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GROWER NOTES

Insect-Killing Fungi

Microbial Insecticides Improve in Quality, Performance and Effectiveness

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There is minimal tolerance for insect damage in greenhouse ornamentals. Chemical pesticides have traditionally been regarded as the only viable control option and have been applied frequently and routinely, often as "insurance" against pest damage. Integrated pest management (IPM) programs are increasingly advocated for suppression of greenhouse pests.

Biological control is a key component of IPM but the broader implementation of these controls has been hindered by the perception that they are less effective, less reliable and slower acting than chemicals. This has been especially true for insect-killing fungi.

Tremendous advances have been made over the last decade, however, to improve the quality, performance and price of these microbial insecticides so that they are now not only cost-competitive with chemical pesticides, but are also as effective. In order to utilize these agents efficiently, though, it is important to understand how they work, and places where they can and cannot be used. They are not effective against all pests or all developmental stages, for example. They are best used against specific target pests in proactive crop protection programs.

Fungi do not have to be ingested to be effective; rather, as with many insecticides, they have "contact activity." Products based on *Beauveria bassiana* are currently available for use on ornamentals: Naturalis®-O, an emulsifiable concentrate from Troy Biosciences; and BotaniGard™, produced by Mycotech Corp., as a wettable powder and an emulsifiable suspension. Like any other biological agent, they take longer to work than many chemical insecticides but today's formulations are stable and easily mixed for spray application using standard spray equipment.

Furthermore, although high ambient humidity can enhance the infection process, it is not a pre-requisite to obtaining good infection and control.

Spore Contact Essential

The "active ingredients" in commercial formulations are spores. These must contact the host directly to be effective, either at the time of spraying, or they can be picked up by motile insects as they move over treated leaves and flowers. Good spray coverage is therefore essential. Once the spores are attached to the insect, they germinate and pierce the body wall. The fungus then multiplies within the body, causing the insect to stop feeding and die a few days later. Insects can lose an infection if they molt

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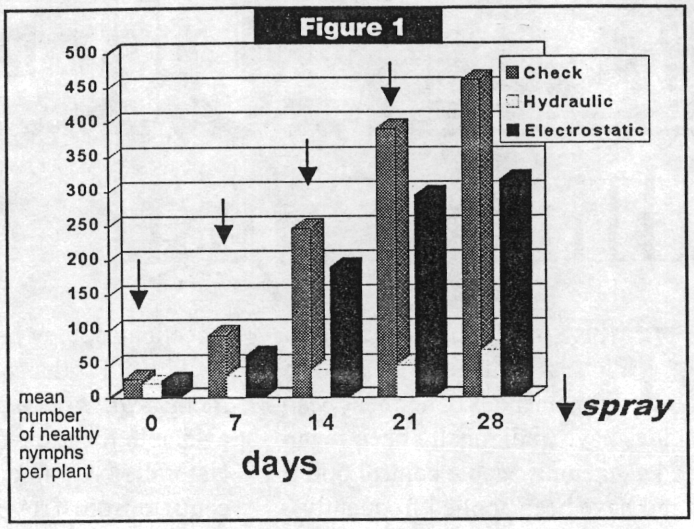
before the fungus has penetrated the body wall, and not all developmental stages are susceptible or suitable targets. Whitefly eggs, for example, are very resistant to infection; adult thrips and whiteflies continue to lay eggs before succumbing to an infection. As with chemical pesticides, it is important to ensure that treatments are targeted against the most susceptible stage and repeat treatments are generally necessary to infect newly hatched larvae, or larvae surviving the first spray treatment.

Maximizing Performance

The following information should help growers maximize performance.

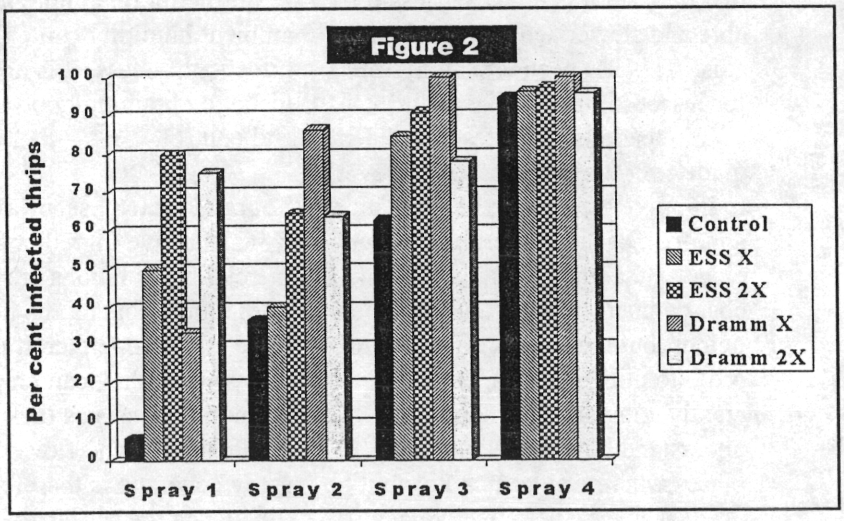
Formulations. Formulations currently available are for use against foliar pests. Growers must select products carefully depending on the crop they are spraying, its stage of development, or weather conditions at the time of spraying. Care must be exercised when spraying oil-based emulsions, for example, especially during periods of high temperature and humidity.

Storage Temperature. Generally speaking, if the products are kept cool and dry, viability and efficacy is maintained for at least a year. Refrigeration is ideal, but storing materials at room temperature (60°F) or cooler will ensure that the fungi remain in good condition. If the fungi are held at higher temperatures (>80°) for an extended period, spores are inactivated; the higher the temperature, the more rapid the decline in viability. This obviously impacts insect infection and the product can be rendered totally ineffective within a few weeks at such temperatures. Storage conditions, therefore, are critical. Remember, these are living agents and must be held under appropriate conditions at all times — in transit and in storage on the farm — to prevent deterioration and maintain potency.



Effect of application method on fungal efficacy against silverleaf whitefly on poinsettia. BotaniGard™ WP applied using hydraulic and electrostatic sprayers.

Application techniques. It is naive to assume that guidelines developed for application of chemical insecticides will hold true for fungi, or that all sprayers will be suitable for their application. High-volume sprays providing a fine mist and good leaf wetting have usually been found to effect the best levels of control. We have been able to consistently control whiteflies on poinsettias using high volume wet sprays. Control has been particularly good when sprays are directed up from the bench into the leaf canopy, targeting spores to the nymphs on the underside of the leaves. Under commercial conditions, a spray program would be initiated before populations grew to the size used in these tests, but 3-4 sprays at 7 day intervals using the recommended dose rate, kept whitefly populations in check throughout the trials and demonstrates that the material can be used as a curative treatment (Fig. 1). Using recommended application procedures, the electrostatic sprayer did not suppress the population as well, even when spray volume was increased, a technique used with good effect with chemical insecticides.



Infection in sampled western flower thrips after treatment with BotaniGard™ WP applied using low-volume electrostatic (ESS) or high-volume (Dramm) sprayers.

Spray trials carried out in California, Maryland and Vermont, have shown that *Beauveria bassiana* (BotaniGard™) efficiently controlled thrips on roses, carnations and potted dwarf sunflower, and suppressed populations in chrysanthemums. Three to five sprays at 3-5 day intervals have generally provided the

best levels of pest control, particularly when population pressures have been high. On chrysanthemums, high volume sprays again seemed to be most effective against thrips, perhaps due to superior leaf coverage or penetration of their cryptic habitats (Fig. 2). Plants were artificially infested and carried heavy thrips populations; in the real world, control measures would have to be applied much earlier. Note that infected thrips were also recovered in the control plots, indicating movement of infected thrips, and transmission of the disease, from treated to non-treated areas.

Ideally, sprays should be initiated before populations reach outbreak levels, so good crop monitoring practices must be implemented. This is ultimately the most economical and effective way of using these materials. Trials carried out in California on roses, carnations and poinsettia, have shown that fungi can be used as a prophylactic treatment over a growing season, and crops have been produced through to the point of sale using fungi in this fashion. This approach necessitates the early treatment of pests at the first sign of a problem, but lower dose rates can be used and longer spray intervals tolerated. However, we need to continue to refine spray protocols to optimize deposition, coverage and insect infection to achieve control in the most cost-effective and efficient manner.

Adjuvants. Many growers will use adjuvants in a spray mix to improve leaf coverage, wetting and persistence. A wide variety of spreader/stickers and wetting agents are available but how compatible are these commonly used products with fungi? Spore viability is not affected by most of the commercially available adjuvants, provided the spray mix is refrigerated or held under cool conditions (<50° F). At higher temperatures (>80° F), though, spores are rapidly inactivated. While some adjuvants may compound these effects, temperature probably has the greatest impact on spore survival rather than the adjuvants. A spray mix should thus be used soon after preparation to achieve the best results. Owing to the diversity and number of spray adjuvants available, the companies producing the fungi should be contacted to obtain an updated list of compatible materials and recommendations. With new product formulations, too, the need to include an adjuvant in the spray tank is reduced, and may even compromise the insecticidal activity of the preparation. Furthermore, some adjuvants have phytotoxic effects on certain plant varieties. As with any spray treatment, phytotoxicity should be assessed on a few plants before spraying the entire crop. In summary, poor coverage of foliage due to selection of an inappropriate wetting agent, storage of a suspension for an extended period under warm conditions, or selection of an adjuvant with fungicidal properties, will seriously impact the level of control obtained.

Integration. In order to rationally incorporate fungi into IPM, interactions with other control components need to be known. Use with other IPM basics such as scouting is essential to their proactive use. Fungi are compatible with greenhouse beneficials such as coccinellid predators and leafminer parasitoids, the whitefly parasitoids *Encarsia formosa* and *Eretmocerus eremicus*, and the thrips predators *Orius insidiosus* and *Amblyseius (= Neoseiulus) cucumeris*. Research evidence strongly suggests that impacts on natural enemies are likely to be minimal. More information is needed, though, to determine which beneficials can be used, to

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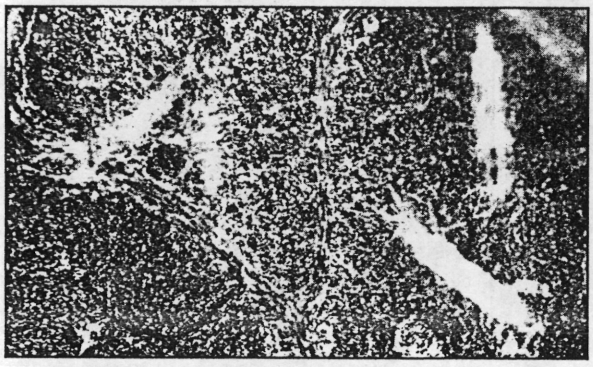
develop appropriate release and spray schedules to maximize insect control, and to determine the most economical way of using both control agents together.

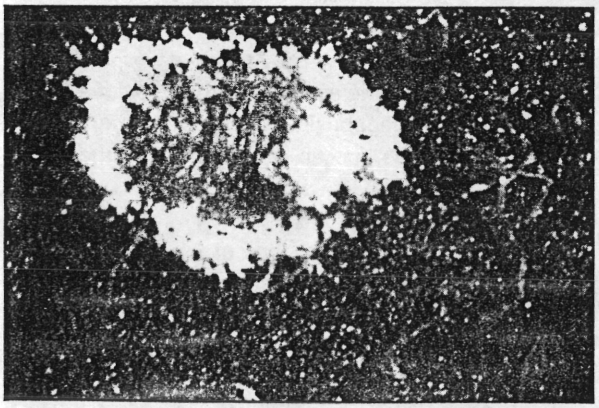
A wide variety of chemicals are used in commercial floriculture. In lab tests, plant growth regulators and biorational insecticides were commonly found to be compatible with fungi and observed effects were usually fungistatic rather than fungicidal. Some older insecticides are inhibitory or even fungicidal (some carbamates for example). Timing of sprays in such cases will be critical to prevent negative interactions.



Western flower thrips (*Frankliniella occidentalis*) infected with the insect-killing fungus *Vecticillium lecanii*. Note, insects showing symptoms of infection are rarely observed in a production house.

Fungi may even be tank-mixed with some insecticides, reducing spray time. Information on compatible tank-mixing is available from the producers and should be consulted prior to the preparation of any spray mixes. In all cases, insecticides should only be used in accordance with their labels. Fungi can be used effectively in a spray program with many insecticides, especially when pest populations are severe. A chemical treatment may be used to rapidly knock down the pest population, for example, and fungal treatments can be used thereafter to maintain low pest populations. Alternatively, chemical insecticides may be targeted at stages unaffected by fungi. Adult whiteflies, for instance, can be regulated through use of a total release aerosol; fungal sprays are targeted against the immature stages on the leaves. In this way, the two control agents are used together in a very compatible manner.

Predictably, fungicides were the most inhibitory in lab tests, although effects varied from product to product. It is safe to assume that effects observed in the lab are likely to be more severe than under true field conditions but it is probably prudent to apply fungi 48-72 hours prior to or after use of fungicides. Use of some of the newer biorational fungicides with a shorter residual would be most appropriate.



Silverleaf whitefly (*Bemisia argentifolii*) nymph infected with *Beauveria bassiana* (BotaniGard, Mycotech Corp., Butte, MT). Nymphs often have a pink coloration, symptomatic of infection with this fungus.

Fungi in Greenhouse IPM.

Fungi are an important new weapon in the IPM arsenal. They are safe, effective and versatile management tools for several important pests encountered on greenhouse crops. They can be used year-round, are compatible with many other crop management practices, and are a viable alternative to many traditional insecticides. It must be remembered, though, that they are living organisms, not chemicals, and must be treated as such in storage and application to obtain the optimal levels of control. ■

Key Points to Remember

The following pointers will help you get the best results from these microbial insecticides.

- Products must be stored under cool, dry conditions to maintain peak viability.
- Select the formulation carefully based on the type of crop being sprayed, its stage of development, and the target pest.
- Prepare sprays only on an as-needed basis and, ideally, use within 1-2 hours of preparation.
- Select adjuvants carefully, based on the crop being sprayed, the formulation being used, prevailing weather conditions, and recommendations on compatibility from the company.
- Do not store excess spray overnight for use the next day.
- Tank mix only with recommended insecticides — remember, some are fungicidal!
- Direct contact between spore and insect is necessary for infection to occur; thorough spray coverage is essential.
- Speed of kill is slower than for conventional insecticides, more like a biorational.
- Use in a proactive IPM program is ideal but fungi can be used as a curative treatment.
- Repeat sprays are generally necessary as not all developmental stages are susceptible.
- Continuous monitoring of the crop is necessary to ensure timely treatment of insect infestations and to assess the efficacy (and need to repeat) the spray treatment.