Advances in Crop Science and Technology

Singh and Sharma, Adv Crop Sci Tech 2016, 4:2
DOI: 10.4172/2329-8863.1000213

Review Article Open Access

Pests of Mushroom

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Introduction

An annual production of mushroom in India is estimated to be 40,000 million tonnes approximately out of which 39,000 million tonnes are *Agaricus* and rest are *Pleurotus* and *Volvariella* (Dhar 1997). Out of this 80-85% is button mushroom, 15-19% is of oyster and the remaining 1% is of other mushrooms. Although there are several hundred species of mushrooms (including edible and non-edible forms) in India but three main types are cultivated on a commercial scale. They are white button mushroom, *Agaricus bisporus*, oyster mushroom, *Pleurotus* spp. and tropical paddy straw mushroom, *Volvariella* spp. Button mushrooms are generally highly susceptible to nematode infection while oyster mushrooms are relatively resistant. They are being cultivated under semi-scientific conditions (use of partially sterilized media and casing soil, use of implements, container, etc. seldom treated with formalin, etc.) with limited inputs. Other biotic stresses such as insects, bacteria, fungi and nematodes cause heavy losses. Hence, the commercial productivity is much less than that of other countries. Today most of the industrialized countries viz., USA, Great Britain, China, Holland and France are producing mushroom.

Cultivation of Mushroom has been in vogue for almost 300 years. However, commercial cultivation in India has started only recently. Growing mushroom under controlled condition is of recent origin. Its popularity is growing and it has become a business which is export-oriented. Today mushroom cultivation has been taken up in states like Uttar Pradesh, Haryana, Rajasthan, etc. (during winter months) while earlier it was confined to Himachal Pradesh, J&K and Hilly areas. Mushroom is an excellent source of protein, vitamins, minerals, folic acid and is a good source of iron for anemic patient. Mushroom cultivation can be done at cottage and small-scale levels besides large-scale farming. Mushroom growing is one of the fastest growing and most technologically sophisticated horticultural industries in the world. They are a natural product with many nutritional advantages. They are cholesterol free and contain virtually no fat or sodium. Mushrooms supply dietary fiber and are a good source of several important B group vitamins, especially niacin and riboflavin. Today, mushrooms are grown commercially in enclosed atmosphere controlled environment, production is therefore largely independent of the environment. They are cultivated around the world, global annual production being in the region of 12 million metric tonnes.

Several control methods have been worked out under Indian conditions, prophylatic (sterilized production substrates, containers, gloves, implements, etc.) and use of plant products (leaves, non-edible oil, cakes of neem, pongamiya, castor, etc.) were more successful in minimizing pest damage to mushrooms and maximizing the yield. The unhygienic conditions of mushroom cultivation provide a congenial atmosphere for many pests and diseases. Of these, the most dangerous are nematodes which, once enter the crop bed, cannot be eradicated without complete elimination of the crop. Their presence in the bed leads to very poor yields or total crop failures.

Discussion

Nematode pests of mushroom

The first report about nematode damage to mushroom in India was made from Himachal Pradesh. An intensive survey of mushroom farms at Solan revealed 84.4% nematode infestation which led to extremely poor flushes in the initial stages followed by total crop failures. Nematode problems in mushroom are unique in that not only have the nematodes adapted themselves fully to the ecological requirements of the crop but also they multiply very rapidly inflicting up to 100% crop losses. Hence the need for more scientific and commercially viable mushroom production technologies is growing.

The nematodes associated with mushrooms can be grouped into five categories based on feeding habits. Of these Myceliophagous and saprophagous nematodes are economically important as they are highly pathogenic to common mushroom fungi like *Agaricus* spp. Mycetophagous females and males, and infective females of the genus *Iotonchium* which had not been known in Japan were found from gill-galled oyster mushrooms, *Pleurotus ostreatus*. [1]. The mushroom *H. atrocaerulea* was cultivated for the first time on paddy straw to produce a sustained supply of basidiocarps to investigate their nematicidal potential. In vitro assays with crude extract of the basidiocarps resulted in 48% mortality of the infective larvae of plant parasitic nematode *Meloidogyne* spp. [2] *Iotonchium ungulatum* is the causal agent of gill-knot disease of the oyster mushroom, *Pleurotus ostreatus*. The insect-parasitic females of this nematode are described. The insect-parasitic female nematodes inhabit and lay many eggs in the haemocoel of the fungus gnat, *Rhymosia domestica* [3].

Fungal feeding nematodes: Twenty-one nematode species representing two orders –Aphelenchida and Tylenchida have been reported to cause damage to mushroom cultivation in various parts of the world. Out of these 20 belong to four genera–*Aphelenchoides*, *Aphelenchus*, *Paraphelenchus* and *Seinura* under the order Aphelenchida and one species *Ditylenchus myceliophagus* of the order Tylenchida. In India eight species of *Aphelenchoides* and *Ditylenchus myceliophagus* has been recorded from mushroom beds.

a. **Aphelenchoides spp:**

I. ***Aphelenchoides agarici*:** This is reported from Himachal Pradesh and the most preferred host is A. bisporus. In its absence, the nematode can multiply on other fungi of the compost media like *Trichoderma*, *Trichothecium* and *Gillaminello*. It has a short life cycle of 8 days and many generations are repeated during single crop season.

II. ***Aphelenchoides asterocaudatus:*** This was first reported from

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Received January 22, 2016; **Accepted** March 03, 2016; **Published** March 09, 2016

Citation: Singh AU, Sharma K (2016) Pests of Mushroom. Adv Crop Sci Tech 4: 213. doi:10.4172/2329-8863.1000213

cropping beds by Bahl and Prasad from India.

III. ***Aphelenchoides compostícola***: In India nearly all the mushroom growing states are affected by this nematode. This is the most prevalent nematode species found in almost all the mushroom growing countries of the world. Three mycophagous nematode species, i.e., *Aphelenchoides compostícola*, *A. avenae* and *Ditylenchus myceliophagus* along with some saprophagous (*Rhabditis* sp.) and predatory (*Seinura* sp.) nematodes were found in compost samples in villages of Sonipat district, Haryana, India. *A. compostícola* was the predominant species and its frequency of occurrence was 50% and *D. myceliophagus* 22.7% [4]. An analysis of mushroom compost soil samples revealed *Aphelenchoides compostícola* (10 individuals/100 ml) in only one instance [5]. However, the yield of button mushroom was highest when 1% neem seed kernel extract and Achook at 400 ppm were applied in combination at the time of spawning. The *Aphelenchoides compostícola* nematode population was also reduced drastically in the treated boxes compared to inoculated untreated control [6]. Neem cake at 20 g was most efficient in reducing the population of *Aphelenchoides compostícola* and 10 g and neem leaf at 16 g dose showed manurial effect on *Agaricus bisporus* in terms of yield potential, but Achook at higher doses proved toxic to fungi as was evident from number of fruiting bodies and yield data [7]. It multiplies very fast, having a short life cycle of 8 days at 23ºC, 10 days at 18˚C and 18 days at 13˚C.

IV. ***Aphelenchoides minor***: Few nematodes of this species were recorded from compost samples of the cropping beds of mushroom farm at Srinagar (Jammu and Kashmir), India.

V. ***Aphelenchoides myceliophagus***: In India this nematode is first reported from mushroom farm in Solan (Himachal Pradesh). It is a highly destructive species and as pathogenic as *A. compostícola*.

VI. ***Aphelenchoides neocompostícola***: The nematode was first found damaging the mushroom mycelium in a mushroom farm at Shimla, India. It is less destructive than *A. agarici*, *A. compostícola* and *A. myceliophagus*.

VII. ***Aphelenchoides sacchari*****:** It is a highly pathogenic nematode found to reduce the sporophore yields by 94.5% and delay the fructification by approximately 2 weeks under natural conditions. In India this species was first recorded from cropping beds of white button mushrooms. It is a bisexual species that completes one life cycle in 12 days. The presence of mushroom nematodes in the cropping system posed a serious threat and a most difficult problem in cultivation to solve, as they were the only ectoparasites in nematode kingdom, which were capable of causing frequent and total crop failure in mushroom. *Aphelenchoides agarici* and *Ditylenchus myceliophagus* also known as Myceliophagous nematodes caused maximum damage to the crop at different stages of cultivation. Yield losses ranged up to 100% in case of *A. sacchari* and 70% in *D. myceliophagus*. Some botanical agents like neem *Azadirachta indica*, coconut, castor and groundnut cakes were quite effective and left no residual effect on the crop [8]. It multiplies rapidly as development period of one generation from egg to egg is completed within 12 days only. The fertility period of females is 28-30 days.

VIII. ***Aphelenchoides swarupi***: This fungal feeding species was for the first time found in a mushroom farm at Ambala (Haryana), India where though brown wet pinheads were observed initially, no fruiting bodies were produced. An average of about 10, 000 individuals/100 g of compost were counted in the beds showing total crop failure.

IX. ***Aphelenchus avenae***: This nematode is frequently present in low numbers in compost and casing soil samples taken from cropping beds. Three mycophagous nematode species, namely *Aphelenchoides compostícola*, *Aphelenchus avenae* and *Ditylenchus myceliophagus* along with some saprophagous (*Rhabditis* sp.) and predatory (*Seinura* sp.) nematodes were found in compost samples of white button mushroom (*Agaricus* spp.) and oyster mushroom (*Pleurotus* spp.) during 2004 to 2005. *Aphelenchoides compostícola* was the predominant species with 80% frequency of occurrence followed by *Aphelenchus avenae* and *D. myceliophagus* and *Rhabditis* sp. with 67, 13 and 13 frequency of occurrence respectively. The saprophagous nematodes (*Rhabditis* sp.) were recorded as the predominant species with 100% frequency of occurrence in oyster mushroom [9].

b. ***Seinura winchesi:*** In India, population of *Seinura* sp. were found from the cropping beds of a mushroom farm at Solan, H. P, India. In this case though the initial mycelial growth was normal, sporophore yields were reduced.

c. **Tylenchids:** *D. myceliophagus* is a widely distributed nematode present in almost all mushroom-growing belts of world. In India, it has been found to be distributed in mushroom farms in Jammu and Kashmir, Punjab, Karnataka, Andhra Pradesh, Himachal Pradesh and Tamil Nadu. Initially it was identified as *D. destructor* but later described as *D. myceliophagous* by Goodey. It is one of the highly destructive species at an initial inoculum of 10-1000 individuals could cause 15-70% mycelial depletion within 60 days. This species can multiply as rapidly as *A. sacchari* and less pathogenic than *A. compostícola* and *A. sacchari*. *Ditylenchus myceliophagus*, *Aphelenchoides compostícola*, *Rhabditidae*, *Mesorhabditis* sp., *Pellioditis* sp. and *Prodontorhabditis* sp. were recorded from Wenzhou City, Zhejiang, China in button mushroom cultivation [10]. Samples of compost, casing soil, floor soil from 22 mushroom farms in 15 villages of Sonipat district, Haryana (India) harboured mycophagous nematodes, including *Aphelenchoides compostícola*, *Aphelenchus avenae* and *Ditylenchus myceliophagus* [11]. The nematicidal activity of 2-hydroxy-1-naphthalanilines, the imines derived from 2-hydroxynaphthaldehye and anilines and their derivatives, against the mushroom nematode, *D. myceliophagus*, was studied by Manrao and Kaul [12] of the 15 compounds tested, 5 resulted in >50% mortality when 1000 p.p.m. were applied. Further studies on concentration of nematicidal compound and exposure time revealed that 2 of the tested compounds would be worthy for further study.

d. **Saprophagous nematodes**: Saprophagous nematodes, belonging to the order Rhabditida have often been recorded from severely damaged mushroom beds on almost all mushroom farms in India and elsewhere. The important genera of common occurrence are *Rhabditis*, *Caenorhabditis*, *Cephalobus*, *Panagrolaimus*, *Diplogaster* and *Acrobeloides*. Karanj cake both at 2 and 4%, coconut, niger and neem cakes all at 4% were effective in reducing *A. compostícola* population. Coconut, karanj and neem all at 2 and 4% and sesamum at 4%

were as effective as chemical treatments in reducing *Rhabditis* spp. population [13]. The greatest development of *Rhabditis cucumeris* (1500/g) was observed when the nematodes were introduced before spawning less (900/g) if the infestation and spawning were simultaneous [14].

e. **Predaceous nematodes:** These nematodes, generally the mononchids are often encountered in mushroom beds but their prevalence is mainly dependent on the population density of their prey. They have a beneficial role in mushroom production since they feed on other nematodes including aphelenchids.

Insect pests of mushroom

Several types of insect pests can attack mushrooms but the major pests belong to three families of flies. Some mites, springtails, beetles and moths also infest the crop (Table 1).

Fungus gnats (Sciarids): Adult sciarids are small (3-4 mm), delicate, two-winged flies which are dark grey/ black with large compound eyes and long, threadlike antennae. Females are generally larger than males and their abdomens are often distended with eggs. Adults do not fly readily but move rapidly across the growing surface in brief jumping flights. They may also be found "roosting" in tight spaces and on the walls of production houses.

Adult flies may be present on mushroom production sites throughout the year but are most numerous during mid January to mid March. On an average, a mated female can lay 150-170 white, oval eggs singly, or in groups within the growing substrate. Depending on temperature, incubation period lasts for three to seven days.

Sciarid larvae are white, elongate, legless maggots with a distinctive black shiny head. At this stage the larvae feed on developing mycelium and uncontrolled will burrow into pinheads and small buttons forming a sponge-like mass. Mature larvae are approximately 8.0 mm in length and can remove mycelial attachments at the base of the stalk. Larval development is temperature-dependent but after approximately 12-15 days, the larvae transform into pupae. This is an inactive stage, which does not feed. Adult emergence normally takes place in 5-7 days after pupation.

It has been demonstrated that a mean of one sciarid larva in 125 g of casing causes 0.5% loss in total yield. As the cost for recommended sciarid control measures also accounts for 0.5% of the value of the crop, this represents an economic threshold for this pest. Fungus gnat problems may result from over wet conditions and diseased roots should alert growers for poor culture.

Hump backed flies (Phorids): Adult phorids are slightly smaller (2-3 mm) but more robust flies than sciarids. They are darker in colour with a hump-backed appearance with no obvious differences between male and female flies. Adult flies tend to remain on the compost surface or in close proximity to the cropping area. They are very active in the presence of light and have a characteristic rapid, jerky movement. The flight of adult phorids is limited by temperature and they are unable to fly when air temperature is below 12°C. Therefore, wild populations do not normally invade mushroom production houses between November and February. Each female can lay up to 50 eggs in close proximity to developing mycelia. Larvae are off-white, legless maggots without a distinct head capsule. The anterior region narrows to a point while the posterior is blunt with small protuberances. The duration of phorid development is temperature dependent and may vary between 15 days (24-27°C) to 50 days (16-21°C). Larval development accounts for approximately 1/3 of the development time and the remainder is spent in pupation.

Midges (Cecids): There are two genera of Cecid flies which are usually present in mushroom houses, Heteropeza (white) and mycophila (orange) cecids. The adult flies are rarely seen as they are too small, but the paedogenic larvae can be seen in large numbers. With the knowledge and practice used by growers related to farm hygiene their infestation is reduced to negligible. Increased use of deep dug pit also helps as the flies are unable to lay eggs. They have considerable potential for spoilage if they enter the farm as they are quite persistant and it is very difficult to eradicate.

Usually larvae forms are white elongate smooth and spindle shaped, 1.5-2.35 mm long with two eye spots giving appearance of "X". Young larvae feed on growing mycelium, tear the bundle of hyphae.

Family - Order	Scientific name	Common name	Source	Damage
Diptera: Sciaridae	**Bradysia paupera, B. tritici Lycoriella auripilla**	Fungus gnats (Sciarids)	common in nature	Maggots burrow into pinheads and small buttons forming a sponge like mass (brown and leathery). Restricted spawn run.
Diptera: Phoridae	**Megaselia sp**	Hump backed flies (Phorids)	common in nature	Yellowish brown caps, tunneling of stalks and leathery brown pinheads. Formation of clean wet zone around the vent.
Diptera: Cecidomyiidae	**Heteropezina cathistes**	Midges (Cecids)	local/compost/ casing	Small size mushrooms with vertical, discoloured stipe sometimes tiny black postules are present
Collembola: Entomobryidae	*Lepidocyrius cyaneus; Xenylla sp. Seira iricolor*	Spring tails		Browning of cap. Destruction of gill linings. Mycelium disappears, slight pitting
Tarsonemidae, Tyrophagidae	**Tarsonemus spp;** *Tyrophagus spp; Pygmephorous spp*	Mites	From infested crop to fresh, soil	Feeds on mushroom tissue or mycelium, poor and deformed growth of cap with rust coloured spots is seen. Sometimes attachment of mushroom to substrate is also affected.
Coleoptera; Staphylinidae, Scarabaeidae	Staphylinus; Alphitobius laevigatus; Cyllodes whiteii; Scaphisoma nigrofasciatum	Beetles	Soil infested with larvae	Small sized holes are formed in hymenium and stipes. Larvae infest the gills.
Lepidoptera: Noctuidae		Noctuid Moth	--	Larvae make tunnels and pits in mushrooms

Table 1: Insect Pests of Mushroom.

Behaviour of mushroom flies:

- After mating, adult females are attracted to developing mushroom mycelia in spawned compost.
- The compost remains attractive to adult females throughout the entire spawn-run period, and is particularly susceptible during the second week.
- Mycelial development, which occurs following casing, renews attraction to adult females.
- Each female can lay up to 50 eggs in close proximity to developing mycelia.
- Duration of the life cycle is temperature dependent and will vary in relation to the environmental conditions associated with cropping periods.
- Increased air temperatures associated with spawn-run and case-run periods facilitate life cycle completion in 24-26 days.
- The lower temperatures following breaking and during cropping periods may extend the life cycle to 40-50 days.

Mites: Usually mites are present in straw and manure and are transferred to mushroom houses. Most species are beneficial to mushroom growing as they feed on eelworms (Nematodes) and other mites. They may also live on other fungi (weeds and indicator molds) found in mushroom culture, although some can cause damage. Mites may feed on mushroom mycelium and on the mushrooms, where they can cause surface discoloration.

a. **Tarsonemid-mites:** These mites are pale brown and are so minute that they are only visible with the aid of a microscope. They cause damage by feeding entirely on hyphae of mushrooms and the grower will know if he has these mites present, as the base of the stem of the mushroom will show a reddish brown discolouration. Where severe infestation occur the whole base of the mushroom may be detached from the growing surface.

b. **Tyroglyphid mites:** These saprophytic mites translucent, with long hairs on their bodies and can be identified from their slow movement. When present in abundance, they eat small pits in the caps and stalks of the fruit. In these pits bacterial decomposition can be observed, which breaks down tissues just below the surface. This results in the skin collapsing which leaves an open pit. Tyroglyphids can feed on mycelium and crop reductions can be caused. Mites usually gain entry into the compost by clinging onto Sciarid flies in the migratory stage. These migratory stages are normally produced when mites become overcrowded.

Little can be done when mites are present in the growing house, therefore efficient composting and peak heating must take place to ensure that they are killed during the pasteurization process. Good hygiene should be practised around the mushroom farm, especially in the clearance of crop debris and presence of stagnant water should not be allowed.

c. **Red pepper mites/ Pygmy mite:** These mites are commonly associated with *Penicillium* and *Trichoderma* molds, upon which they feed. They are not regarded as primary pests; their presence is usually an indicator that *Trichoderma* (green mould) is present in the compost thus indicates that the compost is unsatisfactory. They do not feed on mushrooms. These mites have the ability to change into an intermediate stage called a hypopus, wherein they develop flattened bodies and a sucker plate with which they attach to moving objects, like flies. Mites at this stage swarm on top of mushrooms. The mites are yellowish-brown in colour, 0.25 mm in length and have a flattened appearance; they also are capable of rapid rates of reproduction. As already stated these mites are secondary pests and they often swarm on the casing and mushroom surfaces. Where this happens their presence makes the mushrooms un saleable. These mites can also spread spores of *Trichoderma* from bag to bag.

d. **Springtails:** Springtails are a group of very small to minute (1-2 mm) wingless insects. They often occur in enormous numbers on the surface of water, on snow, in mushroom houses, under the unattended articles in or near the garden and other damp places. They occasionally invade houses and are particularly common in basements, bathrooms and kitchens. Damp environmental conditions are preferred since springtails respire through their cuticles. If their habitat becomes too dry, they will actively seek a more favourable environment. They may move indoors through window screens, open doors, through vents or with the soil brought into the mushroom house. They may also be found in cracks and crevices, or occur in damp wall voids. Springtails feed on algae, fungi and decaying vegetable matter.

Springtails damage mycelium and sporophores of button and oyster mushroom. The adults are of ground colour with violet band along the sides of the body. Dark and rounded scales are present all over the body. Dark and rounded scales are present all over the body. The female lays eggs singly or in the cluster on moist paddy straw, compost and mushroom buttons. Eggs hatch in three days at 30°C. The life span of adult is 70-80 days at 26°C and remain active through out the year.

In mushroom house these insect feeds on either mycelium in the compost or attack on fruiting bodies. In the buttons slight pitting and browning can be seen at feeding site. It also feeds on gill hence destruction of gill lining can be seen.

e. **Beetles:** Most Staphylinidae, as adults and larvae, are predators or facultative predators. However, minorities feed only on plant materials including fungi. It is observed damaging oyster mushroom. The adults are attracted to the smell of decayed mushroom and lay eggs in the discarded or over grown mushrooms. The grubs feed in the soft gills and complete its life cycle in three weeks. Removal of waste and debris of the mushroom from the mushroom house and surrounded areas prevent the adults from laying eggs. The population will be checked. Mature/rejected mushrooms should not be left in the bed.

Prophylactic measures: Looking into the limitations of pest management in mushroom production, adoption of prophylactic measures can be a better option for prevention of crop from insect and nematode pests. Thus following practices, if adopted, may be useful to manage insect and nematode pests with successful cultivation of mushroom.

- Undertake mushroom farming in properly ventilated rooms having doors and windows with wire net of 14-16 mesh/cm to avoid entry of insect pests.
- Basic amenities like clean irrigation water and sewage disposal system and irrigation should be ensured.

- Floor used for the preparation of compost should be cemented, to avoid the direct contact of compost with infested soil.
- Maintain cleanliness inside, outside and surroundings of the production unit. Composting yard must be washed thoroughly with some disinfectant (5% formalin, hot water, etc.) after every stacking.
- Composting platform should be away from the cropping rooms.
- Workers and visitors should be asked to disinfest their feet by dipping them in the disinfectant prepared with 5% formalin. Workers should frequently disinfect their hands and clothes.
- The area for mushroom cultivation should be such that it is free from effluent of chemical industries and air is free from toxic fumes and gases.
- Ready to use compost should have about 70% moisture and pH 7-7.2.
- Pasteurization should be proper as over/under pasteurization may invite many pest problems.
- Spawn should be fresh and free from all contaminants and all equipments/implements used in it must be washed and disinfected.
- The important considerations include previously cleaned implements and maintaining overall hygiene by wearing clean boots and gloves.
- Already used trays should be sterilized and polythene bags should not be reused.
- Picking should be started from new or cleaner crops towards older crops.
- Try to maintain optimum environmental conditions in operational rooms and waste from various operations should be collected and disposed off daily.
- Manage insect and nematode pests well in time to avoid the spread of pathogen by them.
- Eliminate the propagation of pests in the growing rooms in successive crops by cooking out at 70°C for 12 hours.
- Spent compost should be carried far away from the cropping area and dumped in a pit. Cover it with soil.
- Thorough washing of mushroom farm with water and then followed by disinfectant must be done after and before running the crop.

Factors identified for improved pest control include

- Monitoring and identification of pests
- Protection of newly spawned compost
- Exclusion by screening air inlets and vents
- Proper sealing of tunnels and closing doors promptly
- Early detection by monitoring
- Judicious use of approved pesticides
- Biological control methods
- Early termination of infested crops

Nematode and insect management

- Use of heat has been the most successful method of nematode control in mushroom cultivation.
- Dipping the appliances i.e., used trays and handling tools in boiling water for 1-2 min is sufficient for complete destruction of nematodes.
- Predatory nematodes, mites, fungi and bacteria are the possible microorganisms which can be used in checking the nematode menace in mushroom. The only attempt in this regard is from Solan (H.P), where two nematophagous fungi, *Arthrobotrys irregularis* and *Candelaretta musiformis* isolated from spent compost, have been demonstrated as highly effective in checking nematode multiplication on mushroom mycelium.
- The insect pathogenic nematode *Steinernema feltiae* was shown to offer an alternative to the use of diflubenzuron for the control of the mushroom fly *Lycoriella auripila* [15].
- Incorporation of oil cakes like neem (*Azadirachta indica*), Karanj (*Pongamia pinnata*), coconut (*Cocos nucifera*), castor (*Ricinus communis*) and groundnut (*Arachis hypogea*) in compost before spawning has been found to reduce nematode multiplication.
- K30 strain of *A. bitorquis* showed tolerance to *A. sacchari* but not to *D. myceliophagous*.
- The organochorine pesticides were the first to be used against mushroom pests. BHC, lindane, Kelthane, aldrin, nemagon, etc. were commonly used. Methyl bromide, a fumigant was used to pasteurize compost which eliminated almost everything including fungi, insect pests, nematodes, etc.
- Thionazin at the rate of 80 ppm is the only recommended nematicide for the control of myceliophagous nematodes without residual toxicity.
- An insect growth regulator Diflubenzuron (Dimilin) is considered to be safe and recommended all over the world for mushroom cropping. Drench treatment by Deltamethrin at the required dose can also be done.
- Outdoors:

  - Cleaning leaves and plant debris from around the house, especially in window wells can reduce insect numbers.

  - Keep turfgrass from growing near the edge of mushroom houses.

  - Keep compost piles or mulch away from house foundations.
- Indoors:

  - Decrease dampness and humidity within the house with de-humidifiers or fans.

- Do not allow organic matter to collect in cracks or crevices.

- Seal any cracks or crevices in the house foundation, or other points of entry.

- Use a vacuum cleaner to remove springtails from around the household.

Conclusion

The demand of growing mushroom is increasing day by day, with an increasing awareness of people regarding its palatability and high food value. The use of pesticides for nematode kill in mushroom crop is not advisable due to residual hazards as mushroom is a short duration crop. There is a need to exploit the use of some plant products which have nematicidal properties and at the same time are safe for mushroom mycelium. Mushroom growing is a young progressive industry all over the world today.

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Citation: Singh AU, Sharma K (2016) Pests of Mushroom. Adv Crop Sci Tech 4: 213. doi:10.4172/2329-8863.1000213