CONTROL OF *MEGASELIA HALTERATA,* A PHORID FLY PEST OF COMMERCIAL MUSHROOM PRODUCTION, BY INSECTICIDAL TREATMENT OF THE COMPOST OR CASING MATERIAL

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(Accepted for publication Oct. 18, 1984)

ABSTRACT

Megaselia halterata (Wood) (Diptera: Phoridae) is a pest of commercial mushroom production in North America and Europe. Compost or casing materials treated with experimental insecticides were placed in commercial mushroom growing rooms that were heavily infested with *M. halterata.* Control was determined by comparing emergence from treated material with that from untreated material. As a compost treatment, the following were ineffective: resmethrin, fenvalerate, permethrin, Lily-7063, and triflumuron. Diflubenzuron was effective only at high doses. Acephate, chlorpyrifos, deltamethrin, diazinon, dimethoate, ethoprop, fenitrothion, and methoprene were effective. As casing treatments malathion, triflumuron, and diflubenzuron were ineffective. Dimethoate, diazinon, acephate, chlorpyrifos, deltamethrin, ethoprop, fenitrothion, and methoprene were effective.

Key Words: Mushroom, *Megaselia halterata,* insecticide, fly-control.

J. Entomol. Sci. 20(1): 50-54 (January 1985)

INTRODUCTION

Megaselia halterata (Wood) (Diptera: Phoridae) is a pest of commercial mushroom culture in the U. S. and is the most important insect pest of mushroom culture in the United Kingdom (P. F. White, personal communication) and the Netherlands (A. D. van Zaayen, personal communication). Mushroom yield is reduced by the larvae feeding on the hyphae of the fungus and by the adults transporting disease organisms from infected to uninfected areas (White 1981). In addition, because of the many millions of adults that can be produced during one crop in a growing room (Cantelo et al. 1977), they are an annoyance to the pickers. Also, the fly is a nuisance to householders in mushroom growing areas as it is attracted to light and can readily penetrate typical window screening.

Except for the study by Cantelo and McDaniel (1978) of the effect of diazinon on mushroom flies there has been little effort to develop chemical control for this species. A major reason may be because the insect is difficult to rear. Larval and adult flies are usually infested by the nematode *Howardula husseyi* Richardson, Hesling, and Riding which essentially stops reproduction (Hussey and Wyatt 1958). However, Rinker and Snetsinger (1981) have recently developed a method to suppress the nematode infestation in *M. halterara* colonies.

The commercial mushroom, *Agaricus bisporus* (Lange) Sing., is grown in rooms on shelves or trays in which has been placed a layer of compost and then a layer of casing. Compost is the source of nutrients for the mushrooms and provides a growing surface. The casing layer is essential for fruiting and is a source of water for the sporophore (the mushroom). The lower layer, the compost, consists mainly

of manure and straw that has been broken down by thermophilic aerobic microorganisms during two composting phases. In the first phase temperatures are 50 - 80°C and in the second phase 50 - 60°C. During cool-down of the second phase, spawn is incorporated into compost, usually with a mechanical device. Spawn consists of the vegetative stage of *A. bisporus* grown on a cereal grain. It is at spawning time that invasion by *M. halterata* populations most commonly occurs. After the mycelium has thoroughly invaded the compost, a period of about 2 wks, casing material which may consist of topsoil, topsoil mixed with used growing media, or peat moss is placed onto the compost. Casing depth is 2.5 - 5.0 cm. In about 3 wks the media will begin producing sporophores at about one wk intervals. Commonly five or six flushes are harvested. U. S. mushroom growers in 1983 sold their crop for $471,000,000, making mushrooms the third most valuable vegetable crop, following tomatoes and lettuce.

This paper describes an investigation to develop chemical control by treating the compost layer or the casing layer of mushroom growing medium using natural infestations of *M. halterata* present in commercial mushroom growing rooms.

MATERIALS AND METHODS

Compost treatment. Insecticide in 200 ml of water was sprayed at a dosage of 100 ppm (active ingredient per wet weight of compost) onto 5 kg of compost in a revolving cement mixer. Then 50 g of mushroom spawn were added and the mixing continued for one minute. For each treatment eight 600 g samples were taken and placed in plastic trays (23 × 14 × 8 cm deep). The following day the treated samples, plus untreated samples, were placed in a randomized block design on the ends of the top beds of commercial growing rooms heavily infested with *M. halterata.* This bed location is where the highest *M. halterata* populations are typically found (Cantelo et al. 1977). After 48 hrs the trays were removed to a chamber held at 23°C and 85% RH. The trays were placed in individual bags of nylon netting held off the surface of the compost by half-hoops of wire. A 3 × 30 cm wooden garden label with an adhesive on one side was placed inside the netting to trap the flies after emergence. The wooden label was kept with the compost from 17 to 35 days after infestation. The control achieved was determined by comparing emergence from treated compost with that from untreated compost.

The chemicals tested were: resmethrin, fenvalerate, permethrin, and deltamethrin. This test was repeated with additional chemicals using dosages of 1, 10, 50, or 100 ppm. The chemicals tested were: acephate, diazinon, ethoprop, dimethoate, fenitrothion, chlorpyrifos, diflubenzuron, Lily L-7063 (N-[[[5- (4-bromophenyl)-6-methylpyrazinyl]amino]carbonyl]-2-chlorobenzamide), methoprene, and triflumuron.

In a commercial situation the insecticide would be incorporated in the compost along with the spawn by a mechanical mixer.

Casing treatment. To simulate commercial conditions, prior to treating the casing eight 500 g aliquots of spawned compost were placed in trays and held at 23°C and 85% RH for 2 wks to permit the mycelium to grow through the compost. Then 500 g portions of a used media-soil mixture were placed on each tray of compost.

Each set of eight boxes was sprayed with an insecticide to produce a concentration in the casing of 10, 50, 100, or 100 ppm based on the dry weight of

the casing. The trays were then handled the same as the compost treatment, i.e, exposed to flies in a mushroom growing facility for 48 hours and subsequently held in an environmental chamber to determine comparative emergence. The chemicals evaluated were: deltamethrin, chlorpyrifos, dimethoate, diazinon, ethoprop, malathion, fenitrothion, acephate, triflumuron, diflubenzuron, and methoprene.

In a commercial situation the chemical would be applied to the casing during the watering of the casing.

RESULTS AND DISCUSSION

Compost treatment. The pyrethroids, except for deltamethrin, and two insect growth regulators were ineffective in controlling the fly at the highest dosage used (100 ppm), producing controls as follows: resmethrin (4%), fenvalerate (42%), permethrin (81%), Lily L-7063 (17%), and triflumuron (29%). Deltamethrin gave 99% control. Methoprene was the only growth regulator effective ($\geq$ 95% control) at dosages of 100 ppm or less (Table 1). Diflubenzuron required very high dose levels to achieve adequate control. Of the chemicals tested, the six best materials were phosphorus compounds. These materials are also effective as compost incorporants in controlling the other major mushroom fly pest *Lycoriella mali* (Fitch) (Diptera: Sciaridae) but at considerably higher dose levels (Cantelo 1979). On the other hand, the growth regulators were effective against *L. mali* at lower dosages. The residual activity of these compounds was not determined but an estimation could be made from the results of testing some of them with *L. mali.* Chlorpyrifos provided 75% or better control for 55 days, ethoprop for 11 days, diazinon for 6 days, and methoprene for 13 days (Cantelo 1981).

Casing treatment. Malathion, triflumuron, and diflubenzuron were ineffective at the highest dose levels used (200 ppm) producing controls of 57%, 27%, and 21%, respectively. The insect was particularly sensitive to fenitrothion (Table 2). Dimethoate and diazinon were very effective (98% control) at dose levels as low as 10 ppm but the variance of data was too high to predict lethal dose levels with confidence. Chlorpyrifos, dimethoate, ethoprop, and methoprene were also effective as casing treatments against *L. mali,* but chlorpyrifos and ethoprop can be phytotoxic in the casing layer (Cantelo 1983).

Controlling infestations that include both fly species could be obtained by the use in the compost of acephate, chlorpyrifos, deltamethrin, diazinon, dimethoate, fenitrothion, or ethoprop and the use in the casing of methoprene or fenitrothion. However, the potential for phytotoxicity has not been determined for acephate, chlorpyrifos, deltamethrin, dimethoate, fenitrothion, and ethoprop in compost and of fenitrothion in casing.

Table 1. Insecticides which controlled *M. halterata* when incorporated into compost.

Chemical	Dose-response equation	LD_{50} (ppm)	LD_{95} (ppm)
acephate 75% WP	% control (probit) = 4.43 + 1.77 (log dose)	2.09	17.62
chlorpyrifos 4E	% control (probit) = 4.51 + 1.69 (log dose)	1.95	18.20
diazinon 4E	% control (probit) = 5.24 + 0.59 (log dose)	0.67	10.75
diflubenzuron 25% WP	% control (probit) = 0.70 + 2.05 (log dose)	126.56	804.86
dimethoate 2E	% control (probit) = 4.89 + 1.78 (log dose)	1.15	9.72
ethoprop 6E	% control (probit) = 4.29 + 0.83 (log dose)	2.36	17.12
fenitrothion 8E	% control (probit) = 4.33 + 1.58 (log dose)	2.67	29.46
methoprene 5E	% control (probit) = 2.12 + 2.27 (log dose)	18.50	97.96

Table 2. Insecticide which controlled *M. halterata* when incorporated into casing.

Chemical	Dose-response equation	LD_{50} (ppm)	LD_{95} (ppm)
acephate 75% WP	% control (probit) = 3.20 + 2.12 (log dose)	7.07	42.24
chlorpyrifos 4E	% control (probit) = 2.17 + 2.65 (log dose)	11.77	49.25
deltamethrin 0.21E	% control (probit) = 2.58 + 1.84 (log dose)	20.58	160.59
ethoprop 6E	% control (probit) = 5.89 + 0.53 (log dose)	0.02	26.26
fenitrothion 8E	% control (probit) = 7.10 + 0.17 (log dose)	0.01	0.07
methoprene 5E	% control (probit) = 5.08 + 0.91 (log dose)	0.82	52.71

ACKNOWLEDGMENTS

The participation in this research is gratefully acknowledged of B. C. Zeichner, and W. R. Smith, Agricultural Research Technicians, and A. M. Wieber and V. K. Boyd, Biological Aides. This study could not have been completed without the fine cooperation of several mushroom growers with heavily infested growing rooms who shall go unnamed.

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