Part I Shiitake

Chapter 5

Pest and Disease Management of Shiitake

PEST AND DISEASE MANAGEMENT IN SHIITAKE BAG CULTIVATION

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Many pests and diseases can occur during bag cultivation of shiitake, because the pests also thrive in warm and humid conditions as they feed on the nutrients in the substrate. If unnoticed, these pests often lower productivity and quality and can sometimes cause total crop failure. The use of pesticide chemicals, however, is not advisable, as these materials can affect the mycelial growth and reduce the quality of the shiitake. These pesticides are also strictly regulated in most countries. As a result, for mushroom growers, energetic precautionary measures should be taken to avoid contamination. Good sanitation and hygienic practices during all stages of cultivation are the keys to successful pest and disease management.

The Basic Preventive Measures

1. Select fresh, pathogen and pest-free substrates and supplements.
2. Eliminate pathogens (spores) and pests (eggs) of shiitake bag by strict sterilization or autoclaving.
3. Clean and disinfect the inoculation room and box (Figs. 1 and 2).
4. Keep hands and tools clean during spawning.
5. Keep the incubation room clean and well-aerated.
6. Timely and carefully inspect the bags and eliminate contaminated bags immediately. Before disposal, sterilize the contaminated bags by autoclave.
7. After harvest, remove shiitake stumps or debris, which might attract pests.
8. Disinfect the spent substrate and shiitake houses, and other materials on a regular basis.
9. Wear clean clothes and shoes all the time (Fig. 3) and wash hands before manual work.

Figure 1. Inoculation box

Figure 2. Alcohol for disinfection during inoculation

Figure 3. Clean clothes during work

Figure 4. Raw material next to contaminated synthetic logs

Fungal Diseases in Shiitake Bag Cultivation

Green mold (*Trichoderma* spp.)

There are many species and strains of the species, such as *T. viride, T. koningii, T. polysporum, T. longibrachiatum* and *T. glaucum*, of which, first two are principal species during shiitake bag cultivation.

T. viride is characterized by dense white mycelial growth (Fig. 5) followed by extensive green sporulation of the fungus (Fig. 6). An apparently normal shiitake spawn run may give way to large patches of green *Trichoderma* sporulation. A browning reaction may occur, or the fruiting bodies may be covered with green mold.

The pathogenic fungus appears to gain entry to growing rooms primarily through contaminated spent mushroom substrate (Fig. 4), personnel and equipment. Other sources include poorly sterilized substrate or poorly disinfected transfer between growing rooms. Once introduced into substrate the fungus rapidly spreads into large patches, interacting with the shiitake mycelia. At the advancing edge of the green mold patches, browning of shiitake mycelia or lysis[1] of small pins is visible macroscopically, suggesting enzymatic degradation. Microscopic investigations have shown mycelial collapse and cellular disorganization. Infestation by green mold results in green sporulation and darkened patches (Fig. 8), which in turn cannot be colonized by shiitake mycelia. When colonized by shiitake mycelia, those patches will produce much lower yields of inferior quality shiitake. The shiitake fruiting bodies may become soft after infection, and may produce black liquid. *T. koningii* is also reported, and it is difficult to distinguish whether a problem is caused by *T. viride* or *T. koningii*. These *Trichoderma* infestations are usually found in poorly sterilized substrates when the environmental humidity is high.

Figure 5. Overwhelmingly infested synthetic log by extensive white mycelial growth

Figure 6. Synthetic log covered by green spores from green mold

[1] lysis: dissolution or destruction of cells by the action of a specific substance that disrupts the cell membrane

Figure 7. Inside the synthetic log well-colonized by shititake

Figure 8. Inside the synthetic log infected by green mold

Control measures

- Do not use green-mold contaminated spawn (Fig. 9).
- Sterilize substrate bags thoroughly.
- Use good sanitation and hygiene and disinfect equipment regularly.
- Avoid high humidity and high temperature in the shiitake house.
- Remove or treat spots with white, dense mycelial growth indicating green mold fungi.
- Remove contaminated bags immediately.

Figure 9. Spawn infected by green mold

Red bread mold (Neurospora sitophila and N. crassa)

Symptoms of red bread mold infestation are similar to those of green mold. The fungus is characterized by white mycelial growth, but followed by extensive red or orange sporulation. The pathogens invade particularly poorly sterilized or highly moistened substrate. Being readily air-borne, it rapidly spreads to be epidemic, when the room temperature and humidity are relatively high. A synthetic log with the plastic bag removed is quite prone to contamination, which might result in primordia malformations.

Figure 10. Substrate bag infected with red bread mold

Figure 11. Infected bags removed from the growing house

Control measures

- In order to prevent pathogenic spores from being dispersed in the growing room, apply limestone powder to the affected part of substrate bag and get the bag out of growing room. Remove plastic and bury the contaminated synthetic log in the ground.
- Do not spray any treatment solutions.

- Remove and treat contaminated synthetic logs in the same way as in control for green mold.

Blue mold (Penicillium spp.)

Blue mold is a lesser threat than green mold. There are many species reported, such as *P. citrinum, P. funiculosum, P. chrysogenum, P. cyclopium, P. pallidium, P. digitatum* and *P. italicum*. The initial symptoms of blue mold are also similar to those of green mold. The blue mold colony shows white mycelial growth first and extensive blue sporulation of the fungus. The colony spreads slowly in comparison with that of green mold. This mold favors acidic substrates.

Control measure

- Ventilate the shiitake house to decrease the relative humidity.
- Treat the diseased area with 5-10% limewater solution and cover it with a wet cloth to prevent the disease spores from spreading.

Mucor spp.

These fungi are commonly found in soil, air, manure, old stale straw and compost. They are characterized by rapid growing colonies, which are cottony and thick owing to abundant upright sporangiophores[2], white at first, olive gray to brown but white on the underside of the petri dish. Spores are brownish. *Mucor* has a higher growth rate than shiitake mycelia. This fungus can occupy substrate, which has the effect of stunting the growth of shiitake mycelia causing them to turn yellow.

Control measures

- Ventilate the shiitake house to decrease the relative humidity.
- Do not use stale substrate materials.
- Spray limestone on the sides of the shiitake house.
- Inject 5-10% solution of ammonium bicarbonate (NH_4HCO_3) into the diseased areas.

Aspergillus spp.

These fungi are recognized by their distinct conidiophores[3] that terminate in a swollen vesicle bearing flask-shaped phialides[4]. The colony is white at first and becomes yellow green, usually thick owing to abundant conidiospores[5]. The fungus is widely found in soil, air and organic litters and highly likely to appear in a humid, poorly ventilated shiitake house.

Control measures

- Stop watering and ventilate the shiitake house to decrease room humidity.
- Spray a 1 : 500 solution of Carbendazol (carbendazim) on the affected area.

Pests in Shiitake Bag Cultivation

Mites

Among the many species of mites, the two mite types in particular that cause damage to shiitake are the pyemotid mite (Siteroptes) and the acarid mite or flour mite (Acarides). The pyemotid mite is small and invisible to the naked eye, brownish when seen in groups on the substrate, while the acarid mite is large, white, and looks like flour when present in large quantities. They both feed on shiitake mycelia and fruiting bodies, lowering mushroom quality and yield.

Control measures

- Clean the substrate storehouse.
- Maintain sanitation practices and general hygiene and disinfection during all stages of cultivation.
- Perform substrate preparation and bag filling away from the cultivation houses.

Springtail

Springtails are tiny soft-bodied invertebrates, mostly less than 10mm in length. They are most distinguished by their small forked tail-like organ on the underside of their abdomen, which enables them to leap away when disturbed. The principal species is purple springtail, *Hypogastrura communis*. They usually hide in the damp corners and feed on shiitake mycelia and fruiting bodies. Sometimes springtails aggregate sufficiently to form visible masses on the substrate. Springtails cause yield lowering and a decrease in quality.

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[2] sporangiophore: a specialized branch bearing one or more sporangia
[3] conidiophore: a specialized fungal hypha that produces conidia
[4] phialide: a particular type of flask-shaped cell that gives rise to conidia (conidiospores)
[5] conidiospore: an asexually produced fungal spore formed on a conidiophore (syn. conidium)

Control measures

- Clean the substrate storehouse and shiitake cultivation houses.
- Maintain sanitation practices and general hygiene and disinfection during all stages of cultivation.
- Build the shiitake cultivation houses separate from the substrate storehouse and other buildings and dwellings.
- Spray a solution of limewater in the shiitake houses before cultivation.

Slugs

Several species of slugs frequently damage shiitake fruiting bodies, including the wild slug (*Agriolimax agrestis*), the phagus slug (*Philomycus bilineatus*) and the yellow slug (*Limax flavus*). They are active at night and during cloudy or foggy days when they can easily hide themselves in humid shade.

Control measures

A good slug management program relies on a combination of practices. The first step is to eliminate slugs' daytime sheltering locations such as plant debris, weeds, and stones around the shiitake cultivation houses. Trapping and handpicking on a regular basis contributes to integrated slug control. By using a flashlight, growers can detect slugs in the dark and picked slugs can be put in a bucket with soap, salt, or a limestone solution.

Further Reading

Shiitake Abnormalities

Mushrooms can be malformed under unfavorable conditions. Like competitor or weed fungi, abnormal mushrooms only consume nutrients in the synthetic log or occupy space without bearing any substantial fruit. Most cases of malformed mushrooms can be prevented by cultural management-temperature and humidity control at a given stage. Common shiitake abnormalities and their respective, possible occurrence conditions are as follows.

※ Low/high temperature or humidity here indicates lower/higher temperature or humidity than required for the growth of a given shiitake strain. Generally, shiitake develops fruiting bodies at 10-20 ℃ and 75-90% R.H..

Double cap

Figure 12. Double capped shiitake

Cracked cap

Figure 13. Fruiting body with cracked cap

Another pin may formed on the cap (Fig. 12) if a fruiting body devlops under low temperatue around 5 ℃ and/or if the synthetic log where it develops has high moisture content. Cracking of cap surface (Fig. 13) is caused by the low temperature and low humidity during fruiting body development. This characteristic conditon of fruiting body happens when inner part of cap outgrows outer part. Ironically, cracked fruiting bodies are priced at much higher than the normal, uncracked ones.

Enlongated stipe with small cap

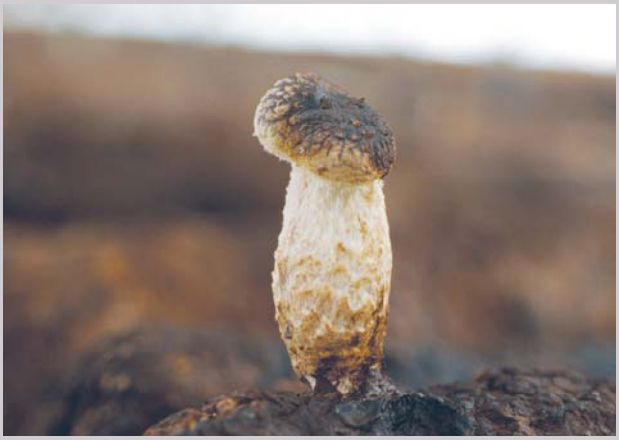

Figure 14. Fruiting body with enlongated stipe and small cap

Swollen stipe

Figure 15. Swollen stipe

Enlogation of stipe (Fig. 14) usually occurs when the pin formation is excessively delayed, when fruiting room lacks lighting, when the synthetic log lacks nutrients, or growing temperature is higher than the optimal temperature condition at fruiting body development. Swelling of stipe in developing fruiting bodies (Fig. 15) occurs when pinning and subsequent fruiting body development is performed at lower temperatures. Immature pin formation at low temperatures may cause stipe to grow thick.

Darkened cap

Figure 16. Fruiting bodies with darkened cap

Pale fruiting body

Figure 17. Pale fruiting body

Surface of cap can be darkly pigmented (Fig. 16) when there is an extremly high humidity and low temperature as well as heavy watering on young or half-grown fruiting bodies. Pale fruiting body (Fig. 17) may be caused by dark conditions at fruiting body development .

Fruiting body without gills

Figure 18. Fruiting body without gills

Small fruiting body

Figure 19. Small fruiting bodies

This deformed condition shown in Figure 18 can be caused when fruiting is induced before the synthetic log is fully colonized by the shiitake mycelium. Reduced size of fruiting body (Fig. 19) can be caused by the low temperature, abrupt decrease in humidity during the develpment of fruiting body, and lack of enough nutrient and moisture in the synthetic log.