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Efficacy of Acaricides and botanicals against *Tyrophagus putrescentiae* (Acari:Acaridae)

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Abstract

Haryana is the leading state in seasonal mushroom production contributing approximately 4000 tonnes per year. Reports are available on the occurrence of mites including *Tyrophagus putrescentiae* in oyster mushrooms. Mites have been found to damage mushrooms right from spawning to the harvest of the crop. Mite damage on the fruiting bodies often shows up as the small cavities in the stem and cap similar in appearance to bacterial pit disease. Mycelium-eating mites can cause high yield losses. Although pesticides (permetrin, perefosmetil, anometrin, forbecide and dichlorvos) are applied, but due to growing ecological and health concerns, bio-control methods are being developed against pests. There is a need to exploit the use of plant products which have acaricidal properties and are safe for mushroom mycelium. Plant-derived alkalis, alcohols, aldehydes, terpenoids and some monoterpenoids show fumigant properties and thus, the use of plant based pesticides is preferred against pests and diseases in mushroom production.

Keywords fruiting bodies, mycelium, monoterpenoids, spawning

Introduction

Mushrooms are edible fungi belonging to the genus *Pleurotus* under the class Basidiomycetes. 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, Jammu and Kashmir. Several types of mite species had been found to be associated with mushrooms, out of which *Histiogaster* sp., *Histiostoma* sp., *Tarsonemus myceliophagus*, *Tyrophagus lantneri*, *Uroobovella* sp., *Tarsonemus dimidatus*, *Tarsonemus dimidatus* and *Caloglyphus mycophagus* are of frequent occurrence [1]. Reports are available on the occurrence of mites including *T. putrescentiae* as pest in oyster mushrooms [2, 3].

The mites enter into mushroom bed with the help of flies on which migratory stage of mites are clung by the means of sucker. Some can directly damage the fruiting bodies, some may attack the mycelium and some mites are predatory on other mites, fly eggs, nematodes or bacteria. Mites have been found to damage mushrooms right from the spawning to harvest of the crop [4].

Moreover, mites themselves pollute the mushrooms by the multitude of faeces that they excrete all over, making the mushrooms uneatable as a food, cause allergies and other diseases. Mites are specifically attracted to the gills of the *Coprinopsis cinerea* mushrooms and consume the mature basidiospores portion of the mushroom[5]. Mite damage on the fruiting bodies often shows up as the small cavities in the stem and cap similar in appearance to the bacterial pit disease. *T. putrescentiae* fed on the mycelium retarding the mycelial growth and suppressing the sporophore formation and resulting in to small irregular pits on stalk and caps [6,7]. Mycelium-eating mites can cause high yield losses [8]. Volatile organic compounds (VOCs) specific for discrete developmental stages of the fungus might yield odors specifically attractive for mites or also insects [9,10]. However, VOCs can also act as repellents helping to protect the mushrooms from consumptions by animals. VOCs (1-octen-3-ol) is found to be abundantly released in the mycelium stage and then, gradually reduces during fruiting body formation. 1-Octen-3-ol at lower concentrations has been defined to be an attractant to certain mites; but at higher concentrations, it acts as repellent [11]. The mite *T. putrescentiae* is known to be attracted by cis-and trans-octa-1, 5-dien-3-ols, eight carbon compounds known to be produced by mushrooms. There have been various VOCs reports on the 1-octen-3-ol formation in *Pleurotus spp*. [12]. Calcium oxalate produced by mushrooms can repel larvae of sciarids to some extent.

Temperature is considered to be a key factor in controlling the population, development and reproduction of astigmatid mites including *T. putrescentiae* [13]. In general, the oviposition period of *T. putrescentiae* increases with decreasing temperatures, though the longest period is found at 15°C. Fecundity is adversely affected by the extreme temperatures, so that the lowest number of eggs is found at 10 °C, and highest at 20°C. However, the maximum number of eggs per female per day (24 eggs) is recorded at 25°C, whereas the minimum value (7 eggs/ female/ day) is obtained at 10°C.

Avoidance of any of these harmful organisms and viruses is necessary for any successful commercial mushroom production. Several control methods have been worked out under Indian conditions, prophylactic measures (sterilized production substrates, containers, gloves, implements, etc.) and use of plant products (leaves, non-edible oil, cakes of neem, *Pongamia*, castor, etc.) are more successful in minimizing pest damage to mushrooms and maximizing the yield[14]. Pesticides (permetrin, perefosmetil, anometrin, forbecide and dichlorvos) are applied [15], but due to growing ecological and health concerns, biocontrol methods are being developed against pest [16]. In mushroom bed, incorporation of diazinon in compost at filing time and dicofol (0.1%) as prophyletic measure against flies is recommended in the crop. There is a need to exploit the use of plant products which have acaricidal properties and that are safe for mushroom mycelium [17].

Use of plant based pesticides was preferred against pests and diseases in mushroom production [18]. Neem seed kernel extracts and its formulation are reported to influence mortality, repellency and fecundity of mites. Das [19] recommended the use of citronella oil for the management of mushroom mites. Plant-derived extracts, powders [20, 21] and essential oils can be better options for mite control [22,23] Sanchez-Ramos and Castanera [23] tested 13 natural monoterpenes against *T. putrescentiae* and concluded that of these, pulegone, menthone, linalool and fenchone had high acaricidal activity, yielding LC90 values out of 14 µl/l or below. There are several studies that showed the effectiveness of plant essential oils for control of stored products pests [22]. Among botanicals [23], *Allium sativum*, *Curcuma longa*, *Azadirachta indica*, *Glycyrrhiza glabra*, *Ocimum* sp. are reported to have toxic and repellent effects on storage mites [24,25,26,27] and insects [28,29,30]. Sharma and Rajesh [31] observed that neem leaf extract (10%) was inhibiting the mycelial growth of *Sepedonium chryospermum*, a causative agent for yellow mould in mushrooms[31]. Plant-derived alkalis, alcohols, aldehydes, terpenoids and some monoterpenoids show fumigant properties [32]. *Withania somnifera* and *Pongamia pinnata* are the other botanicals that showed acaricidal activity against phytophagous mite, *Tetranychus urticae* [33].

Potential of botanicals for mite management

The plant kingdom is recognized as the most efficient producer of chemical compounds, synthesizing many products that are used to defend plants against different pests. Nagesh and Reddy [14] have reviewed the use of plant products (leaves, non-edible oil cakes of neem, *Pongamia*, castor, etc.) in minimizing nematode damage to mushrooms and maximizing the yields as equal in control and treatments by 3 days. Essential oils are an alternative control method for mushroom mites because of their insecticidal, repellent or antifeedant properties. He reported that clove and cinnamon extracts induced 88.7 percent mortality of *L. perniciosus* when applied at the rate of 125µg/cm^2. Moreover, dichloromethane extracts of clove and cinnamon showed the highest toxicity against *L. perniciosus* with the LD50 values of 34.97 and 35.57 µg/cm2, respectively [34]. Adding 0.01 percent *L. cubeba* oil to *P. nigrum* and *C. nardus* oils could increase the mortality rate of the mushroom mite in all treatments where 16 and 45 percent increase was observed. The antifeedant and growth inhibitory activities of various crude extracts and purified fractions of the plant were evaluated well against economically important polyphagous pest *Spodoptera litura*. Pumnuan et al [35] observed that the effect of five concentrations (0.5, 1, 2, 4 and 8%) on mycelial inhibition of *Fusarium oxysporum* varied significantly i.e., with the increase in concentration from 0.5 to 8 percent, there was an increase in the inhibition of mycelial growth of pathogen (*Fusarium oxysporum*). However, *Pleurotus sajor caju* also showed the same results except in the treatments which contain *Metricaria* and *Azadirachta indica* extract, inhibiting the mycelium of pathogen by 84.4 and 85.1 percent. The least toxicity to *Pleurotus sajor-caju* was shown by *M. spicata*, inhibiting mushroom by 19.6 percent. Jeyasankar and Ignaimathu [36] evaluated neem leaves and neem cake against False Truffle (*Diehliomyces microspores*) disease of *Agaricus* spp. and recorded good results in controlling this disease *in vitro*. Sharma and Rajesh [37] observed that 10 percent neem leaf extract was inhibiting the mycelial growth of *Sepedonium chryospermum*, that is responsible for causing yellow mold in button mushrooms. Sanchez Ramos and Castanera [23] studied the acaricidal activity (direct contact application) of 12 fennel seed oil extracts against *T. putrescentiae* and found them to be the most toxic. *A. indica* and *A. Juss* prolonged the developmental time of the stored product mite *T. putrescentiae* [38]. Addition of neem leaf powder @ 2% on w/w basis of compost has been recommended for controlling nematodes as well as incorporation of neem cake @ 5% on w/w basis of compost at spawning has been reported to hamper the multiplication of *A. compostiocola*. Ethanol extract of seed of *P. pinnata* (Sapindaceae) showed insecticidal activity against *C. pavonana* with LC50 value of 0.16 percent. The leaf extract of *Lantana camara* has excellent acaricidal activity (23-9%) against red spider mite in tea [39]. *Withania somnifera* and *Pongamia pinnataa* are the other botanicals which showed acaricidal activity against *phytophagous* mite, *Tetranychus urticae*. Gurusubramanian et al. [33] [40] reported the acaricidal activity of clove essential oil that at the concentration 0.1% v/v killed house dust mite (*D. pteronyssinus*) within 10 min, while lemon grass and betel vine essential oils killed within 15 and >20 min, respectively. The active essential oils of clove, lemon grass and betel vine showed LC50 values (24 h) at 0.0026, 0.0091 and 0.0091 ml/ml, respectively.

Use of Bio-control agents

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* [41,42] Riichardson [43] used entomophilic nematodes of the genus *Steinernema* and *Heterorhabditis* for the control of insect/pests infestating mushroom crops in the United Kingdom. He used a formulation of *B. thuringiensis* subsp. *israelensis*, ABG-6193 to control larvae of both *Lycoriella mali* and *Megaselia* in mushroom compost. In addition, *B. thuringiensis* 656-3 showed a high level of toxicity against mushroom flies, *L. mali* and *C. fuscipes*. [44] Various fungal metabolites have been used as biocontrol agents against nematodes. Metabolites from *Pleurotus sajor-caju* [45] and *Penicillium* spp [46] were used to inactivate the pathogenic nematode, *Aphelenchoides composticola*. *Hypoaspis aculeifer* and *H. miles*, the predatory mites can control cecid, phorid and sciarid. Grewal et al and Jess and Bingham [47,48] reported that *Agaricus bisporus* growing bags when inoculated with *Lycoriella solani* and predator *Parasitus bituberosus*, the mite reduced adult pest numbers by 50-66 percent.

Pest management in mushrooms

A large number of pesticides have been used for the management of the mushroom mites. Nicotine was the first plant product used for the mite control although it was proved ineffective [49]. Petroleum oils although effective against mites, but proved phytotoxic to mushroom mycelium, hence could not be used for the control of mushroom mites [50-51]. Paradichlorobenzene 1½ lbs/11000 cubic feet was found to be highly effective for mushroom mites. Application of TE-PP, DDT and Gamma BHC dusts before and after casing were proved highly effective against mushroom mite. 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 reported by Sanchez Ramos and Castanera [39]. A high mortality (>90%) was recorded when *T. putrescentiae* females were exposed to vapour concentrations of 66.7 µl/l of the tested compounds (pulegone, eucalyptol, linalool, fenchone, menthone, α-terpinene and γ-terpinene). Pinene and terpineol yielded a mortality of 56 and 38 percent, respectively. Sanchez Ramos and Castanera [23] tested 13 natural monoterpenes against *T. putrescentiae* and concluded that out of these, pulegone, menthone, linalool and fenchone had high acaricidal activity, yielding LC90 values of 14 µl/l or below.

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