Fungus Gnats and Diatomaceous Earth

Does this amendment work efficiently for fungus gnat control? Find out with University of Illinois research.

By Ray Cloyd

Deli containers with growing media containing diatomaceous earth inside an environmental control chamber. A yellow sticky card was placed on the surface to capture adult fungus gnats that emerged. (Photos courtesy of Ray Cloyd)

Figure 1. Percent moisture content of growing media containing diatomaceous earth (DE)

Formulation Name	Concentration (lb. DE/yard^3)	Percent Moisture Content		
		Before Second and Third Instar	After Second and Third Instar	
Diafil	10	53	78	75
Diafil	20	52	76	71
Diafil	30	53	76	68
Dicalite	10	53	76	69
Dicalite	20	52	80	71
Dicalite	30	53	74	65
Fine Perlite	10	61	78	75
Fine Perlite	20	56	77	73
Fine Perlite	30	53	76	65
Teufel Mix	N/A	50	62	57
Sunshine LC1 Mix	N/A	66	82	76
SB300 Universal	N/A	24	49	53
Mean		*52.1*	*73.6*	*68.1*
Range		*24-66*	*49-82*	*53-76*

Greenhouse producers are well aware of the problems associated with fungus gnats, *Bradysia spp.* Although fungus gnats are more problematic during propagation they can also be a concern throughout a crop production cycle. The adult stage is primarily a nuisance, whereas the larval stage is directly responsible for plant injury by feeding on plant roots or tunneling into stems. In addition, larva can vector soil-borne pathogens directly through feeding or creating wounds that allow entry for soil-borne pathogens. The primary way of dealing with the larval stage of fungus gnats involves drench or "sprench" applications of insecticides to the growing medium. A number of insecticides including insect growth regulators or the microbial-based insecticide have been used for control. For years, greenhouse producers have been seeking more long-term alternative management strategies to alleviate problems with fungus gnats.

One alternative management strategy that has been considered is the use of growing media that contain amendments such as diatomaceous earth. Diatomaceous earth (DE) is composed of the silicaceous fossilized skeletons of diatoms. Diatomaceous earth works by removing the waxes on the insect's body and by absorbing oils and waxes on the outer cuticle. Another way in which DE can kill insects is through desiccation or by rupturing or abrading the insect cuticle and causing extensive water loss. Insects typically pick up DE particles on their cuticle as they move.

It has been suggested that incorporating DE into growing media or applying to the growing medium surface will kill larvae as they move within the growing medium or adults that emerge from the pupae stage. However, there is no information to prove that the use of growing media containing DE provides control of soil-borne insect pests such as fungus gnats.

We conducted a study at the University of Illinois to evaluate the potential of using DE incorporated into growing media for control of the fungus gnat, *Bradysia sp. nr. coprophila*.

MATERIALS AND METHODS

Two experiments were conducted by testing a series of growing media containing various concentrations of DE and several without. The effects of the growing media containing DE on both the second and third instars of fungus gnat larvae were determined by recording the number of adults captured on yellow sticky cards.

The growing media used in the study was Sunshine LC1 Mix, SB300 Universal and Teufel Mix. Sunshine LC1 Mix was the base-growing medium in which DE was added to obtain the desired formulations. The components of this growing medium include peat moss, perlite, lime, a fertilizer charge and a wetting agent. The growing media SB300 Universal and Teufel Mix, in addition to the components found in Sunshine LC1 Mix, also contain bark and vermiculite. Neither of these growing media contained DE. The DE formulations used in the study were Diafil (World Minerals, Inc.), Dicalite (Grefco) and Fine Perlite (Seba Beach).

The growing media were placed into a moistened dishpan. The samples consisted of 300 ml of growing medium. Rolled oatmeal was applied to each sample, and 100 ml of deionized water was added, except for the Teufel mix in which 85 ml of deionized water was added. The samples were mixed and then placed into a deli container and compressed. Ten to 12 small holes were punctured into the bottom of each container. The samples were placed into an environmental growth chamber for 48 hours, which allowed time for fungal growth, before inoculating with fungus gnat larvae.

Both second and third instar fungus gnat larvae were used. The fungus gnat larvae were collected in a petri dish with water and applied to the growing medium samples. Twenty larvae were poured onto each sample, and then the petri dish was rinsed to ensure that all larvae had been placed onto the growing medium. There were seven replications per sample for each larval instar for a total of 168 samples.

The inoculated samples were then placed into the environmental growth chamber. Each deli container was placed onto the lid of a petri dish containing water, which could be taken up through the holes on the bottom of the containers. This prevented the growing medium from drying out. Every week, 50 ml of deionized water was added to the petri dish lids to maintain a consistent mois-

ture level. In addition, 4.0 ml of deionized water was applied to the surface of the growing medium every week. Each deli container had a yellow sticky card attached to the underside of the lid to capture adults that emerged from the growing medium.

The moisture content of each growing medium sample was determined both before and after conducting the experiments to establish the mean moisture content for each growing medium, expressed as a percentage.

RESULTS

Experiment One. The percent moisture content before the experiment ranged from 24 to 66 percent. The percent moisture content after the experiment ranged from 49 to 82 percent for the growing media inoculated with second instars and 53-76 percent for growing media inoculated with third instars. The moisture content for the SB300 Universal was always much lower than the other growing media (see Figure 1, left).

The growing medium has a significant affect on the number of fungus gnat adults recovered from samples inoculated with second instar larvae, with the growing medium containing the highest concentration of DE in the Dicalite formulation having the lowest adult emergence (see Figure 2, below). This growing medium was significantly different from all the other growing media tested, with the exception of the Sunshine LC1 Mix, SB300 Universal, and the lowest concentration of DE in the formulation Diafil. Growing medium was not significant for the number of fungus gnat adults recovered from samples inoculated with third instar larvae (see Figure 2, below).

Experiment Two. The percent moisture content before the experiment ranged from 43 to 66 percent. The percent moisture content, after the experiment, ranged from 71 to 85 percent for the growing media inoculated with second instars and 75-85 percent for the growing media inoculated with third instars. In contrast with the first experiment, the moisture content for the SB300 Universal was only lower before the experiment was conducted (see Figure 3, below).

Growing medium was not significant for the number of fungus gnat adults recovered from samples inoculated with second instars; however, growing medium was significant for the number of fungus gnat adults recovered from samples inoculated with third instars, with all the growing media having lower adult emergence values than SB300 Universal (see Figure 4, page 84).

Top: *Growing medium containing diatomaceous earth. It has been hypothesized that growing medium containing diatomaceous earth will reduce the emergence of fungus gnat adults.* ***Bottom:*** *Fungus gnat,* Bradysia sp. nr. coprophila *larvae.*

DISCUSSION

The insecticidal activity of DE depends on a number of factors, such as uniform particle size (less than or equal to 10 µm), percent of particles with a diameter less than 12 µm, distribution of diatom particles and oil adsorption capacity. However, insect sensitivity to DE may be related more to anatomy and physiology. For example, insects with a large surface area in relation to volume of body, rough or hairy body surface and thin cuticle thickness are more sensitive to DE, which may be related to larval instar stage or adult.

There is wide variation in insect susceptibility to DE and any variability in larval susceptibility, such as the second and third instars of fungus gnat, may be due to reduced movement, cuticle thickness and where fungus gnats pupate. Insects that are active are more likely to be damaged than sedentary insects. DE will affect insects as long as there is a sufficient concentration to ensure that insects come in contact with enough diatom particles.

It has not been proven that one instar of fungus gnat is more active than the other or that there are differences in larval stage susceptibility. In the first experiment, growing media (those with and without DE) appeared to have a numerically greater negative effect, based on adult emergence, for second instars compared to third instars as more adults (on average) tended to emerge from growing media inoculated with third instars than second instars (see Figure 2, below).

Also, the location of fungus gnat larvae in the growing medium profile may influence the efficacy of DE. Studies have demonstrated that fungus gnat larvae and pupae are distributed throughout the growing medium profile, which may influence susceptibility to growing media containing lower concentrations of DE. In addition, fungus gnat larvae feeding with-

Figure 2. Mean adult fungus gnat emergence based on yellow sticky card counts from growing media samples initially inoculated with 20 second and third instar fungus gnat larvae for media containing DE and other media tested for the first experiment.

Formulation Name	Concentration (lb. DE/yard³)	Second Instar (mean)	Third Instar (mean)
Diafil	10	6.5 bcd[z]	11.5 a
Diafil	20	10.0 a	10.7 a
Diafil	30	9.0 abc	11.3 a
Dicalite	10	10.8 a	11.6 a
Dicalite	20	10.0 a	12.6 a
Dicalite	30	5.4 d	8.4 a
Fine Perlite	10	9.5 ab	12.3 a
Fine Perlite	20	9.4 ab	11.1 a
Fine Perlite	30	9.4 ab	12.6 a
Teufel Mix	N/A	9.7 a	7.8 a
Sunshine LC1 Mix	N/A	6.0 cd	11.4 a
SB300 Universal	N/A	8.4 abcd	11.3 a

[z]*Means not followed by a common letter are significantly different as determined by Fisher's protected least significant difference test.*

Figure 3. Percent moisture content of media containing DE tested before and after the second experiment.

Formulation Name	Concentration (lb DE/yard³)	Percent Moisture Content Before Second and Third Instar	After Second Instar	After Third Instar
Diafil	10	52	84	83
Diafil	20	50	83	82
Diafil	30	43	82	81
Dicalite	10	50	84	82
Dicalite	20	50	78	82
Dicalite	30	50	82	81
Fine Perlite	10	58	85	84
Fine Perlite	20	55	84	83
Fine Perlite	30	48	84	81
Teufel Mix	N/A	50	71	65
Sunshine LC1 Mix	N/A	66	85	85
SB300 Universal	N/A	43	76	75
Mean		*51.2*	*81.5*	*80.3*
Range		*43-66*	*71-85*	*75-85*

Figure 4. Mean adult fungus gnat emergence based on yellow sticky card counts from growing media samples initially inoculated with 20 second and third instar

Formulation Name	Concentration (lb. DE/yard^3)	Second Instar (mean)	Third Instar (mean)
Diafil	10	7.5 a[z]	4.3 bc
Diafil	20	8.4 a	4.1 bc
Diafil	30	10.4 a	3.8 bc
Dicalite	10	8.7 a	3.7 bc
Dicalite	20	9.0 a	2.0 c
Dicalite	30	5.1 a	3.3 bc
Fine Perlite	10	5.7 a	5.0 b
Fine Perlite	20	7.2 a	3.7 bc
Fine Perlite	30	10.3 a	3.3 bc
Teufel Mix	N/A	6.1 a	5.8 b
Sunshine LC1 Mix	N/A	8.1 a	3.7 bc
SB300 Universal	N/A	9.0 a	9.3 a

[z]Means not followed by a common letter are significantly different as determined by Fisher's protected least significant difference test.

in plant roots or stems may escape any harmful affects from growing media containing DE. It has been suggested that fungus gnat adults may be negatively affected by growing medium containing DE as they emerge from pupae, resulting in increased mortality and/or reduced fitness and reproduction. The reason why there were no significant differences among the growing media for the third instars was due to the low adult emergence from all the growing media (see Figure 4, above).

In general, the percent moisture content of the growing media before each experiment was similar based on the mean moisture content and the range of moisture contents (see Figures 1 and 3, pages 82 and 83) with the exception of SB300 Universal. The variable moisture content of the SB300 Universal may be due to physical characteristics or composition of the growing medium components.

The one noticeable difference, based on recovery rate, was the lower number of fungus gnat adults obtained from third instars in the second experiment compared to the first experiment (see Figures 2 and 4, page 83 and left). This may be a response to the different moisture contents between both experiments. Studies conducted at the University of Illinois have shown that excessive moisture levels may be harmful to fungus gnat larvae, thus affecting adult emergence. Although not directly evaluated in this study, moisture content may also have influenced the efficacy of DE to control fungus gnats, as DE has been shown to be less effective under moist conditions.

In conclusion, based on the results from both experiments, the incorporation of DE into growing medium had no effect on fungus gnat second and third instars. This suggests that the use of DE as an amendment incorporated into growing media may not be beneficial to greenhouse producers. However, further studies are needed to access whether there is differential larval susceptibility (first instar vs. later instars) to DE and if moisture content influences the ability of DE to control soil-dwelling arthropods. GPN

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