Chang S T., 1999, World production of cultivated edible and medicinal mushrooms in 1997 with emphasis on Lentinus edodes in China. International Journal of Medicinal Mushrooms. 1:291-300. https://doi.org/10.1615/intjmedmushr.v1.i4.10

Edgington L V, Khew K I, Barron G L., 1971, Fungitoxic spectrums of benzimidazole compounds. Phytopathology. 61:42-44. https://doi.org/10.1094/Phyto-61-42.

Francisco J G and María J N., 2017, Mushroom Diseases and Control. Edible and Medicinal Mushrooms: Technology and Applications, First Edition. Cuenca, Spain: Centro de Investigación, Experimentación y Servicios del Champiñón (CIES) https://doi.org/10.1002/9781119149446.ch12

Gill, W. M., and A. L. J. Cole. 1992. Cavity disease of Agaricus bitorquis caused by Pseudomonas cepacia. Can. J. Microbiol. 38:394-397

Gill, W. M., and A. Tsuneda. 1997. The interaction of soft rot bacterium Pseudomonas gladioli pv. agaricicola with Japanese cultivated mushrooms. Can. J. Microbiol. 43:639-648.

Glamoclija J, Sokovic´ M, Grubisic D, Vukojevic J, Milinekovic I, Ristic M., 2009, Antifungal activity of *Crithmum maritimum* essential oil and its components against mushroom pathogen *Mycogone perniciosa*. Chem. Nat. Compd.; 45:96-97. https://doi.org/10.1007/s10600-009-9242-0

Grogan H, Piasecka J, Zijlstra C, Baars J J P, Kavanagh K., 2009, Detection of *Verticillium fungicola* in samples from mushroom farms using molecular and microbiological methods. Agricultural Research Forum, 1-31.

Gupta S, Summuna B, Singh R, Gupta M, Gupta A., 2018, Mushroom Diseases: A potential threat to mushroom cultivation. Transformation of Indian Agriculture through Innovative technologies. Astral International Pvt.Ltd. 5:57-70.

Kettawan A, Chanlekha K, Kongkachuichai R, Charoensiri R, 2011, Effects of cooking on antioxidant activities and polyphenol content of edible mushrooms commonly consumed in Thailand. Pakistan Journal of Nutrition, 1094-1103

Kumar N, Mishra A B, Bharadwaj M C., 2014, Effect of *Verticillium fungicola* inoculation in casing soil and conidial spray on white button mushroom *Agaricus bisporus*. African Journal of Agricultural Research. 9:1141-1143. https://doi.org/10.5897/AJAR2013.7554

Lakhanpal TN, Rana M. Medicinal and nutraceutical genetic resources of mushrooms. Plant Genetic Resources. 2005;3(2):288-303. https://doi.org/10.1079/PGR200581

Molitoris H P., 2002, Mushrooms in medicine, folklore and religion. Feddes Repertorium.; 113:165-182. https://doi.org/10.1002/1522-239X(200205)113:1/2%3C165::AID-FEDR165%3E3.0.CO;2-M

Munshi N A, Dar G H, Ghani M Y, Kauser S, Mughal N., 2010, Button Mushroom Cultivation. Communication and Publication Centre SKUAST-K., 1:1-28.

Pandey, N. 2004. Chemical Analysis of Mushroom of Kathmandu valley. Submitted to University Grant Commission.

Shah Z, Ashraf A M, Ishtiaq M., 2004, Comparative study on cultivation and yield performance of oyster mushroom (*Pleurotus ostreatus*) on different substrates (wheat straw, leaves, and saw dust). Pakistan Journal of Nutrition. 3(3):158-160. https://doi.org/10.3923/pjn.2004.158.160

Singh Nalini and Brar J. S., 2024, "Mushroom and its Nutraceutical Properties" International Journal of All Research Education and Scientific Methods, Vol. 12, pp. 3844-3849

Ukpebor J E, Akpaja E O, Ukpebor E E, Egharevba O, Efedue E., 2007, Effect of the Edible Mushroom,

Pleurotus tuberregium on the Cyanide Level and Nutritional Contents of Rubber Seed Cake. Pakistan Journal of Nutrition. 6(6):534-537. https://doi.org/10.3923/pjn.2007.534.537

Wells J M, 1996, Postharvest discoloration of the cultivated mushrooms *Agaricus bisporus* caused by *Pseudomonas tolaasii*, P. 'Reactans' and P. 'Gingeri'. Phytopathology. 86:1098-1104. https://doi.org/10.1094/Phyto-86-1098

Woo S L, Di Benedetto P, Senatore M, Abadi K, Gigante S, Soriente I, 2004, Identification and characterization of Trichoderma species aggressive to Pleurotus in Italy. Journal of Zhejiang University, Agriculture and Life Sciences. 30:469-470.

Zhang C L, Xu J Z, Kakishima M, Li Y., 2017, First report of wet bubble disease caused by *Hypomyces perniciosus* on *Pleurotus citrinopileatus* in China. Plant Dis., 101:13-21. https://doi.org/10.1094/PDIS-02-17-0179-PDN

How to cite this article:

Nalini Singh, Praveen Singh and Brar, J. S. 2024. Diseases and Pests in Mushroom Crop and their Management. *Int.J.Curr.Microbiol.App.Sci.* 13(7): 10-21. **doi:** https://doi.org/10.20546/ijcmas.2024.1307.002